# Cognitive disability and embodied, extended minds

Zoe Drayson and Andy Clark

Forthcoming in the *Oxford Handbook of Philosophy and Disability*, edited by David Wasserman and Adam Cureton – please cite published version

# **1. Introduction**

Human beings are capable of impressive feats of intelligence and skill. Chess grandmasters can think fifteen moves ahead, for example, and baseball outfielders can anticipate exactly where a fly ball will land. It is often assumed that such feats are the result of the human capacity for rational thought: the way we can apply mental processes like reasoning, calculating, and predicting to different task domains. Furthermore, these mental processes are assumed to be located in our brains. There are research programs in cognitive science, however, that challenge these assumptions by showing how our bodily interactions with the world can achieve the sort of cognitive success normally associated with neurally-located thought. Proponents of these approaches to cognition allow that the brain plays a large role in generating our intellectual abilities, but they urge us to looks beyond the brain: to the way that our cognitive skills are *embodied* in our more basic capacities for sensing and moving, and to way that tools in the external environment can *extend* the cognitive abilities of our brains. This trend toward understanding cognition as embodied and extended has implications for how we think about both cognitive abilities and cognitive disabilities. If cognition is not solely the province of the brain, then cognitive impairment might occur without neural damage, and strategies for cognitive rehabilitation might be less reliant on neural intervention.

This chapter introduces the theory behind embodied cognition and extended cognition, and suggests that they have implications for how we understand cognitive impairment and the rehabilitation strategies toward it. Furthermore, it proposes a new way to think about ‘cognitive reserve’, the resilience that allows some people to function better than others with the same degree of neural damage. It concludes by suggesting that that the ideas behind embodied and extended cognition can change the way we think about the distinction between medical and social models of cognitive disability.

# 2. Embodied and Extended Minds

## 2.1 Brains, bodies, and beyond

What best explains our capacity for flexible, adaptive, intelligent behaviour? The reasoning abilities of the human brain, of course, play a key role. But some cognitive scientists are concerned that if we focus solely on the thinking brain, we might lose sight of the contributions that our bodies and environments can make to our skilled behaviours. We focus here on two related approaches to cognition that challenge ‘neurocentric’ assumptions in cognitive science: embodied cognition and extended cognition.

Embodied cognitive science shifts the focus away from thinking and reasoning as the explanation of our abilities, and toward our bodily abilities like sensing and moving. Proponents of embodied cognition suggest that if our sensory and motor processes are coupled in the right way, they can allow us to perform complex tasks that we might previously have explained in terms of thought and reason. And even when our abilities seem to require thinking and reasoning, work on extended cognition suggests that such complex mental processes (e.g. calculating or remembering) need not be confined to the brain. Proponents of extended cognition suggest that mental processes can straddle the brain-world divide, manipulating and retrieving information that is stored in the environment as well as the information that is stored in the brain.

## 2.2 Embodied cognition

Traditional approaches to cognitive science have often assumed that our sensory and motor skills are primarily just inputs to and outputs of ‘genuine’ cognition: the reasoning processes which take information from the senses and issue motor instructions. Embodied approaches to cognitive science suggest that we should take more seriously the contributions of perception and action, and the way that they can combine directly with each other and the environment.

Consider a baseball outfielder successfully catching a fly ball. What explains their accuracy? On one approach, we might consider solely what is going on in their heads. Their sensory systems, notably vision, process information about the speed and location of the ball, which allows the player to calculate (perhaps unconsciously) the trajectory of the ball, and to predict where it will land. This gives the player the information they need to decide where and how fast to run in order to catch it.

Embodied approaches to cognitive science challenge this picture (McBeath et al., 1995). They demonstrate that if an outfielder simply moves in the right way with respect to the ball, there is no need for them make any predictions about the where the ball will land. If a fielder moves laterally so as to make the ball appear to trace a straight line, or if they align themselves with the path of the ball and run in a way that makes the ball appear to have a constant velocity, then they will end up at the same place as the ball when it lands.

The outfielder example demonstrates the ways that sensory input (e.g. the visual experience of the moving ball) couple with motor output (e.g. running in a certain direction at a certain speed) to solve a particular problem (e.g. how to catch a ball). The brain is still vital, but not for doing anything that looks like thinking or reasoning: there is no need for complex cognitive processes like calculation, prediction, or decision-making. Instead, more basic sensory and motor capacities engage with an environmental problem to find a solution that bypasses the need for more complex cognition. The lesson from the outfielder is example is that we should not necessarily assume that abstract reasoning processes do the main causal work in explaining our abilities. If we focus instead on the way that cognition is embodied, we can appreciate how our the sensory and motor capabilities of our bodies can solve problems without being mediated by high-level thought.

Contemporary embodied cognitive science can trace its roots back to the work of J.J. Gibson in perceptual psychology (Gibson 1967, Gibson 1979). Gibson challenged the view that visual processing builds up a detailed representation of the world for us to reflect upon before deciding how to act. Instead, he proposed that the visual stimulus is already far richer than we think, once we take into account its relation to action: as we move around in the world, our sensory input changes in ways that provide information about our opportunities for action. Gibson claimed that once we understand how our sensory systems and motor systems interact, we can reject the need to posit detailed perceptual representations of the world in order to explain intelligent action.

Some of greatest subsequent advances in embodied cognitive science have been made in robotics. Traditional approaches to cognitive science focused largely on the complex information processing that took place *between* sensory inputs and motor outputs, so roboticists often tried to program their robots with complex computational systems that mediated between the sensory inputs and motor outputs. Rodney Brooks was one of the first to realize that other ways of designing a robot could yield intelligent behaviour (Brooks 1991). He rejected the assumption that robotic systems should feature a central reasoning component that bore the computational load, and peripheral systems for sensing and moving. Instead, he proposed that robots could be designed as systems of activity-producing layers, each of which solves a basic task by coupling a particular kind of sensory to a certain motor output (e.g. light-directed motion). While each layer is little more than a reflex, Brooks showed that complex behavioural patterns emerge when the layers are stacked up. The robot has no equivalent of central reasoning processes, no overall perception of the world beyond each layer’s specialized sensors, and no overall goals beyond the individual tasks performed by each layer. Communication between the layers is minimal: all they do is switch each other on and off.

To see how this might work, consider a robot based upon rats’ abilities to navigate mazes (Mataric 1991). The robot rat investigates and maps its territory using a built-in compass and sonar sensors. Its first activity-producing layer generates ‘boundary tracing’ or wall-following behaviour. Whenever the robot comes across an obstacle, the second layer takes over and notes the obstacle as a landmark, by registering it as a combination of the robot’s sensory input and its motor output. A third layer generates a map of the landmarks, using this information. Notice that the map is not an objective description of the territory that the robot could use to direct another system, or to plot absolute distances: the robot registers the landmarks egocentrically, in terms of its own sensory inputs and motor outputs. To find its way back to a landmark, the robot doesn’t have to first consult the map and then plan a route: the information about each landmark both describes where it is *and* how to get there, and can control the robot’s movement back to a landmark without any further processing.

Similar processes can be found in the natural world. Female crickets identify sounds made by the males of their species, and follow the noises to locate a mate. To complicate matters, each species of cricket has its own sound, and the male cricket can be moving all the time. One might assume that the female cricket has to solve the following problem: first, experience sounds from the environment via her auditory sensors and then filtering out irrelevant (non-cricket) noise; second, identify a mate from her own species by comparing the sounds she can hear to an exemplar, either learned or innate; third, plan a sequence of movements that will direct her to the male cricket. (Notice that if the male cricket has moved by the time she reaches the spot, she would have to start again.) In actual fact, the problem is solved very differently. Sounds arrive at the cricket’s ears via two routes, one external and one through its body, causing its eardrums to vibrate. The external and internal routes to the eardrums are different distances, and the resulting phase-shift causes a higher amplitude of vibration in the eardrum closer to the sound-source. The strength of the vibration determines the firing rate of the motor-controlling neuron connected to each ear, and causes the crickets to turn towards whichever side has the faster neural firing rate and move in that direction. So even if the male cricket is moving, the female cricket will keep moving towards it. And the female cricket doesn’t need to first build up an auditory representation of all the sounds in the environment in order to select the male cricket of her species: her sensory organs are only effective at a certain species-specific frequency. Barbara Webb demonstrated that a robot cricket can be built on the same principles, generating flexible and adaptive behaviour from basic sensory-motor couplings without any central planning, controlling, or goal-setting (Webb 1996).

When it comes to explaining human behaviour, embodied cognitive science has had most success at explaining the sorts of abilities that require environmental engagement and real-time skills, such as the outfielder example above. The extent to which these sensory-motor explanations scale up to account for offline intelligence (e.g. counterfactual thought, semantic memory, language comprehension) remains to be seen.

## 2.3 Extended cognition

Both embodied and extended approaches to cognitive science challenge the centrality of brain-based explanations in accounting for our problem-solving abilities. We have shown how embodied cognitive science focuses on the way the non-neural body can do some of the work attributed to complex thought processes. Extended cognitive science takes a different but complementary approach, by focusing on way that aspects of the environment beyond our bodies can do some of the explanatory work we might otherwise attribute to the brain. Proponents of extended cognition claim that there is no important difference between information that is stored in the biological brain and information that is stored in nonbiological structures: what matters in both cases is how the information is organized and accessed, rather than where the information is stored.

One of the most well-known arguments for extended cognition is Clark and Chalmers’ (1998) thought experiment featuring Inga and Otto in New York. Inga and Otto each hear about an exhibition at the Museum of Modern Art (MoMA) and decide to visit. Inga thinks for a moment about the location of MoMA, before recalling that it is on 53rd St and setting off. Otto suffers from a mild form of Alzheimer's, but he always carries a notebook and writes any useful new information in it. When Otto hears of the exhibition at MoMA, he retrieves the museum’s address from his notebook (where he’d written it down previously) and sets off. The key step in Clark and Chalmers’ argument is their claim that before he consulted the notebook, Otto had the dispositional belief that the museum is on 53rd St., and that this dispositional belief is the explanation of why Otto walks to 53rd St. when he wants to go to the museum. (We take it to be uncontroversial that after consulting the notebook, Otto has the occurrent belief that the museum is on 53rd St.) If we resist this move in Otto’s case, then we have to say why we attribute the same dispositional belief to Inga before she retrieves it from her memory. Clark and Chalmers claim that the information stored in Otto’s notebook plays a similar role to the information stored in Inga’s brain: in both cases, we can explain why they headed to 53rd St by saying that they both wanted to go to MoMA and believed that MoMA was on 53rd St. There is, of course, a difference between the two cognitive processes for storing and retrieving long-term information: Inga’s process is implemented entirely neurally, whereas Otto’s process extends beyond his brain to include the notebook. But Clark and Chalmers argue that this locational difference ought not to make a difference as to whether we accept the processes as a cognitive process, encouraging us to endorse the ‘Parity Principle’:

Parity Principle (PP): If, as we confront some task, a part of the world functions as a process which, were it to go on in the head, we would have no hesitation in accepting as part of the cognitive process, then that part of the world is (for that time) part of the cognitive process. (Clark and Chalmers 1998, 8)

Clark and Chalmers are not claiming that *any* external information can mimic the resources of internal biological memory. Rather, they claim that are certain circumstances in which external information can become so deeply integrated into cognitive systems that it would be arbitrary to draw a cognitive boundary at the metabolic boundary of the biological human. In the case of Otto and Inga, they argue, the functional poise of the stored information is sufficiently similar in both cases to warrant similarity of treatment. We should therefore attribute to Otto the same dispositional belief as Inga, that MoMA is on 53rd St., despite the fact that Otto’s mental state is not confined to his brain or body.

These embodied and extended approaches to cognition, we propose, have implications for our understanding of cognitive impairment and its rehabilitation.

# 3. Cognitive impairment and rehabilitation

## 3.1 Cognitive impairment

The World Health Organization’s International Classification of Functioning, Disability, and Health (WHO-ICF) recognizes that both body structures and functions can be impaired as a result of disease or injury, resulting in limitations to people’s activities (Institute of Medicine 2011, 27). (We will return to the relationship between impairment and limitation when we consider in theories of disability in Section 4.) In the case of cognitive impairment, the limitations involved might include declining memory function, deficits in language comprehension, or problems with decision making and planning. Cognitive impairment is generally considered to be the result of neural impairment: disease or injury to the brain, following stroke, traumatic brain injury, or degenerative diseases such as dementia.

We have already shown how embodied and extended approaches to cognition challenge the traditional assumption that our success at cognitive tasks is explained solely by the reasoning capacities of the human brain. Proponents of embodied and extended cognition encourage us to look to the way our brains rely on interactions with our non-neural bodies and aspects of the world beyond. In doing so, they suggest that some our cognitive abilities might be best explained by sensory-motor couplings or external information storage. But notice that if this is the case, we cannot assume that a decline or deficit in our cognitive abilities is the direct result of neural impairment.

Consider a Scrabble player who, after a stroke, loses the ability to make long words. We might be tempted to assume that they are suffering from some neural deficit affecting linguistic processing the brain. But what if the stroke has affected their movement, such that they don’t have the manual dexterity to shuffle the Scrabble tiles on the rack in front of them? Perhaps their previous Scrabble performance relied on their ability to physically rearrange the letter tiles, so now they are reliant on their neural ability to mentally shuffle the letters in their head, which works less well than the manual shuffling. There need not be anything wrong with the areas of their brain associated with lexical capacities or mental imagery: their cognitive impairment is only a neural impairment to the extent that the motor impairment has a neural basis. Their previous skill at Scrabble was partly reliant on the incorporation of the external rack of letter tiles into their cognitive processes, just as Otto’s ability to remember is reliant on his notebook. If cognitive function can be reliant on external factors, then impairment of that cognitive function need not involve neural impairment.

The Scrabble case may seem like a contrived example: someone watching the Scrabble player would immediately realize that that there was no impairment to their cognitive capacities more generally. But diagnosis of cognitive impairment often takes place in a clinical setting that neglects the normal environmental and social environment of the patient. Consider ideomotor apraxia, a dysfunction of gestures or skilled movements of the limbs. The common diagnostic test for ideomotor apraxia is the use of pantomime: subjects are asked to mime, just using their hands, how they would brush their teeth or use scissors. Apraxic patients are unable to pass this test, and it is tempting to think that a neural impairment is solely responsible for their inability. But this cannot be the case: Andrew Sneddon points out that many patients who fail the mime test in the clinical setting have no problems brushing their teeth or using scissors when toothbrushes and scissors are provided in their normal home environment (Sneddon 2002). Their inability to pass the mime test is no doubt partly due to a neural impairment, but also partly due to the test environment: their ability to perform the action seems to be context dependent. The assumption that the problem in question is entirely due to a brain deficit rules out the possibility “that such particular apraxias are problems of brain-world coordination” (Sneddon 2002, 306) rather than exclusively neural problems. Embodied and extended cognitive science suggests that some of our ability to perform such routine functions is a matter of such brain-world coordination. If certain of our abilities are dependent on our external environments, then we cannot assume that loss of those abilities is due to internal neural damage. The impairment in question might be an impairment of some part of the complex interactions between brain, body, and world that normally generate the cognitive capacity.

## 3.2 Cognitive rehabilitation

Rehabilitation is the attempt to enhance human functioning and quality of life following some form of impairment. Rehabilitation takes two broad forms: *restorative* interventions aim to lessen the impairment by restoring it to its previous unimpaired state, and *compensatory* interventions leave the impairment as it is but aim to lessen the disabling impact of the impairment by compensatory strategies (Institute of Medicine 2011, 75-76).

This distinction between restorative and compensatory rehabilitation is found throughout the literature on both physical rehabilitation and cognitive rehabilitation. Cognitive rehabilitation aims to enhance functioning and quality of life (e.g. by increasing independence) following cognitive impairment. If we understand cognitive impairment as the result of neural damage or decline, then *restorative rehabilitation* will be focused on repairing circuitry: either through neurosurgery or by cognitive exercises designed to rewire the brain. Restorative techniques for memory loss, for example, might include training the patient to remember longer and longer lists in an attempt to build or strengthen neural connections*. Compensatory rehabilitation* strategies for cognitive impairment, on the other hand, leave the neural impairment as it is and focus on helping the patient adapt to it. Brain-focused training techniques such as the increased usage of mnemonics or associative imagery, for example, might be used to compensate for deficits in biological memory, alongside external aids and larger-scale environmental structuring. According to the neurocentric view that cognitive impairment results only from neural impairment, any rehabilitation technique which did not focus on the brain could only be a compensatory technique.

Restorative rehabilitation is often seen as the main goal of rehabilitation, with compensatory techniques understood as a fall-back when restoration of the impairment is impossible or unlikely. In the case of cognitive impairment, compensatory techniques such as those involving external aids are generally understood as a useful substitute when neuroscience lacks either the knowledge or the technology to restore the damaged brain networks. Some neuroscientists think that as we learn more and more about the brain, compensatory strategies will be unnecessary because all rehabilitation will be restorative: Coltheart (1991), for example, suggests that models of neural functioning from cognitive neuropsychology are sufficient to plan cognitive rehabilitation.

Contrast this picture with the approach of embodied and extended cognitive science. If cognition is embodied or extended, then cognitive impairment does not necessarily arise from neural impairment. If cognitive functioning relies on the interactions between our brain, body and the external world, then cognitive impairment can result from changes to those interactions. On this view, restoring a damaged cognitive function need not involve strengthening neural connections: restorative rehabilitation might involve intervention at other points in the web of brain-body-world interactions responsible for cognitive function. Some non-neural rehabilitation techniques which are currently dismissed as merely compensatory may actually be restorative, according to the implications of embodied and extended cognitive science.

Now reconsider the case of ideomotor apraxia described above. The neurocentric approach would class this as a case of cognitive impairment, where the patient lacks the ability to brush their teeth. Placing them in a certain environmental situation with toothbrush at hand would be considered compensatory rehabilitation, in the sense that it doesn’t restore their cognitive ability to brush their teeth, but merely allows them to function better. On the embodied and extended approach, however, we can say that the whether the patient’s neural impairment results in cognitive impairment will depend on the nature of the cognitive task. Their ability to mime certain actions can be impaired without their ability to perform those actions being impaired. Being in their home context with the appropriate tools is does not just *compensate* for impairment: it restores the interactions between brain, body, and world that were previously responsible for their teeth-brushing ability.

On the extended approach to cognition, the role of external aids takes on a new importance in cognitive rehabilitation. Andy Clark documents an encounter between himself and Carolyn Baum, then the head of occupational therapy at the Washington University School of Medicine in St Louis, Missouri (Clark 2003, 139-140). Baum felt that Clark’s work on extended cognition was highly relevant to her own work with a subpopulation of inner-city Alzheimer’s sufferers in St. Louis. These patients performed poorly on standard tests such as the CERAD protocol, which suggested that they should have been unable to cope with the demands of unassisted living; but they still lived alone successfully in the city. On a sequence of visits to their home environments, Clark discovered that their homes were full of cognitive props, tools and aids: message centers where they stored notes about what to do and when; photos of family and friends complete with indications of names and relationships; labels and pictures on doors; ‘memory books’ to record new events, meetings and plans; and open-storage strategies in which crucial items (pots, pans, chequebooks) are always kept in plain view, rather than hidden in drawers. Clark suggests that their homes were carefully calibrated to scaffold their biological brains, and invites us to view cases of potent non-biological 'scaffolding' as implementing alternative but perfectly genuine forms of control and recall, rather than viewing them merely as compensatory props and patches enabling better performance. With increases in technology, the role of ‘intelligent assistive technology’ (IAT) applications for people with cognitive impairment has changed. Ienca et al. (2017) observe that the number of IAT applications is doubling every five years, and they have evolved from safety-focused devices (e.g. GPS trackers, fall detectors) into more general cognitive support:

“the main focus of most current IATs is not simply monitoring older adults with dementia, but empowering them by promoting the autonomous and successful completion of daily activities and the support of their psychosocial dimension (e.g., entertainment, engagement, and communication)” (Ienca et al. 2017, 1336)

If we take the embodied and extended approaches to cognition seriously, it becomes increasingly difficult to draw distinctions between restorative and compensatory rehabilitation on the basis of a biological/environmental divide.

# 4. Cognitive reserve

Embodied and extended cognitive science raises questions for our understanding of cognitive impairment and rehabilitation, but it might also shed new light on remarkable resilience that some people have in the face of neural generation and disease. For several decades, we’ve known that people with the same degree of apparent brain damage can show very different symptoms (Katzman et al. 1989, Ince et al. 2001, Knopman et al. 2003). Some people seem to have a sort of ‘mental padding’ or a ‘buffering’ capacity, which protects them from showing the most serious effects of brain damage.

Archer and colleagues document the following case study of ‘John’, a 73-year-old man who visited the National Hospital for Neurology and Neurosurgery in London (Archer et al. 2005). John was concerned that his ability to play chess had declined over the past two years: he would previously plan his game seven moves in advance, but now he was only able to plan three or four moves in advance. His family were not aware of him showing any sign of cognitive impairment, there were no changes in personality or language, and he continued to look after the household finances. He scored normally on all the neuropsychological tests, and his condition hadn’t changed by the time of his death three years later. But when the autopsy was carried out, John’s brain was discovered to have all the signs associated with advanced Alzheimer’s disease: severe neurofibrillary tangle pathology, cerebral amyloid angiopathy, and Lewy body pathology in the brainstem and limbic structures. This was unexpected, because most people with such severe brain degeneration would have lost many of their mental abilities and wouldn’t be able to function without lots of help and support. But John’s only problem seemed to be that his chess game wasn’t as good as it used to be.

John’s case is surprising, but not unique. Neuropsychologists have introduced the concept of ‘cognitive reserve’ to refer to this capacity for resilience that people like John exhibit (Baltes et al. 1992, Stern 2002, Stern 2003). The higher a person’s level of cognitive reserve, the less likely they are to show the cognitive decline associated with age, head injury, stroke, HIV, Parkinson’s disease, Alzheimer’s disease, or poisoning with neurotoxins.

We know very little, however, about the mechanisms that underlie the phenomenon of cognitive reserve and protect some people from the most devastating effects of neural degeneration. The standard theory behind cognitive reserve assumes that neural mechanisms are responsible, such as the formation of new nerve cells in the brain (neurogenesis), and the brain’s capacity to reorganize itself (neural plasticity). Cognitive reserve seems to be correlated with high levels of educational and occupational attainment, high IQ and literacy, and a stimulating and social lifestyle, which prompts neuropsychologists to propose that “specific mental stimuli and challenges during both childhood and adulthood stimulate the formation of complex neuronal networks and promote cognitive reserve capacity” (Bosma et al. 2003), and that “neuronal plasticity permits cognitive reserve to be enhanced or maintained during the adult years” (Richards and Sacker 2003).

If proponents of embodied and extended cognition are correct, however, then we should be wary of assuming that our performance on cognitive tasks is to be explained solely by neural factors. Embodied and extended cognitive science suggests that cognitive impairment does not require neural impairment, and that restoring cognitive function need not necessarily require neural intervention. If some people are able to perform cognitive tasks better than others with similar neural degeneration, perhaps it is precisely because they aren’t relying solely on neurally-implemented reasoning. Perhaps such people are using embodied and extended cognitive processes to supplement their neural resources.

There are similarities between the case of John and the Alzheimer’s patients in St Louis, discussed previously. They both function better and more independently in everyday life than their degree of brain damage would suggest. In the St Louis Alzheimer’s patients, we explain their abilities in terms of the structure of their immediate environment, their support networks, and the way they rely on gadgets and tools. So why, in John’s case, do we assume that the reason for his resilience must have a neural basis? Admittedly, there is no evidence that John was reliant on environmental scaffolding. But not all reliance on external props is obvious: even those of us with undamaged brains count on our fingers, write shopping lists, and use pen and paper for complex arithmetic. Perhaps John had always been someone who relied on such tools and props, and so found it easier to adapt to neural degeneration without his family noticing much difference.

Recall that high cognitive reserve is correlated with high educational and occupational achievement, stimulating hobbies and busy social lives. Instead of assuming that these factors increase cognitive reserve by supporting neurogenesis or neural plasticity, why not consider whether these factors increase people’s reliance on non-neural forms of cognitive support? Perhaps people with more complex or demanding lives develop ways to offload some of the cognitive work on aspects of the environment and their bodily interactions with it. It is possible that people who rely heavily on such tools and props in everyday life could find it easier to adapt to some forms of brain damage, because they’re already supplementing their brain’s abilities with external aids. As neural functioning declines, these embodied and extended aspects of the mind might be relied upon more and more. The damage might only become functionally salient in artificial conditions, such as those enforced by the rules and practices of chess. At least one mechanism for cognitive reserve might involve this ‘off-loading’ of cognitive tasks.

# 5. Cognitive disability

We have thus far focused on cognitive impairment and its rehabilitation, and said little about cognitive *disability*. Models of disability focus on the limitations that people face in their everyday lives. In physical disability those limitations might involve limited access (e.g. being unable to enter a building with stairs) or limited knowledge (e.g. being unable to read documents that aren’t available in braille). In the disability literature, different models are proposed to account for these limitations. We focus here on two of the most salient: the medical model of disability and the social model of disability (Wasserman et al. 2016).

According to the *medical model of disability*, the limitations in question are the result of an objective, biologically-grounded impairment or dysfunction: being paralyzed, for example, or being partially sighted. In other words, there is a medical impairment that is responsible for causing their limitations. The *social model of disability*, by contrast, denies that such limitations should be attributed to medical impairment and instead looks to environmental factors. If buildings were step-free, for example, a paralyzed person in a wheelchair would not face limitations to their access; if documents were available in Braille, a partially-sighted person would not face limitations to their knowledge. According to the social model of disability, medical impairments only result in limitations if society does not cater to those impairments. On this view, disability should not be seen as an intrinsic property of people, but rather as a relational property that they possess only relative to certain environments.

How does this work for *cognitive* disability? We have seen that the neurocentric approach to cognitive impairment understands the impairment as a medical condition resulting from neural trauma or degeneration. People with cognitive impairments can face limitations: they might be unable to remember to feed themselves on a regular basis, for example. If we apply the medical model to a neurocentric view of cognitive disability, then a person who cannot remember to feed themselves is disabled, and their disability results from neural impairment. If we apply the social model of disability to the same neurocentric view of cognitive disability, then someone who forgets to feed themselves will be disabled if they live in a society where people tend to live alone and are expected to look after themselves. If we apply the same model to a society in which multigenerational families live together and eat together, however, it is less obvious that forgetting to feed oneself results in any form of disability.

The medical and social models of disability offer radically different ways of thinking about disability: *either* disability results from an objective biologically-grounded dysfunction, *or* disability results from the disabled person’s environment. But if we reject the idea that cognitive impairment is solely a neural matter, then something interesting happens to the relation between these two models when applied to cognitive disability.

We propose that embodied and extended approaches to cognition change the nature of the debate about models of cognitive disability. If cognitive impairment can be the result of changes to the interactions between the biological brain and the environment, then cognitive impairment is not necessarily the sort of biologically-grounded dysfunction that the medical model of disability requires. Instead, it can involve the sorts of environmental factors that social models of disability think are key to the nature of disability. But the embodied and extended approaches don’t entail that the medical model is wrong: there is still objective cognitive impairment to cognitive processes, just cognitive processes that extend beyond the biological brain. And the degree of disability will tend to map onto the degree of cognitive impairment, as the medical model would predict. But the degree of cognitive impairment will be partly a feature of the person’s interactions with their environment, so the degree of disability will also be a matter of environmental context, as the social model would predict.

The tension between medical and social models of disability, when applied to cognitive disability, relies on being able to draw a clear line between the biological and environmental aspects of cognitive impairment. Our point is that once we understand cognition as environmentally scaffolded rather than wholly neural, we have lost any clear distinction between biologically-caused cognitive limitations and environmentally-caused cognitive limitations.

# 6. Conclusion

Embodied and extended approaches to cognitive science can be understood primarily as methodologies or research programs. They suggest that when thinking about cognition, we should be prepared to look beyond the brain. They can also be understood, however, as making a stronger and more metaphysical claim. Proponents of embodied or extended cognitive science can be interpreted as claiming that our minds are partly constituted by the non-neural stuff, such that Otto’s notebook, for example, would literally be part of his mind.

On this stronger constitutional claim, ethical issues come to the fore. Consider the forceful relocation of an Alzheimer’s patient from their own home into a hospital setting: this might not merely change their external environment, but actually damage their cognitive processing further. And when an Alzheimer’s patient like Otto has their notebook stolen, are they merely the victim of theft, or has some greater damage been done to them as a person or moral agent? As a society, we do not yet enjoy a structure of laws and social policies that recognizes the deep intimacy of agents and their cognitive scaffoldings: intimacy such that certain harms to the environment can simultaneously be harms to the person. And reflections on embodied and extended cognitive science alone don’t seem to settle such questions. If anything, they highlight the complicated relationship between minds, persons, individuals, and agents. The question of morality arises with respect to mental interventions because having a mind generally denotes having other properties: consciousness, rationality, personhood, or agency, for example. But it is not clear that thinking of the mind as embodied or extended has direct implications for any or all of these features: it will depend on whether we identify the *individual* with the biological body, for example, while identifying the *agent* with the locus of causation and action. Whatever implications one takes extended and embodied cognitive science to have for ethics may be further mediated by one’s views of personhood and agency in their various guises. Extended and embodied minds thus raise new ways of looking at the relationship between embodiment, individuality, and agency, while still leaving many important (and potentially morally salient) issues unresolved.

## References

Archer HA, Schott JM, Barnes J, et al. (2005) Knight’s move thinking? Mild cognitive impairment in a chess player. Neurocase. 11(1):26-31.

Baltes M, Kühl K, Sowarka D. (1992) Testing for limits of cognitive reserve capacity: a promising strategy for early diagnosis of dementia? Journals of Gerontology. 47(3):165-167.

Bosma H, van Boxtel MPJ, Ponds R, et al. (2003). Mental Work Demands Protect Against Cognitive Impairment: MAAS Prospective Cohort Study. Experimental Aging Research. 29(1):33-45.

Brooks, R. (1991) Intelligence without representation. *Artificial Intelligence* 47: 139-159.

Clark, Andy (2003). *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence*. Oxford University Press.

Clark A. and Chalmers D. (1998) The Extended Mind. Analysis.58(1):7-19.

Coltheart M. (1991). Cognitive psychology applied to the treatment of acquired language disorders. Handbook of Behavior Therapy and Psychological Science: An Integrative Approach, 216.

Gibson, J. J. (1967) New reasons for realism. *Synthese* 17 (1).

Gibson, J. J. (1979) *The Ecological Approach to Visual Perception*. Houghton Mifflin.

Ienca, M., Fabrice, J., Elger, B., Caon, M., Pappagallo, A. S., Kressig, R. W., & Wangmo, T. (2017). Intelligent assistive technology for Alzheimer’s disease and other dementias: a systematic review. *Journal of Alzheimer's Disease*, *56*(4), 1301-1340.

Ince et al. (2001) Pathological correlates of late-onset dementia in a multicentre, community-based population in England and Wales. The Lancet. 357(9251):169-175.

Institute of Medicine (2011) *Cognitive Rehabilitation Therapy for Traumatic Brain Injury: Evaluating the Evidence*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13220.

Katzman R, Aronson M, Fuld P, et al. (1989) Development of dementing illnesses in an 80-year-old volunteer cohort. Ann Neurol. 25(4):317-24.

Knopman D, Parisi J, Salviati A, et al. (2003) Neuropathology of Cognitively Normal Elderly. Journal of Neuropathology & Experimental Neurology. 62(11):1087.

Mataric, M.J. (1991) Navigating with a rat brain: A neurobiologically-inspired model for robot spatial representation., S. Wilson & J. Arcady-Meyer (eds.), *From Animals to Animats: Proceedings of the Adaptive Behavior Conference '91* (169-175). MIT Press.

McBeath, M.K., Shaffer, D. M., & Kaiser, M. K. (1995). How baseball outfielders determine where to run to catch fly balls. *Science, 268* (5210), 569-73.

Richards M, and Sacker A. (2003) Lifetime Antecedents of Cognitive Reserve. Journal of Clinical and Experimental Neuropsychology. 25(5):614-624.

Sneddon, Andrew (2002). Towards externalist psychopathology. *Philosophical Psychology* 15 (3):297-316.

Stern Y. (2002) What is cognitive reserve? Theory and research application of the reserve concept. Journal of the International Neuropsychological Society. 8(03):448-460.

Stern Y. (2003) The Concept of Cognitive Reserve: A Catalyst for Research. Journal of Clinical and Experimental Neuropsychology. 25(5):589-593.

Wasserman, David, Asch, Adrienne, Blustein, Jeffrey and Putnam, Daniel (2016) Disability: Definitions, Models, Experience, The Stanford Encyclopedia of Philosophy (Summer 2016 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/sum2016/entries/disability/>.

Webb, B. (1996) A robot cricket. *Scientific American*, 275(6): 94-99.