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The dancing mind

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Abstract

How is it that we go from the unknown to the known? Is there a parallel relationship between mind and body? How does the brain inform the body? An active approach to cognition conceives of the mind as one with the body. The human brain controls feeling, cognition, perception, action, learning and other basic functions, and therefore it is vital to consider the influence of neuroscience on the development of cognitive psychology and vice versa, when looking at a dancing body/mind.
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Introduction:

How is it that we go from the unknown to the known? What are the sources of human knowledge? How is knowledge represented in the mind? How do the cognitive and motor systems interact? Is there a parallel relationship between mind and body? How does the brain inform the body? Our interest in human intelligence; what it is, where it came from, and how it is used, is as old as civilization itself. Over the centuries, philosophers since Plato and Socrates have pondered questions about the nature of human comprehension. According to Socrates, having knowledge is a kind of consciousness fortification, where through the medium of learning, the teacher makes the student aware of what he or she already identifies with (Haberlandt, 97, 4). This acquisition of knowledge is just one of the many manifestations that typify the study of human information processing or knowledge, now distinguished also as cognitive psychology. Information processing is based on what we know and, consequently, cognitive psychology investigates knowledge structures and the processes that operate on those structures. A field of study deeply rooted in experimental psychology, modern cognitive theory freely draws its premises and methodology from nine principal areas of research being: sensation, perception, memory, attention, imaging, language functions, developmental psychology, thinking, and the science of artificial intelligence (Ibid, 97, 1). However, these conceptions of cognitive processes leave out one important factor in the analysis of the cognitive sciences, the brain. As it is the brain that controls feeling, cognition and other basic functions, it is vital to consider the influence of neuroscience on the development of cognitive psychology and vice versa.

For years, philosophers and scientists have debated whether the differing entities of mind and body are related, and if so, how? While some argue that information processing should be studied separately from neuroscience, others believe that because cognition depends on the brain, cognitive research must be based on brain research, for; "how could we study learning, memory, language, and other cognitive processes without knowing their basis in the central nervous system?" (Ibid, 97, 27) Regardless of which argument is eventually proven to be correct, ever since Descartes, scholars have been convinced that the two must interact in some fashion. Therefore, I propose to explore how the correlation between
cognitive psychology and neuroscience when applied to movement perception, affects movement acquisition and, in turn, movement replication in relation to dance. Thus far, there has been limited research conducted to support the convergence of these topics, and as such, I will endeavour to discuss different ways in which scientific and artistic thought are co-dependent on each other, implying a context embracing mind, brain and body.

**Philosophy – An Overview:**

Defined as a field of study that questions and creates theories about the nature of reality, philosophy includes such diverse subfields as, ontology, ethics, metaphysics, logic, aesthetics, and epistemology. Pondering fundamental mysteries like, whether God exists, what makes actions right or wrong, what is the nature of the universe, and whether any true knowledge really exists, the field of philosophy is a vital starting point for investigation into the scientific field of cognition.

Philosophers have wondered and investigated how people perceive, know and learn ever since the time of the ancient Greeks. Their ideas shaped and continue to shape how psychologists study learning and the theories they have constructed to explain learning and cognition (Leahey, 97, 1).

**Knowledge:**

What is knowledge? How does knowledge arise? What knowledge is most reliable or important? What do people know? The answer to all of these questions and more lies in the branch of philosophical science referred to as, epistemology. A study of the nature, warrant, and sources of knowledge, the task of an epistemologist is to logically analyse the processes or mechanisms by which knowledge develops and hence, provide a representation of the mind that may render learning practices comprehensible. However, before we go on to discuss studies in the theory of knowledge, we must first acquaint ourselves with the concept of knowledge itself.
Defined as the confident understanding of a subject, the premise of knowledge has always been of interest to philosophers. This consciousness may have something to do with the fact that knowledge and philosophy were both built on the foundations of thought or perhaps it is knowledge’s intimate association with projected ideals of civilization, changing technologies and scientific models, which invites such equally varying discourse and evaluation?

The first theories of knowledge stressed the importance of its absolute, perpetual character, whereas the later theories place the emphasis on its relativity or situation-dependence, its continuous development or evolution, and the active interference by the world and its subjects and objects on what might be knowable. The whole trend moves from a static, passive view of knowledge towards a more and more adaptive one, hence giving rise to a variety of traditions of philosophical interpretation. According to Greek philosopher Plato, knowledge is merely an awareness of absolute, universal ideals or forms, existing independent of any subject trying to apprehend to them, its genuine source coming from within (Heylighen, 93). Aristotle on the other hand, although in acceptance of Plato’s view that knowledge is an apprehension of necessary and universal principles; placed more emphasis on logical and empirical methods of gathering knowledge.

Following the Renaissance era, a period of great intellectual ferment and growth, three main epistemological positions dominated philosophy, the empiricist method, the rationalistic approach and the Kantian synthesis (Heylighen, 93). Scholars who promote the epistemological position of empiricism see knowledge as the product of sensory perception, with rationalists seeing knowledge as the effect of rational reflection. “For Plato, thought was based on the stimulation derived from each of the senses, [where as] Aristotle argued that the human mind acted on the perception of objects” (Solso, 79, 9).

In the empiricist tradition, incipient science is taken as the primary model. Natural phenomena are discovered by experience; they are not divulged by intuition, nor are their interrelationships derivative of self-evident maxims. According to philosopher and empiricist David Hume, the elements of knowledge are; smell, colour, movement, and extension in space (Haberlandt, 94, 7). He believed that our ideas are based on experience
with the external world and with our personal reflection. In the rationalistic tradition, mathematics is the model of science. Truths based on mathematical analysis are universal and necessary, established by deductive chains which link them to patently obvious basic truths. Philosopher, Renee Descartes investigated the fields of physics, geometry, physiology and linguistics, and after much thought came to the supposition that human rationale, the product of the mind, was unique (Haberlandt, 1994, 4), providing more definitive insights than those acquired from the senses. Another theory which developed is the Kantian synthesis (Heylighen, 93) of empiricism and rationalism. Philosopher Immanuel Kant claimed that both the mind and experience are sources of knowledge, with such knowledge arising from the organization of perceptual data on the basis of inborn cognitive structures referred to as ‘categories’ (Haberlandt, 94, 7). “The mind provides the structure for the knowledge, whereas experience with the external world provides the facts to fill the mental structures” (Haberlandt, 94, 7). Philosophers, Descartes, Hume, and Kant identified important questions that not only influenced experimental psychology throughout the nineteenth and twentieth centuries, but also led to the development of what we know today to be contemporary cognitive psychology.

Epistemology:

How do people acquire knowledge, and how do they use it? (Leahey, 80, 1) Epistemology is the philosophical study of what is required in order to have coherent beliefs and knowledge. In an attempt to answer the basic question; what distinguishes true knowledge from false knowledge, epistemology endeavours to decipher the possibilities, natures, and limits involved in human intellectual attainment. By striving to eliminate the difference between knowledge and opinion, or the difference between good reasoning and poor reasoning, epistemologists are trying to understand what it is really to know, or really to think reasonably, even if people routinely fail to know or are frequently irrational in their thoughts. Both traditional a priori methods of philosophy and a posteriori methods of cognitive science are at the frontier in relation to this topic (Baergen, 95, 189). The distinction between the a priori and the a posteriori is epistemic, as it has to do with how one comes to realize certain propositions (Baergen, 95, 189). A thought is deemed a priori, if its justification does not depend in anyway upon experience; if it does however, the
thought is deemed *a posteriori*, with the notion of experience playing the vital role (Baergen, 95, 189).

Experience includes any sort of sensory input (for example, seeing, tasting, touching, etc.) as well as introspection and memory; beliefs formed on the basis of any of these are *a posteriori*. Experience does not include such things as one’s understanding of a proposition (or portions of it), and usually it is not taken to include what is often called intuition (Baergen, 95, 189).

It is generally said that any proposition that is not *a priori* is *a posteriori*, though this assumption is not mutually exclusive (Baergen, 95, 189). Another distinction may be drawn between epistemology aimed towards individuals and epistemology oriented towards social institutions or practices. Perhaps the best distinction between differing epistemic propositions is that *a priori* epistemology aims to investigate the specific domains of knowledge or rational beliefs oriented towards social institutions, whereas *a posteriori* epistemology aims to understand general and omnipresent elements of individual human inquiry, such as procedural knowledge and inductive conjecture (Baergen, 95, 189). It is the latter of these two distinctions, the *a posteriori* method that is of most utility to this discussion. We shall concentrate on the general construction of individual epistemology and its relation to cognitive science as, “cognitive science gives epistemologists detailed and empirically robust accounts of the origins of thought” (Cruz, 27).

**Naturalised Epistemology:**

Although traditionally conceived as a matter of logic rather than psychology, of theoretical means rather than concrete facts (Mischel, 71, 64), every epistemology is wrought by underlying conceptions of the mind and behaviour, of which cognition is a consequence. In modern cognitive science, the empirical-psychologist and some philosophers have come together to pursue naturalised epistemology, an account of knowledge resting upon psychological research instead of on philosophical speculation. According to current thinking philosophy can add perspective, but only scientific processes can actually advance a discipline of study.
Philosophers and psychologists have dismantled the boundary fence dividing them, jointly considering what new light empirical studies of cognitive development can throw on the philosophical analysis of epistemic concepts, enhancing conceptual analyses on the empirical questions developmental psychologists should be asking (Mischel, 71, 37).

**Learning – The Acquisition of Knowledge:**

How is the cognitive field of knowing related to the educational field of learning? The realm of learning has always been a predominant subject in investigations of philosophers and psychologists alike, because it is fundamental for human cognition (Haberlandt, 94, 196). According to early analysis, learning describes a change in understanding and achievement through experience, changes which are derived from associations between ideas. When two events take place at the same time, we are predisposed to connect them in our mind, so that when one event occurs again, the other event is also evoked. This view of learning came to be known as associationism (Haberlandt, 94, 196), a sub-field of psychology, which influenced the experimental investigations of memory by Ebbinghaus (Haberlandt, 94, 196), and the conditioning theories of Pavlov (Haberlandt, 94, 196) at the turn of the 21st century.

In regard to the psychology of learning and knowing, two philosophical quandaries arise; firstly, the quandary of the cognitive ‘how’ and, secondly, the impasse of cognitive ability. Learning how to do something is classified as a form of procedural knowledge. Also referred to as skill-based knowledge, procedural knowledge is a precursor to the comprehension that generates motor and cognitive skills such as calculation, computer programming, playing the piano, dancing, riding a bike or speaking another language. Once an individual has acquired complex skills or techniques describable in terms of knowing ‘how’, he/she possesses the ability to execute such procedural knowledge. Hence one can now say, ‘I know how to program a computer’, ‘I know how to play the piano’, ‘I know how to dance’, or ‘I know how to speak Japanese’. It is important to realize that this
skill-based knowledge does not yet factor in the cognitive ‘can’, which comes under the second of our abovementioned philosophical quandaries.

One might say that the divergence between the cognitive ‘how’ and the cognitive ‘can’ rests simply in the repetition of practice. To say that a person knows how to do something without first making a certain sort of contextual ability attribution, is merely an assumption. A person may well have all the pertinent information concerning some skill, but this knowing ‘how’ to perform the skill is completely irrelevant when repeated trial or practice is thought to be at the essence of ability, and where it (practice) only requires minimal conditions of knowledge. “It is to do a bit of theory and then to do a lot of practice” (Scheffler, 65, 96).

The word practice is typically defined as, skills developed through learning in a continuous way by means of routine assessments or performances (Scheffler, 65, 95). If this training process becomes habitual, however, one might ask as to when we decide that the skill has been achieved (Scheffler, 65, 95)? We are competent at a skill when our performance of the task has become erudite and error free. According to cognitive psychologists, the transition from slow and error-prone performance of a skill, towards instantaneous and precise performance of the same skill, advances in three phases: the cognitive phase, the associative phase, and the autonomous phase (Scheffler, 65, 94). During phase one, the instructor teaches the agent the complex techniques fundamental to the skill. In the instance of classical ballet, for example, the teacher shows the student technical ballet steps and gives useful corrections pertaining to those steps. In the associative phase, the student practices the ballet steps through repeated assessments or performances and begins using the correct technique almost without being aware of it. Finally, in the autonomous phase, steps are performed automatically with dexterity and precise technical ability. Once the individual has passed phase three and proficiency has been acknowledged, the whole process undergoes a cyclic repetition each time a new set of complex techniques pertaining to the skill of classical ballet are introduced. It is important to be aware, however, that this cyclic process does not apply to all skill bases and that the complex technique of classical ballet is in fact an advanced one.
Standards we employ to decide when particular skills or competencies have been reached vary analogously from context to context and will normally become more stringent with educational development. Standards and achievements are, in a fundamental way, open ended in the case of advanced skills (Scheffler, 65, 95).

For advanced skills, which fall under intelligent capacities, the agent is always still learning (Scheffler, 65, 105).

Following extended practice of a certain skill, the disparity between the cognitive ‘how’ and the cognitive ‘can’ no longer exists. One can now confidently say, ‘I know how to dance’ and ‘I can dance’. The acquisition of procedural understanding has become analogous with one’s ability to execute such skill-based knowledge.

**Embodied Cognition:**

Embodied cognition is a developing research program in the field of cognitive science, which highlights the seminal role that the body within an environment plays in the development of cognitive structures and processes. The general hypothesis maintains that cognitive processes develop through goal-directed interactions between organisms and their environment and that the nature of these interactions influence, the formation and characteristics of the developing cognitive capacities. However, as cognitive science is comprised of a diverse range of sub-fields including, developmental psychology, linguistics, artificial intelligence, and the philosophy of the mind, embodied accounts of cognition have been formulated in a variety of different ways. This said, all theorists in the field of cognitive neuroscience are congruent in their view that embodiment is a fundamental condition of cognition (Cowart, 06). The inimitable way that an entity’s sensorimotor capacities enable it to effectively interact with its environmental nook, or an entity’s embodiment, is responsible for developing cognitive explanations that summarize the manner in which mind, body, and world mutually interrelate and affect one another to advance an organism’s adaptive success.

The central claim of embodied cognition theorists is that an organism’s body, environment, and sensorimotor capacities are inextricably linked, that is, they are directly relational to
each other and to the organism with the degree of this interrelationship solely responsible for the development and nature of specific cognitive competencies. When we state that cognition is embodied, we are averring that cognition evolves out of one’s corporal interactions with the world.

Cognition depends on the kinds of experiences that come from having a body with particular perceptual and motor capacities that are inseparably linked and that together form the matrix within which memory, emotion, language, and all other aspects of life are meshed (Cowart, 06).

The claim that thought results from an organism’s ability to act in its environment; evolves out of the assumption of embodied cognition philosophers that goal-directed actions occur in real time. More precisely, an organism learns to control its own movements and perform certain actions, developing an understanding of its own basic perceptual and motor-based abilities, skills that are an essential first step towards acquiring more complex cognitive processes like language. In essence, low order actions and movements are viewed as essential for the development of higher order cognitive competencies.

Two other assumptions by embodied cognition theorists are important to this research hypothesis; firstly, the belief that the form of embodiment determines the type of cognition and, secondly, that the results of analysis are productive. In order to consider evidence in support of these theoretical postulations, and so affirm the aforementioned primacy of actions unfolding in real time (Cowart, 06), one ought to look at the cognitive science sub-field of developmental psychology and the significant research contributions of developmental psychologists like, Esther Thelen and Linda Smith. According to Thelen, action is the seed of thought, the starting point that fuels the engine of transformation (Thelen, 95, 69).

Through the processes of trial and error, activity brings about changes in the dynamical systems framework of the body, so that new types of behaviour can emerge from behaviours that already exist in the system. This means of generating new behavioural patterns from those that already exist in the system results in environmental scaffolding (Cowart, 06). Furthermore, this dynamic systems analysis of development, allows the
researcher to measure how different movements and actions change and progress over time. However, at this stage in the embodied cognition research program, this dynamic systems analysis is limited to low-level actions such as crawling, walking and reaching, and is not able to explain the diachronic emergence of higher level cognitive abilities that require alternative categorization. If what neuroscientists tell us about the plasticity of the brain is correct, organisms are continually learning something about the perceptual-motor systems and their relations to the world in their repeated spontaneous activity. "What infants sense and what they feel in their ordinary looking and moving are teaching their brains about their bodies and about their worlds" (Cowart, 06). Through repeated spontaneous activity, they explore what range of forces need to be delivered to their muscles in order to get their arms to move in particular directions. Subsequently, organisms must learn how to perform certain activity patterns such as reaching and then remember when it is appropriate to generate those patterns again to achieve a desired goal. In order to effectively perform these behaviours at the appropriate times, the organism must learn to categorize particular situations and correctly apply the action solution that corresponds with that situation. The way in which an organism can conceptualize and categorize is essential to the embodied cognition hypothesis, as the way in which we are embodied determines the variety of activity patterns that we can perform.

**Cognitive Psychology:**

Wilhelm Wundt and other colleagues were the first experimental psychologists to study the mental elements and their associations. Given cognitive psychology’s deep-seated roots in experimental psychology and conscious experience (Leahey, 97, 5), it is not surprising that the spheres of attention, sensation, perception, learning, memory, and developmental psychology are at the nucleus of the modern cognitive form. According to Solso; cognitive psychology deals with how we acquire information about the world, how such information is represented and transformed as knowledge, how it is stored and how that amassed knowledge is used to articulate our thoughts and behaviours (Solso, 79, 2). Also defined as, the experimental study of human information processing (Haberlandt, 97, 1), cognitive psychology theorists draw inferences about knowledge structures and mental processes. This issue of mental representation was discussed by Greek philosophers as early as the
seventh century, philosophers who studied the focus of interest shifting backwards and forwards between the two representations continuously. Although this continuous change in emphasis is still present throughout modern cognitive psychology, there is an increased awareness that a definitive psychology of thought embraces the representations of structure and process working simultaneously.

Much of the current excitement in cognitive psychology is generated by the discovery of new structures and processes associated with them, and the recognition that both structure and process contribute to our understanding of the cognitive nature of the human mind (Solso, 79, 8).

The term structure, as it relates to the institution of the cognitive system is largely a figure of speech. In other words, the structures hypothesised are agents of the organisation of mental entities, not verbatim metaphors of them. The term process, on the other hand, denotes schemes of operations or functions that in some way scrutinise, transform, or modify intellectual measures. “Process is active as contrasted with the relatively static structure” (Solso, 79, 9). As human beings we acquire information, we transform it and finally, we reformulate it to produce data that can be communicated through sensory output. This dichotomy and interaction between the two mental representations of structure and process illustrate how they perform concomitantly in the processing of information, each partially the corollary of the auxiliary counterpart. Some structures are formed as information is processed and, subsequently, mental processes are often dominated by structure. Because structures and processes work in tandem, it is sometimes difficult to separate their function in analytic cognitive psychology and, hence, processes and structures must be interrelated for a cumulative cognitive system to function. The ideas of Aristotle, as contrasted with those of Plato, resemble our concept of process, while Plato’s views are manifest in the mental representation of structure.

**Cognitive Neuroscience:**

A discipline rooted in psychology, cognitive science, neurology, and neuroscience, the scientific field of cognitive neuroscience was so named in the 1970s when Michael S.
Gazzaniga and the great cognitive psychologist George A. Miller were searching for a name to express the study of how the brain facilitates the mind (Gazzaniga, 02, 1). Having a profound influence on our conceptions of cognitive processes over the last thirty years, these theorists developed new research paradigms, which, along with traditional anatomical and behavioural methods, have been put to effective use by cognitive neuroscientists, looking for parallels between neural and cognitive phenomena. Learning phenomena have been correlated with neural activity in the cerebellum and brain stem, perceptual effects can be traced to certain regions in the thalamus and cerebral cortex and deficits in short-term memory and language have their source in the temporal lobe. For neuroscientists, the cognitive manifestations of perception, attention, learning, and memory are of paramount interest.

Perception is a branch of psychology, philosophy and biology directly involved with the detection and interpretation of sensory stimuli. Attention plays a role in the perception of such stimuli as a concentration of mental effort on sensory or mental events. The articulation of learning refers to the acquisition of knowledge, an individualistic process framed or shaped by a student's consistent way of responding to and using stimuli in the context of learning. Finally, the cognitive manifestation of memory works simultaneously with perception as without memory, what an individual thinks he or she perceives, would not be verified.

**Sensation:**

As human beings, we 'know' through our senses. We see, hear, taste, feel and smell the singularity of the world as the first connection in a string of events that subsequently involves the coding of information, storing of information, thinking, and finally, reacting to information that, in turn, leads to a new sensory cue that may again initiate the cyclic process. The term sensation refers to the initial experience of elementary forms of stimulation (Solso, 79, 26), the study of which generally deals with the structure of the sensory mechanisms like the ear and the eye, and the impetus that affect these mechanisms. The point of contact between the inner world and the external reality seems to be centred in the sensory system. Our knowledge of the world is initially sensory in nature and,
therefore, as we come in contact with stimuli above a certain level of intensity, our sensory receptors are activated. Phenomena from the external world are distinguished by means of the sensuous system, which is comprised of the five senses of sight, sound, taste, touch and smell. Each one of these sensuous organs has the capacity to transform incoming stimuli into neural energy. “It is only through our bodily senses that we have contact with the outside world and through our sensuous system we must interpret all that comes from without” (Field, 73, 21).

**Attention:**

The various processes by which the brain selects among internal and external sensory stimuli is referred to as attention (Hagendoorn, 03). An individual’s attention can be caught by a single sensory event or be actively directed at a number of events occurring inside or outside one’s brain. By orienting the senses to the source of a sudden change in environment, and by preparing for the occurrence of an unexpected event, the cognitive process of attention is able to modulate an observer’s perception.

**Perception:**

In psychology and the cognitive sciences, perception is the process of acquiring, interpreting, selecting and organizing sensory information. One of the oldest fields in scientific psychology, perception evokes many philosophies about its underlying processes. One such philosophy is the Weber-Fechner Law (Wagner, 06), which enumerates the relationship between the intensity of corporeal stimuli and their perceptual effects. In relation to this psychological principle, many cognitive psychologists hold that, as we move about in the world and sense its objective, we construct a model of how the world appears through the perception and elucidation of sensory impetus (Wagner, 06). That is, our sensations map to provisional perceptions and, as we cognize new information, our precepts change.

Cognitive theories of perception assume that there is a poverty of stimulus. This with reference to perception is
the claim that sensations are by themselves, unable to provide a unique description of the world. Sensory consciousness arises only after perceptual information has been interpreted (Baergen, 95, 187).

Studied psychologically through the philosophy of the mind, the process of perception requires the elements of attention and categorization to operate. In any situation, we can only pay attention to a few things. One can observe a lot by just watching, but in any observation induced situation, focalization and the concentration of one’s consciousness unconsciously filters the myriad of external sense stimuli so that the mind can deal clearly and effectively with the objects or trains of thought that appear to be the most pertinent to the situation. After such filtration, when awareness has been attained, the brain pre-processes the accumulated sensory impetus prior to it reaching one’s consciousness. This pre-processing scheme describes the categorization phase of the percept’s process. According to cognitive psychologists, we perceive the world in terms of consequential, efficient units, not simple movements (Borgatti, 96). For example, when my mouth is moving and timbres are emanating, I am talking.

Perception is affected by knowledge, that is, prior learned acquisition that is already stored in the brain in a categorical analogous schema. “Just as one object can give rise to multiple percepts, so an object may fail to give rise to any percept at all: if the percept has no grounding in a person’s experience, the person may literally not perceive it” (Wagner, 06). The mind also creates schemas or frames, patterns of behavioural norms that are internalized by participants so that they know what to expect the next time that they are faced with the same or a similar situation. Schemas themselves can also be categorized either culturally or experientially. Cultural schemas organize learned acquisition from others, books, institutions or the television. Experiential schemes, on the other hand, organize what the mind perceives as routine behaviours, like what happens at a restaurant, a typical dinner party, or a meeting. These schemas, built from our sensory experience with the external world, are the edifices that enable us to comprehend and remember prior learned behaviours acutely.
Providing one with a direct link to objects or substances in close proximity, perception requires the sensuous outlets of the eyes, skin, ears, nose and tongue. Through sight, the perception of light as reflected by external objects (Field, 73, 22), the eye transmits information about the visual world to the brain. Through touch, the perception of feeling by contact with external substances, the skin receives tactile information transferred to the brain by way of the nervous system. Through sound, the ears act as an auditory or sound receiver, monitoring the differences in air pressure (Baergen, 95, 171). Smelling involves detecting the shapes of tiny airborne particles, the nasal cavity acting as an olfactory (Field, 73, 21) or smelling receiver and, lastly, tasting involves the tongues’ response to certain chemical structures (Baergen, 95, 171).

There are two domains of perception; direct perception and indirect perception. Simply put, direct perception is awareness without any intermediary objects. Indirect perception or veridical perception is awareness with a transitional entity involved, as is the circumstance when one looks at their reflection in the mirror. Direct perception is also referred to as true perception because one can be more confident about what something is like if they perceive it directly than if they perceive it indirectly. Indirect perception is only accurate if the intermediary entity passes the information on accurately.

**The Central Nervous System:**

The human brain is a biological entity: it is born, it grows, it matures, it collects information and eventually it dies. Comprised of billions of nerve cells, neurons and supporting tissue, the brain controls cognitive activities from sensation and perception to attention, acquisition, recognition and discovery. “Just as specific members of a large orchestra perform together in a precise fashion to produce a symphony, a group of localised brain areas performing elementary operations work together to exhibit an observable human behaviour” (Haberlandt, 97, 51).

Every bodily movement we make, whether of an appendage such as a head or a limb, or the body moving by walking or self-directed transference, is under the direct control of the nervous system. The control and coordination centre of the human body (Field, 73, 20), the
The central nervous system describes the integrated relationship between the dominant brain, the spinal cord and the body’s sensuous system. The purpose of the brain is to produce behaviour, and as virtually all behaviour consists of movements resulting from the actions of the skeletal muscles, it has been said that, “the fundamental purpose of the brain is to produce movement” (Thompson, 00, 286).

According to Spanish anatomist, Santiago Ramon Cajal, “the neuron is a basic processor of the human nervous system; a communication station” (Haberlandt, 97, 41). The foremost researcher to show that neurons are the smallest units of the central nervous system, Cajal’s work is regarded as one of the greatest achievements in scientific history (Thompson, 00, 2). Subsequent research has shown that signals travel within neurons, between neurons and along axons, passing from neuron to neuron at the adjacent junction known as the synapse. This is possible when, the membranes of two neurons come into close vicinity. Composed of a soma and two types of protuberances; the axons and dendrites of each neuron, when stimulated by an event of sufficient intensity, outputs an active potential that is propagated along the axon projection to the synapse. Communication at this site is based on neurotransmission, whereby vesicles release chemical substances that cross the synaptic cleft and further travel towards postsynaptic receptors. One may wonder how a simple neuron could support such cognitive functions as perception, attention, acquisition, and memory. However, neurons exist in multiple connections forming innumerable networks, each network highly capable of learning.

The foremost brain structures of interest to cognitive neuroscientists include the cortex, the cerebellum, the thalamus, the limbic system, and the hippocampus. The cortex, which is also referred to as the cerebrum or the neocortex, sub-serves such cognitive operations as sensation, perception, language comprehension and production, motor control, thought and planning. Anatomically consisting of two hemispheres; a right and a left, each hemisphere is composed of four lobes; the frontal, the parietal, the temporal and the occipital. According to neuroscientists, the frontal lobes of each hemisphere are responsible for motor functionality and the higher-level functions of memory and planning, with the projection and association areas of the parietal, temporal and occipital lobes responsible for the body’s sensory functions. As most of the brain’s neurons reside in the cerebrum, this is the site at
which neural information processing takes place. Neurons in the brain stem (thalamus, limbic system, and cerebellum) and forebrain (hippocampus) send information via the presynaptic and postsynaptic membranes to the cerebrum, to be processed, translated and finally output via the previously mentioned synaptic structures to the contiguous regions of the brain. Multiple communication channels exist between structures and fibres within the cortex to connect the two neighbouring hemispheres. An example of one of these communication channels is the corpus callosum. Neuroscientists have always been intrigued by communication sites such as the corpus callosum, believing that they hold the key to unlock the age old mystery of how fibres from one hemisphere cross over to the other side of the body and, in turn, cause contralateral movement specialization. For example, “the movements of the right hand are governed by centres in the left hemisphere” (Haberlandt, 97, 52).

The Mind and the Body:

Are the mind and body related, and if so, how? In philosophy the idea of two kinds of things, existences or substances is commonly referred to as dualism (Bode, 76, 19). A doctrine that evolved out of Descartes’ philosophies about the mind and body being two distinct entities, Dualism in relation to the phenomena of the ‘mind’ and the ‘body’ is a controversial quandary still disputed today. According to Descartes’ ‘mind-body dualism’ thesis (Skirry, 06), the nature of the mind, a thinking non-extended entity, is completely divergent from that of the body, an extended non-thinking unit, and therefore it is feasible for one to subsist without the other. However, what this hypothesis fails to consider is that a human being requires the dualistic entities of mind and body working cohesively, in order to function.

How can our mind cause some of our bodily limbs to move (for example, raising one’s hand to ask a question), and how can the body’s sense organs cause sensations in the mind when their natures are completely different? (Skirry, 06)
The physical reactions, reflexes and habits that are stored in our muscles (Schrader, 05, 127) go hand in hand with our mind to compose what is known as our body intelligence. Defined as the ability to learn from experience, intelligence is usually associated with the brain, a biological entity that has the ability to process mental associations and information. However, the idea of the brain being the sole organ of intellectual prowess has come under much current scrutiny, with psychologists, such as Kate Stevens, studying the relationship between the mind and body in an effort to prove that in order to ‘make sense’ of something, we require effort from both the mind and the body. The body intelligence theorem suggests that a person who is physically coordinated and responsive should be able to mobilize appropriate muscles with appropriate force, anticipate or sense cause and effect, synthesize information from sensory, emotional and cultural sources and, finally, coordinate the four components of human action, being pattern, skill, sensation and emotion.

Just as a person can memorize a series of mathematical formulas and still not be able to solve a problem, so it is possible for a dancer to memorize a series of steps and still not be able to dance the whole phrase. Without an understanding of the relationships in a math problem it is difficult to manipulate the figures. Similarly, without a sense of the relationships of the steps in a dance sequence, it is difficult to create a whole that is more than its parts (Schrader, 05, 127).

Movement Acquisition:

The acquisition of movement involves the brain and the cognitive manifestations of sensation, perception and learning. This ability to learn is an expression of our adaptiveness to a continuously changing environment and, consequently, the premise of learning movement brings into context the idea of the ‘dancing mind’ (Hagendoorn, 03). According to Ivar Hagendoorn, “the limbs move, but it is the brain that dances” (Ibid, 03). Psychologist Kate Stevens and neuroscientist Patrick Haggard are presently exploring the ideas of an embodied mind or thinking body which presents a scientific scrutiny of an idea that ‘the mind is a muscle’ proposed by Yvonne Rainer in the 1960s. The foremost thing about the mind is that it is a product of the brain. According to Haggard, the mind inhabits the body, thus enabling it to provide the brain with its vehicular source of interaction with
the external environment (Haggard, 06). All of the information that is transmitted to and from the brain, is filtered via the body. If the brain was disconnected from the body it would literally become an unconscious entity. Nowhere is the idea of the thinking body more evident than in the motor development phase during infancy. According to Stevens, “Infants definitely think through movement. It is the first way they engage with the world. They experiment with kicking and reaching and grasping movements and I believe that it is a very early form of cognition” (Stevens in Mitchell, 05). These findings by Haggard and Stevens further enhance the prior discussion on embodied cognition hypotheses; that, low order actions and movements are essential for the development of higher order cognitive abilities.

**Proprioception:**

How does the brain inform the body? An understanding of the science of proprioception is required to explain the acquisition of movement and how it is perceived. Described as the ability to coordinate any kind of movement unconsciously (The Science of Proprioception, [author unknown], 06), proprioception is the body’s predetermined response scheme, sending information to the brain about the progress of the prior sent movement directive so that the brain knows when it needs to transmit the subsequent movement commandment. “While the brain can send messages to our muscles to make them move, without proprioception the brain doesn’t receive any feedback to verify whether the movement has been completed or not” (The Science of Proprioception, [author unknown], 06).

Every movement we make, voluntary or involuntary, is initiated by the brain. Sensory information from the muscles, the joints, the tendons, and the tactility of touch, is sent to the brain where it is then sorted hierarchically. The brain has learnt to organize this mass of information categorically, so that expectant signals, such as the stretching of our skin when we walk or the sensation of the soles of our feet on the ground, can be ignored. These signals are dealt with lower down in the unconscious parts of the brain, allowing the conscious parts to focus on new or unexpected sensorimotor capabilities. Once a conscious decision to move has been made, the motor cortex within the brain transmits an outgoing message to the appropriate muscles to make them move. Within sixty milliseconds, a
succeeding afferent message is transmitted to the brain from the body’s sensuous system, indicating the degree of competency of the prior executed movement. Based on this information, the brain transmits an improved outgoing commandment in an effort to perfect the executed movement.

Transmitted via the brain, this looped message system is how we learn to control our body’s sensorimotor capabilities. In advanced skills such as dancing, agents learn to shortcut this cyclic process through practice, enabling them to send messages with more accuracy from their brain to their muscles, and vice versa. Through repeated training, they learn how to better predict the consequences of their movement commands and how to make fast and accurate corrections without conscious thought. For instance, they learn that when you lift your left leg off the ground, you need to compensate by shifting the distribution of your body weight to the right. In dancers, these advanced skills become expectant signals, dealt with hierarchically in the lower unconscious parts of the brain.

**Mirror Neurons:**

“When we observe someone performing an action, do our brains simulate making that action” (Calvo-Merion, 04)? According to neuroscientist Marc Jeannerd, such observation causes the premotor cortex of the brain to not only respond to visual kinematics of body movement, but also, to transform visual inputs into the specific motor capabilities of the observer. Acquired motor skills, as discussed previously, offer an inimitable way to test the coupling of perception and action, because people differ greatly in the actions they have learned to perform. A scientific discovery involving primates attests to this thinking. By chance, a group of Italian scientists discovered a special set of neurons in monkeys’ brains. The brain cells they found were active both when monkeys carried out a particular movement and when they were completely still but watched another primate perform the same movement. The neurons weren’t concerned with who performed the action, they were just concerned with what the parallel action was, and as a result of this affect, the neurons involved were given the term, mirror neurons. This experimental development in neuroscience showed that the brain has a very social form of representation and is therefore interested in what you do, as it were, and what I do, using the same codification system to
represent both circumstances. The mirror neurons, also referred to as ‘Monkey See Monkey Do’ neurons (Hagendoorn, 03), materialize to illustrate some form of motor simulation. The monkey appears to understand the actions of another primate and, by using the same predetermined code in the brain that it would employ if it were to perform the same action itself, the monkey is able to represent the actions of the other primate. These mirror neurons have now been proposed as the basis for all kinds of social situations like, empathy, communication, and the interpretation of the intentions and actions of others.

Neuroscientists have discovered that an almost identical mirror system exists in roughly the same part of the human brain and, as a result, are likening mirror neurons to the development of psychology in the same way that the discovery of DNA was likened to biology many years ago. According to Haggard, “mirror neurons hold the key to understanding many enigmatic aspects of human evolution, because they go to the heart of how we came to learn and socialize by imitation” (Haggard in Mitchell, 05). Haggard wanted to test this mirror system theory out on professional dancers, because they are so highly skilled in very specific movement patterns. To conduct his experiment, he took a group of ten leading dancers from the Royal Ballet, a group of ten Capoeira performers, and a control group of ten people who had experience in neither of the abovementioned dance forms. The control groups were asked to remain completely quiescent whilst they watched a series of ballet movements and then a series of Capoeira movements, which had been matched for style and form. What the experiment showed was that there was more activity in the mirror system areas when the expert dancers watched their own genre of dance, because in their minds they have a pre-existing motor program for that specific movement style. When they watched the disparate style of dance, although physically and kinematically roughly similar, there appeared less activity in the mirror neurons, because the dancers did not possess a pre-existing motor program for that specific movement style. Therefore, ballet dancers had more activity in the pre-motor cortex when they watched ballet than when they watched Capoeira and, conversely, Capoeira dancers had more activity in the pre-motor cortex when they watched Capoeira than when they watched ballet. The control group on the other hand, was quite interesting. Although these people were particularly inexpert in the field of dance, with no special experience in either doing or watching, they did exhibit some activity in both the pre-motor cortex and the
interparietal cortex structures of the brain. The activity, however, was lower than that exhibited by the professional dancers and, more importantly, was completely unselective in regards to the genre that they watched. What these findings prove is that, if you have the pre-existing motor program for the action that you are observing someone else perform, you internally simulate the action while you’re watching, almost as though you were covertly emulating or rehearsing in empathy what you are watching someone else do.

**Action Observation:**

How does knowledge embedded in the motor system influence how we process visual motion? As observers, we engage in motor imagery whenever we prepare, intend, mentally rehearse, or listen to a verbal description of a movement. The quintessence of this question resides in the understanding of apparent motion. In 1983, cognitive psychologist Jennifer Freyd showed that still photographs of an object in motion convey information about its dynamics. A phenomena referred to as ‘implied motion’ (Hagendoorn, 03), because the perception of the object is veridical, its motion only evident through the transitory entities of the still photographs, watching such action stills activates the same areas in the brain that are activated when one is perceiving motion directly. The camera freezes the action, but in such a way that it appears to continue, creating a sensation of movement in the viewer. This can also be experienced when a sequence of still frames are rapidly displayed, as is the case in the science of motion pictures. If we consider a simple film consisting of two frames that are played sequentially, the first with a dot to the left, and the second with a dot to the right, the dot appears to move from the left to the right and back again. According to scientists, this illusion occurs because the brain chooses the shortest pathway to connect the two sequential images. However, if the dots are replaced by images of the human body in two differing position, the brain will choose an anatomically possible route to connect the two positions, suggesting that the brain’s inherent knowledge of the movements that the body is capable of making somehow influences perception. Moreover, perception is constrained by the properties and limitations of the observers own motor system.
**Human Mirror System:**

Mirror neurons provide a neural bridge between action and perception. The mirror system of the brain seems to understand the movements of others by referring them to its own motor vocabulary, if you like, or the repertoire of movements that the individual can make. These results suggest that there is a brain process of motor simulation based on direct correspondence between the neural codes for action observation and the neural codes for action execution. Neuroscientists, such as Haggard and Jeannerd, feel that dance is a wonderful way to study this interplay between the cognitive and motor systems, “because you have people who have trained for years to develop very precisely coordinated motor programs for very specific actions” (Mitchell, 05). This neuropsychological evidence also provides a hypothesis for why certain dancers perceive, ascertain and replicate the same learned movement in differing ways. What it fails to surmise, however, is how new movement is found, learned and hence replicated, processes indispensable if dance as an art form is to continue to exist, live and breathe.

**Conclusion:**

An active approach to cognition conceives of the mind as one with the body, two entities fused together to form what N. Mitchell has termed the ‘dancing mind’. The relationship between cognitive psychology and neuroscience is reciprocal, a system in which knowledge, perception, and action are always dynamically coupled and embedded in the world acting indissolubly in time. Cognitive processes such as perception and learning depend on the brain, and henceforth, influence brain functions. The neural codes for action observation depend on action execution, and vice versa, postulating that how we learn and reproduce movement is dependant on what we have cognized in the past. Dancers rehearse a movement until their bodies’ proprioceptive feedback system informs them that the movement “feels right” (Hagendoorn, 03). In doing this, dancers are exercising the brain properties involved in perception, action and emotion, properties that require the apparatus of the body for epistemic knowledge to be reinforced or activated. According to British neuroscientist Semir Zeki, all artists are neuroscientists, because they examine the
mechanisms of the brain and divulge its capabilities (Zeki in Hagendoorn, 03). Perhaps if choreographers and dancers performed in research laboratories and neuroscientists analysed dance performances, we might learn more about dance and the brain. “Thought grows from action and that activity is the engine of change” (Thelen, 95, 69).
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