Embodiment

Peter J. Marshall

Temple University

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The field of embodied cognition encompasses various empirical approaches that are connected through a shared recognition of the importance of bodily factors in mental life (e.g., Anderson, 2003; Foglia & Wilson, 2013; Shapiro, 2011, 2014; Wilson, 2002). The implications of embodiment continue to be the focus of much debate, particularly in terms of the extent to which the body plays a constitutive versus simply an enabling role in cognitive processing (Menary, 2010a; Müller & Newman, 2008; Rowlands, 2010; Wheeler, 2005). The current chapter initially examines similarities and differences between two particular approaches to embodiment, specifically the functionalist and enactive accounts. The discussion will then turn to considerations of embodiment in the process-relational developmental systems metatheory (Lerner, Agans, DeSouza, & Hershberg, 2014; Overton, 2014). In the process-relational approach, embodiment is a construct that integrates the various standpoints (neural, individual, sociocultural) from which human mental life can be studied. It will be argued that the inherently ontogenetic orientation of this approach, which is less apparent in other views of embodiment, can facilitate progress towards a truly integrative developmental science of psychological life.

One major impetus for the rise of embodied cognition as a field of study stems from a loss of confidence with the cognitivist emphasis that came to dominate cognitive science during the second half of the 20th century (Miller, 2003). From the cognitivist perspective, the physical body is irrelevant to the understanding of cognition. Instead, cognition consists of computations, or the manipulation of symbols to which meaning has been pre-assigned by a programmer or designer. Whether or how these computations might be implemented in biological systems was deemed unimportant, with the primary goal instead being to develop algorithmic routines that transform inputs into outputs (Marr, 1982). This line of reasoning was partly a pragmatic response to the barriers presented by the immense complexity of the brain and nervous system. It was also buttressed by the philosophical argument known as functionalism, which stated that the specific way in which problem-solving routines are implemented (e.g., on a machine vs. in a living organism) is less important than the problem-solving process itself. These arguments led both to a neglect of neuroscience in cognitive science and to a sustained lack of consideration of the role of the body in mental life (see Marshall, 2009, 2015).

Reactions to the disembodied nature of cognitivism began to be more visible in diverse theoretical initiatives appearing in the early 1990s that pushed for a paradigm shift in the way that cognitive processes are conceptualized (e.g., Brooks, 1990; Hutchins, 1995; Varela, Thompson, & Rosch, 1991). These initiatives stimulated wider interest in the ways in which the body might play a role in mental life, and led to the emergence of embodied cognition as a field of study. Various efforts have since been made to delineate the similarities and differences of the various main approaches within the field of embodied cognition (Anderson, 2003; Shapiro, 2011). In a useful summary, Kiverstein (2012) distinguishes between three broad views that he calls *body-conservatism*, *body-functionalism*, and *body-enactivism*. From the *body-conservative* viewpoint, the implications of embodiment are limited. Research from this perspective acknowledges a role for the body in cognition, but only by virtue of providing inputs for computational processing within the brain and as the vehicle for carrying out efferent motor commands. In this respect body-conservatism does not differ substantially from the traditional cognitivist model and will not be discussed further here.

The other views discussed by Kiverstein (2012) are *body-functionalism* and *body-enactivism*. Both of these views center on the proposal that cognition does not reside primarily "in the head" but instead is a process that encompasses body, brain, and environment. There are various arguments for this claim, which is related to a historical debate within philosophy between proponents of internalist (in-the-head) cognition and those who favor a more externalist view of

mind (see Carter, Kallestrup, Palermos, & Pritchard, 2014). Within the analytic tradition of the philosophy of mind, this debate was stoked by the proposal that meaning cannot exist solely in the head, and that the study of individual, isolated brains would not suffice for understanding human mental life (Burge, 1979; Putnam, 1975). In subsequent iterations of the externalist viewpoint, the radical notion was raised that cognitive processes are extended out of the boundaries of the brain due to the interdependence of nervous systems, external artifacts, and other agents. There is some variation in the type and breadth of externalist claims, although a shared theme is that the work of cognition is not carried out solely in the head but is spread across the wider brain-body-environment system (Clark, 2008; Hutchins, 1995; Rowlands, 2010; Rupert, 2010; Susswein & Racine, 2009).

This chapter will focus initially on the distinction between the body-functionalist and body-enactivist approaches. While these approaches share an externalist bent, it will be seen that they differ significantly on the nature and implications of embodiment. A further discussion of body-enactivism will focus on one particular approach (autopoietic enactivism) that has roots in biology, philosophy, and cognitive science. Connections between this approach and the process-relational developmental systems framework of Overton and Lerner will then be considered.

Body-Functionalism and the Extended Mind

One particular externalist position that has inspired a great deal of discussion and debate is the *extended mind hypothesis* as put forward by Clark and Chalmers (1998), who proposed that mental states such as beliefs can extend outside of the body and brain. The extended mind hypothesis relies on the notion that "if as we confront some task, part of the world functions as a process which, were it done in the head, we would have no hesitation in recognizing as part of the cognitive process, then that part of the world is…part of the cognitive process" (Clark & Chalmers, 1998, p.8). Among other examples, these authors used the fictional case of an Alzheimer's patient who, in order to compensate for the deficits in his biological memory, relies on information that he writes down in a notebook. Clark and Chalmers use this particular example to suggest that, in certain cases, external features can stand in for mental representations such as beliefs, when these features play "the right sort of role in driving cognitive processes" (p. 7). Subsequent writing by Clark (2008) further outlined this view, which Kiverstein (2012) calls the *body-functionalist* account.

Given its seemingly radical nature, it is hardly surprising that the status of the body-functionalist account has been subject to a good deal of criticism, ranging from disagreement on emphasis to outright rejection of the basic premise. On the milder side, Sterelny (2010) acknowledges the utility of the body-functionalist approach, but sees the extended mind model as occupying one corner of a much larger space in which "the most critical, mind-and-brain-shaping environmental supports for cognition are those cumulatively built, collectively provided tools for thinking" (p. 479). Although outside the purview of this brief chapter, this sentiment connects with a broader view of extended cognition that also redefines the relations among cognition, social learning, and evolutionary processes (Laland et al., 2014). Along these lines, Sterelny (2010) further suggests that the extended mind hypothesis understates the importance of broader cultural and environmental scaffolds by emphasizing "highly trusted, individualized and entrenched, single-user resources" (p. 480) such the personal notebook example employed by Clark and Chalmers (1998). In response, advocates of the body-functionalist account would argue that it is exactly the trusted and readily accessible nature of these individualized resources that allow them to be considered as parts of what is usually seen as the "internal" cognitive apparatus.

Harsher criticism of the extended mind hypothesis has come from the internalist camp. Adams and Aizawa (2010) maintain that Clark (2008) and other advocates of a functionalist approach cannot show that their purported extensions of the mental apparatus are constitutive parts of cognition, rather than simply being sources of information for central ("in the head") processing. A related objection comes from Fodor (2009) who suggests that only internal mental states can have intentional content that is *underived*. According to Fodor, Clark's examples of notebooks and smartphones have only *derived* content. Although he acknowledges that the boundary between derived and underived content is hazy, Fodor (2009) believes that a reliance on

internal mental representations is the only way to bridge "the gap between mind and world".

At first glance, the extension of mental states in the body-functionalist approach seems to present a stark contrast to the internalist emphasis that characterizes the cognitivist tradition. However, it is worth noting that body-functionalism and cognitivism are both inherently computational accounts, with the point of departure being in the location of the computations that are posited to underpin mental life: In body-functionalism, these computations are not implemented solely within the head but, depending on task demands and context, are flexibly carried out across a distributed system encompassing brain, body, and environment. Wheeler (2014) brings up this issue as a problem: He suggests that realizing the paradigm shift presented by embodied cognition requires the rejection of the principle that intelligent thought and action are to be explained in terms of content-bearing representations. While body-functionalism sees the body as being relevant to explaining how cognitive processes are implemented, according to Wheeler (2014), it does not herald a fundamental change in the understanding of the relations between material embodiment and cognition. Therein lies a key distinction between the body-functionalist notion of the extended mind and the third view of embodiment outlined by Kiverstein (2012), which is *body-enactivism*. As will be made clear in the following sections, the distinction between extension and enaction (Thompson & Stapleton, 2009) is key to understanding the meaning of embodiment and its associated implications for developmental science.

Body-Enactivism and the Embodiment of Mental Life

Enactivism encompasses various approaches (e.g., Chemero, 2009; Hutto & Myin, 2012; Noë, 2004; Thompson, 2007; Varela et al., 1991) that are bound together by broad theoretical commonalities (see Kiverstein & Clark, 2009). Generally speaking, these approaches share the emphasis of body-functionalism in challenging the traditional framing of cognition as a process occurring solely "inside" the individual. Where the concept of *enaction* differs from the notion of *extension* is through the enactivist emphasis on structural coupling and the co-determined relations between an organism and its environment.

Central to enactivist accounts is the notion of the action feedback loop, such that the actions of the organism modify its relation to the environment, which then influences subsequent actions (Stewart, Gapenne, & Di Paolo, 2010). For the enactivist, the processes of activity and adaptation involved in this loop represent a form of structural coupling between organism and environment, which as a consequence are seen as being co-determined by each other. This emphasis on structural coupling leads to another recurrent theme in the enactivist approach, namely that mental life can be studied without relying on the concept of representation. For proponents of more radical versions of this emphasis, this position stems from the non-linear nature of the coupling between organism and environment. As framed by Silberstein and Chemero (2012):

> Non-linearly coupled animal-environment systems are taken to form just one unified system. This removes the pressure to treat one portion of the system as representing other portions of the system – at least for many cognitive acts. That is, if the animal-environment system is just one system, the animal portion of the system need not represent the environment portion of the system to maintain its connection with it. There is no separation between animal and environment that must be bridged by representations. (p. 40)

This sentiment takes enactivism in a different direction to the body-functionalist approach, which relies on representations as the vehicle for computation, even if aspects of the computational process are located outside of the head. For the enactivist, representations are jettisoned in the service of finding a model of mental life that is unadulterated by computation in the conventional sense. This goal leads to a further emphasis on the use of tools from dynamical systems theory to model the structural coupling of organism and environment (Carter et al., 2014). For proponents of enactivism, dynamical systems methods are well suited for modeling the coupling of an agent's behavior over time with the changing state of the environment, without relying on the manipulation of symbols or the need to invoke the concept of representation (Chemero, 2009).

As pointed out by various critics, the enactivist emphasis on dynamical systems methods raises certain challenges. One criticism of this emphasis has been that although dynamical systems methods are well suited to modeling some behavioral phenomena, they do not lend themselves to solving the "representation-hungry" problems typically encountered in the study of more complex cognitive tasks (Clark, 1997). As noted by Witherington (2015), another issue is that some developmental approaches relying on dynamical systems methods have inherited the Gibsonian assumption of preexisting environmental structure (e.g., Thelen & Smith, 1994). This assumption is mistaken, since "meaning must be actively constructed and does not inhere in the world….the world becomes meaningful…only in the context of an organism actively structuring it – assimilating it – and in turn actively accommodating to it" (Witherington, 2011, p. 287). This sentiment would be likely endorsed by developmental scientists who see constructivism as being fundamentally consistent with system approaches (van Geert, 2012; Witherington & Margett, 2011). From a broader developmental viewpoint, how meaning is constructed is the central focus of one particular enactivist approach that will now be discussed in more detail.

Autopoietic Enactivism. From the enactive perspective, cognition is not seen as being located inside the brain—or indeed in any specific location—and arguments about the boundaries of the cognitive system are viewed as meaningless. In a summary of the issues arising from this radical notion, di Paolo (2009) presents enactivism as an

> intellectual move that that puts traditional intuitions about cognition into question, not just intuitions about boundaries. After the move is concluded, new genuine questions arise: how can we then make sense of a cognitive system as an agent, with a perspective, values, norms, and even subjectivity? After tearing down the boundaries, in what sense can we recover an unprejudiced notion of an *individual* cognizer, a center of activities and perspectives (and responsibilities), if at all? (p.11)

The question here is how the notion of "an individual cognizer" can mesh with radical enactivist approaches in which the identity of the individual organism disappears into a diffuse web of dynamic couplings. One attempt to avoid this issue comes from a biologically-oriented systems view of embodiment that has become known as *autopoietic enactivism*. Although this account does not specify cognition as being "located" in a particular place, it does place a central focus on the embodied organism as a living, biological agent whose identity is defined by the nature of the interactions which it can engage in. For some autopoietic enactivists, this leads to a broad view of cognitive processes as being constituted by those interactions (or perturbations) between the organism and the system that it inhabits (Thompson, 2007).

The concept of autopoiesis, as put forward by Maturana and Varela (1980), refers to an organizational characterization of a system, or the relations among the components of a system. An autopoietic system is characterized by a particular pattern of organization that is maintained even as patterns of connectivity are rearranged in response to perturbation of the system. As autopoietic systems, living systems are self-creating and self-organizing in a fundamentally different way to nonliving systems. Central to this approach is the idea that living systems "construct themselves by generating the very boundary conditions necessary for the creation and maintenance of their self-organization" (Witherington, 2011, p. 79). The centrality of self-organization for the autopoietic-enactivist account connects to historical discussions of how a living system perpetuates itself through activity that provides a causally-relevant organizational structure that is part of, and not external to, the system itself. These discussions date back to Aristotle, with related ideas being voiced in the writings of the biologically-oriented theorizing of Piaget (see Müller, Ten Eycke, & Baker, 2015)

Autopoietic systems construct and actively maintain themselves in the midst of what enactivist sometimes call the *precarious circumstances* in which living organisms exist. One central idea here is that without this property of self-maintenance, the individual processes that make up an system itself will cease to operate. In other words, without the adaptive, emergent self-organization that characterizes an autopoietic system, the system would cease to exist. This leads to the

notion that an autopoietic system is an autonomous system, through the fact that "intervenes in its own substrate in order to sustain a form which is made out of the components that paradoxically provide the very tendencies towards the dissolution of the same form" (di Paolo, 2009 p. 16). This important idea differentiates the concept of autonomy in the autopoietic approach from the usage of the term in other branches of cognitive science. Froese, Virgo, and Izquierdo (2007) highlight a differentiation between *behavioral autonomy*, in which the identity of a system is externally imposed by a designer (e.g., in robotics), and *constitutive autonomy*, which is closely related to (but not identical with) the notion of autopoiesis. The processes that characterize a constitutively autonomous system are "related as a network, such that they recursively depend on each other in the generation and realization of the processes themselves, and…they constitute the system as a unity recognizable in the space (domain) in which the processes exist" (Varela, 1979, p.55).

In an extension of his original ideas about autopoiesis into a theory of enaction, Varela (1997) contended that the organizational properties of self-production and self-distinction are key to understanding the nature of an organism's values and norms (i.e., its identity). What Varela was suggesting is that the process of forming an identity is a fundamental aspect of the individual organism, and that this emergent identity both arises from, and provides a reference point for, the range of interactions that the organism can have with its environment. More specifically, this range of interactions encompasses the perturbations that can result in structural changes in the living (autopoietic) system that includes the organism and its environment. In this view, it is the range of relevant perturbations that enacts, or "brings forth" the cognitive world of the organism. In simpler terms, the identity of the organism is realized (and constrained) by the nature of its embodiment – an idea that will be expanded on below and will be returned to towards the end of this chapter.

The idea that an organism's world is brought forth or enacted through the range of relevant possibilities is connected of a line of thinking about the nature of the organism by philosophers such as Jonas and Plessner (for discussion see Weber & Varela, 2002). In combination with the notion of autopoiesis, the concept of enaction provides a distinctive way of thinking about the biology of cognitive processes by placing an emphasis on autonomy and identity at the level of the individual organism. The autopoietic-enactive perspective makes a connection between the concept of autonomy and the normative engagement of a system with its world, or what has been called *sensemaking* (Thompson & Stapleton, 2009). This notion centers on the idea that as an adaptive agent, the organism possesses mechanisms through which the various possibilities for action or for responding to environmental signals have meaning for that individual organism. The range of responses reflect the way in which the possibilities for action "make sense" in the world that the organism enacts. In turn, this nature of sensemaking for an individual organism is tightly interwoven with its identity. In line with the biological roots of autopoietic enactivism, this principle as seen as being relevant to all living organisms, from bacteria to *Homo Sapiens*. Connecting these ideas with those of others such as Jonas (1966), proponents of autopoietic enactivism such as Thompson (2007) have suggested that the process of identity generation is linked to the notion of sense-making in terms of the normative relation between the identity (the autonomous, agentive organism) and the system. Although the domain of interactions that a bacterium can have with its environment is quite different from that of a fly, a shrew, or a human, the range of possibilities is relevant to – and actually constitutes – the identity of that individual organism. However, while the processes of identity generation for a unicellular organism may simply be about the maintenance of metabolic processes, for more complex organisms the enactivist notion of sensemaking extends to all levels of interactions with the environment, including social aspects (De Jaegher & Di Paolo, 2007).

The construct of sensemaking in the enactivist account presents a move away from the problem of *making meaning* that has hobbled more mainstream, cognitivist approaches in cognitive science. In framing cognition as a disembodied process occurring on an isolated computational device, cognitivism precluded any serious consideration of meaning (Bruner, 1990). By viewing the mind as a computational engine that manipulates representations according to rules that operate

on the syntactic, formal properties of representations (i.e., their physical properties) rather than their semantic contents (i.e., their meaning), cognitivist approaches are fundamentally limited in their scope for understanding human cognition (Searle, 1980). This problem, which is also known as the *symbol grounding* problem (Harnad, 1990), was at the heart of arguments that were initially voiced by critics of the cognitivist focus of early work in artificial intelligence (Dreyfus, 1972). According to these critics, the disembodied nature of symbol-crunching computational approaches could not adequately address the question of how these symbols can be meaningful for the device on which their manipulation is being carried out. Early expectations for progress in artificial intelligence through a cognitivist framework were, therefore, misplaced because of the fundamental problem faced by an isolated computational system in "needing to impose a meaning on a meaningless Given" (Dreyfus, 2006, p.45). Indeed, the inadequacy of cognitivism to account for meaning has been highlighted by various theorists including Edelman (1992) and Thompson (2007). This same issue is at the heart of Overton's writings on development and embodiment, which will be discussed in the final section of this chapter.

Embodiment and Development in the Process-Relational Metatheory of Overton

In viewing cognition through a systems lens, enactivism has an inherently ontogenetic aspect, in the sense that the structural coupling of organism and environment is continuously modified through the activity of the individual in combination with environmental perturbations. This adaptation introduces a developmental aspect that Vernon (2014) calls the "process of establishing and enlarging the space of mutually-consistent couplings that the cognitive system can engage in" (p.166). However, despite their central importance, developmental considerations tend to remain in the background of enactive accounts. In contrast, one view of the embodied mind that emphasizes ontogenesis comes through the writings of Willis Overton (2004, 2006, 2008; 2013b, 2015). In particular, the process-relational developmental systems metatheory of Overton and Lerner demonstrates how embodiment can play a key role as an integrative "bridge construct" linking different areas of the study of the person within developmental science.

For scientists interested in moving towards more integrative accounts of mental life, autopoietic enactivism offers a way of moving beyond a split mind-body dualism by challenging the Cartesian conceptions of mind as "a thinking thing". Similarly, Overton does not pit mind and body against each other but instead integrates them into a whole. To use a phrase from his developmental lectures to undergraduates at Temple University, mind is "an active system or organization of cognitive, conative, and affective meanings or understandings, along with procedures for implementing and changing these meanings". This move away from the mind as a thing, combined with an developmentally-oriented conceptualization of the relations between structure and process, takes us to an integrative view of mind that can move us beyond the dead-end, split conceptualizations of Cartesian cognitive science.

As well as emphasizing developmental aspects, Overton's writings on embodiment bring out the importance of considering the "lived body" in theorizing on embodiment. Overton (2008) takes the view that our perceptions, thoughts, feelings, and desires are contextualized by our being active agents with a particular kind of body. According to this view, "the kind of body we have is a constitutive precondition for having the kind of behaviors, experiences, and meanings that we have" (Overton, 2013b, p.55). In turn, this suggestion brings with it a wider view of embodiment as the relationally interpenetrating process among person, biology, and culture. As Overton (2008) points out:

> Embodiment references not merely physical structures, but the body as a form of lived experience, actively engaged in and with the world of sociocultural and physical objects. The body as form references a biological standpoint, the body as lived experience actively engaged references a phenomenological or psychological person standpoint, and the body actively engaged in and with the world points to a contextual social, cultural, and environmental standpoint (p. 3).

Within the process-relational developmental systems metatheory of Overton and Lerner (see below), embodiment is therefore a concept that bridges and joins in a unified whole the various standpoints from which human mental life can be studied. This view of embodiment goes far beyond the simple accommodation of bodily factors as inputs into cognitive models, and it starkly exposes the limitations of the cognitivist account of mental processes running on an isolated computational device.

Overton's emphasis on the lived body relates to phenomenological influences on embodiment, particularly Merleau-Ponty (1967), who also distinguished between the kind of structure or forms of behavior that are realized in living and nonliving systems. As part of this endeavor, Merleau-Ponty noted that the processes of active self-creation and self-maintenance distinguish the self-organization of living systems from nonliving phenomena. While this line of thought became central to the autopoietic enactivist account, self-organization in biological systems has been studied from various other perspectives (Camazine et al., 2003). The overall patterns that arise in self-organizing systems are sometimes considered as originating from the dynamic balance between opposing processes (e.g. inhibition and activation) at the local level, without reference to the global pattern. However, from the perspective of embodied developmental accounts such as that of Overton (2015), it is a mistake to ignore the influence of the global pattern on local processes.

For Overton, the mutuality of local-to-global and global-to-local influences adds an emergent aspect to self-organization in living systems, and puts an emphasis on what the causal role of what can be called *pattern explanation*. This type of explanation is allowed by the idea that the structure or organization of the endogenously active system can have more than a descriptive role. A useful way of understanding the causal role of pattern explanations is as top-down constraint, which "involves a lessening of variability, a narrowing of degrees of freedom, and as such plays a critical role in causal explanation by virtue of establishing limitations for what kinds of bottom-up processes…are available to a given system" Witherington (2015, p. 89-90). This focus on *emergence* then turns the focus to developmental aspects, and it connects with the suggestion that contemporary developmental science risks an overemphasis on mechanism without acknowledging the causal import of structure (Overton, 2010; Witherington, 2011; 2014).

Although developmental aspects of embodiment are implicit themes in the biologically-oriented enactivist approaches, the importance of applying the principles of embodiment to developmental science is increasingly evident (Lerner & Benson, 2013a, 2013b; Marshall, 2014; Overton, 2008). In this respect, embodiment can be considered a core construct of what has become known as process-relational developmental systems metatheory (Overton, 2014; Overton, 2015). Rather than being associated with a specific methodology, it is helpful to view process-relational developmental systems as a "midrange" metatheory that combines the broader relational worldview with the tenets of developmental systems theory (Overton, 2013b). More specific constructs and empirical methods can then be viewed as being coherent (or not) with the metatheoretical approach of process-relational developmental systems. According to Overton (2013b), coherence among more specific theories and methods and the midrange metatheory comes through the core concepts of system, action, and embodiment.

In line with the theorizing of Overton (2008; 2013b, 2015), it is suggested here that embodiment can take us beyond the problematic dichotomies that have historically impeded the emergence of a truly integrative developmental science. As such, embodiment enables a coherent account of the development of body, brain, and mind as a differentiated and unified system, operating within a broader socio-cultural system. This view of embodiment goes beyond the idea that developmental aspects of embodiment are most applicable to research on physical and motor development in infancy (Needham & Libertus, 2011). While this more constrained view of embodiment may be useful for some purposes (although see Longo, 2009), the theorizing of Overton (2008) emphasizes the wider and deeper implications of embodiment for lifespan developmental science.

As noted by Overton (2015), embodiment is one of the necessary defining features of the processes involved in developmental

change as well as the relational developmental system. From this wide-angle viewpoint, "Embodiment represents the relationally interpenetrating process among person, biology, and culture" and "embodied action constitutes the fundamental process for all developmental change" (p.50). Development occurs through embodied actions-in the-world that operate epigenetically and that form complex positive and negative causal feedback loops. Here embodiment is seen as a necessary defining feature of developmental change processes, with embodied action constituting the fundamental process for all developmental change (Overton, 2015). In this view, embodied action is carried out by an enactive agent, not a passive agent, with this distinction echoing the notions of action and autonomy that were discussed in the previous section on autopoietic enactivism.

In the process-relational account, embodiment further introduces an emphasis on the individual that echoes the motivations of autopoietic enactivists to counter what Di Paolo (2009) called "the worrying evaporation of the organism from contemporary biology" through a focus on scientific endeavors below the level of the organism (neuroscience and genetics) and above it (ecological and evolutionary approaches). In many ways, Overton's work helps us work against the disappearance of the *person* in contemporary developmental science. From the perspective of process-relational developmental systems, the focus moves from the autonomous agency of the organism to the "person-agent" as the enactive source of action, with action being the source of meaning (Overton, 2008).

According to Overton, acts can be at the subpersonal level in terms of the activity that characterizes any self-organizing system. Acts at the personal level refer to intentional, goal-directed activity that are instrumental/adaptive and expressive of meanings (conscious or now) and constitutive of the world as known, felt, or desired. As noted by Overton (2008):

> At the agent level, embodiment specifies the characteristic nature of the activity of any living system (e.g., the world of the fly is necessarily shaped by the nature of the fly's embodied acts). At the person level, embodiment affirms that from the beginning, bodily acts constrain and inform the nature of intentionality (p. 8).

In this view, while intentionality involves a symbolic, reflective system of meanings, it emerges from a system involving engaged and embodied actions at an implicit, more minimal level of cognition (Bermúdez, 2000). At a psychological level, this emergence may depend in part on aspects of the early-developing body schema, a construct that has been considered from a developmental perspective both in terms of psychological meanings (Gallagher & Meltzoff, 1996) and neuroscience aspects (Marshall & Meltzoff, 2015).

Through the lens of process-relational developmental systems metatheory, we come to see embodiment as a key aspect of understanding the person as a "dynamic, self-creating, self-organizing, and self-regulating system that is embodied, embedded, and encultured" (Overton, 2013a). This statement brings us to a central part of Overton's view of embodiment: That the thread of embodiment runs through transformational developmental change as new capacities for practical, symbolic and reflective thought emerge in an epigenetic fashion. This emphasis from Overton's work brings important developmental considerations to what has become known as "4E" cognition, which stands for *embodied*, *embedded*, *extended*, and *enacted* (Menary, 2010b). While wider developmental aspects of 4E cognition have sometimes been considered (Stotz, 2014), they have been underemphasized in the literature. It could further argued that 4E cognition is not sufficiently balanced for an integrative view of mind. The consideration of three additional "Es" (epigenesis, emergence, and enculturation) in the process-relational developmental systems account allows us to appreciate both the wider implications of embodiment for developmental science, and the implications of development for understanding embodiment (Overton, 2013a). It is hoped that the coming years will see the emergence of this complementarity in the fullest sense.

Literature Cited

Adams, F., & Aizawa, K. (2010). *The bounds of cognition* (2nd ed.). Oxford, UK: Wiley-Blackwell.

Anderson, M. L. (2003). Embodied cognition: A field guide. *Artificial Intelligence, 149*, 91-130.

Bermúdez, J. L. (2000). *The paradox of self-consciousness*. Cambridge, MA: MIT Press.

Brooks, R. A. (1990). Elephants don't play chess. *Robotics and Autonomous Systems, 6*, 3-15.

Bruner, J. (1990). *Acts of meaning.* Cambridge, MA: Harvard University Press.

Burge, T. (1979). Individualism and the Mental. *Midwest Studies In Philosophy, 4*, 73-121.

Camazine, S., Deneubourg, J., Franks, N., Sneyd, J., Theraulaz, G., & Bonabeau, E. (2003). *Self-organization in biological systems*. Princeton, NJ: Princeton University Press.

Carter, J. A., Kallestrup, J., Palermos, S. O., & Pritchard, D. (2014). Varieties of externalism. *Philosophical Issues, 24*, 63-109.

Chemero, A. (2009). *Radical embodied cognitive science*. Cambridge, MA: MIT Press.

Clark, A. (1997). The dynamical challenge. *Cognitive Science, 21*, 461-481.

Clark, A. (2008). *Supersizing the mind*. Oxford, UK: Oxford University Press.

Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis, 58*, 7-19.

De Jaegher, H., & Di Paolo, E. (2007). Participatory sense-making. *Phenomenology and the Cognitive Sciences, 6*, 485-507.

Di Paolo, E. (2009). Extended life. *Topoi, 28*, 9-21.

Dreyfus, H. L. (2006). Overcoming the myth of the mental. *Topoi*, 43-50.

Dreyfus, H. L. (Ed.). (1972). *What computers can't do: A critique of artificial reason*. New York: Harper & Row.

Edelman, G. M. (1992). *Bright air, brilliant fire: On the matter of the mind.* New York: Basic Books.

Fodor, J. A. (2009). Where is my mind? *London Review of Books, 31*, 13-15.

Foglia, L., & Wilson, R. A. (2013). Embodied cognition. *WIREs Cognitive Science, 4*, 319-325.

Froese, T., Virgo, N., & Izquierdo, E. (2007). Autonomy: A review and a reappraisal. In F. Almeida e Costa, L. Rocha, E. Costa, I. Harvey & A. Coutinho (Eds.), *Advances in Artificial Life* (Vol. 4648, pp. 455-464). Berlin: Springer.

Gallagher, S., & Meltzoff, A. N. (1996). The earliest sense of self and others: Merleau-Ponty and recent developmental studies. *Philosophical Psychology, 9*, 211-233.

Harnad, S. (1990). The symbol grounding problem. *Physica D., 42*, 335-346.

Hutchins, E. (1995). How a cockpit remembers its speeds. *Cognitive Science, 19*, 265-288.

Hutto, D. D., & Myin, E. (2012). *Radicalizing enactivism: Basic minds without content*. Cambridge, MA: MIT Press.

Jonas, H. (1966). *The phenomenon of life: Toward a philosophical biology*. New York: Harper & Row.

Kiverstein, J. (2012). The meaning of embodiment. *Topics in Cognitive Science, 4*, 740-758.

Kiverstein, J., & Clark, A. (2009). Introduction: Mind embodied, embedded, enacted: One church or many? *Topoi, 28*, 1-7.

Laland, K., Uller, T., Feldman, M., Sterelny, K., Müller, G. B., Moczek, A., . . . Hoekstra, H. E. (2014). Does evolutionary theory need a rethink? *Nature, 514*, 161.

Lerner, R. M., Agans, J. P., DeSouza, L. M., & Hershberg, R. M. (2014). Developmental science in 2025: A predictive review. *Research in Human Development, 11*, 255-272.

Lerner, R. M., & Benson, J. B. (Eds.). (2013a). *Embodiment and epigenesis: Theoretical and methodological issues in understanding the role of biology within the relational developmental system. Part A: Philosophical, theoretical, and biological dimensions.* Advances in Child Development and Behavior (Vol. 44).

Lerner, R. M., & Benson, J. B. (Eds.). (2013b). *Embodiment and epigenesis: Theoretical and methodological issues in understanding the role of biology within the relational*

developmental system. Part B: Ontogenetic dimensions. Advances in Child Development and Behavior (Vol. 45).

Marr, D. (1982). *Vision.* San Francisco, CA: W.H. Freeman.

Marshall, P. J. (2009). Relating psychology and neuroscience: Taking up the challenges. *Perspectives on Psychological Science, 4*, 113-125.

Marshall, P. J. (2014). Beyond different levels: Embodiment and the developmental system. *Frontiers in Psychology, 5*, 929.

Marshall, P. J. (2015). Neuroscience, embodiment, and development. In W. F. Overton, P. C. M. Molenaar & R. M. Lerner (Eds.), *Handbook of child psychology and developmental science* (Vol. 1, pp. 244-283). New York: Wiley.

Marshall, P. J., & Meltzoff, A. N. (2015). Body maps in the infant brain. *Trends in Cognitive Sciences, 19*, 499-505.

Maturana, H. R., & Varela, F. J. (1980). Autopoiesis and cognition: The realization of the living. *Boston Studies in the Philosophy of Science* (Vol. 42). Dordrecht, The Netherlands: D. Reidel.

Menary, R. (2010a). *The extended mind*. Cambridge, MA: MIT Press.

Menary, R. (2010b). Introduction to the special issue on 4E cognition. *Phenomenology and the Cognitive Sciences, 9*, 459-463.

Merleau-Ponty, M. (1967). *The structure of behavior*. Boston: Beacon Press.

Miller, G. A. (2003). The cognitive revolution: A historical perspective. *Trends in Cognitive Sciences, 7*, 141-144.

Müller, U., & Newman, J. L. (2008). The body in action: Perspectives on embodiment and development. In W. F. Overton, U. Müller & J. L. Newman (Eds.), *Developmental perspectives on embodiment and consciousness* (pp. 313-342). New York, NY: Erlbaum.

Müller, U., Ten Eycke, K., & Baker, L. (2015). Piaget's Theory of Intelligence. In S. Goldstein, D. Princiotta & J. A. Naglieri (Eds.), *Handbook of intelligence: Evolutionary theory, historical perspective, and current concepts* (pp. 137-151). New York, NY: Springer.

Needham, A., & Libertus, K. (2011). Embodiment in early development. *WIRES Cognitive Science, 2*, 117-123.

Noë, A. (2004). *Action in perception.* Cambridge, MA: MIT Press.

Overton, W. F. (2004). A relational and embodied perspective on resolving psychology's antinomies. In J. I. M. Carpendale & U. Muller (Eds.), *Social interaction and the development of knowledge.* (pp. 19-44). Mahwah, NJ: Erlbaum.

Overton, W. F. (2006). Developmental Psychology: Philosophy, concepts, methodology. In R. M. Lerner & W. Damon (Eds.), *Theoretical models of human development* (6th ed., pp. 18-88). Hoboken, NJ: John Wiley.

Overton, W. F. (2008). Embodiment from a relational perspective. In W. F. Overton, U. Mueller & J. L. Newman (Eds.), *Developmental perspectives on embodiment and consciousness.* (pp. 1-18). New York: Erlbaum.

Overton, W. F. (2010). Life-span development: Concepts and issues. In W. F. Overton & R. M. Lerner (Eds.), *The handbook of life-span development, Vol 1: Cognition, biology, and methods.* (pp. 1-29). Hoboken, NJ: Wiley.

Overton, W. F. (2013a). *Relationism and relational developmental systems: A conceptual paradigm for the emergent, epigenetic, embodied, enacted, extended, embedded, encultured mind*. Paper presented at the 42nd Annual Meeting of the Jean Piaget Society, Toronto, Canada.

Overton, W. F. (2013b). Relationism and relational developmental systems: A paradigm for developmental science in the post-Cartesian era. *Advances in Child Development and Behavior, 44*, 21-64.

Overton, W. F. (2014). The process-relational paradigm and relational-developmental-systems metamodel as context. *Research in Human Development, 11*, 323-331.

Overton, W. F. (2015). Process and relational-developmental systems. In W. F. Overton, P. C. M. Molenaar & R. M. Lerner (Eds.), *Handbook of child psychology and developmental science* (Vol. 1, pp. 9-62). New York: Wiley.

Putnam, H. (1975). *Mind, language, and reality*. New York: Cambridge University Press.

Rowlands, M. (2010). *The new science of the mind: From extended mind to embodied phenomenology*. Cambridge, MA: MIT Press.

Rupert, R. D. (2010). *Cognitive systems and the extended mind*. New York: Oxford University Press.

Searle, J. R. (1980). Minds, brains, and programs. *Behavioral and Brain Sciences, 3*, 417-457.

Shapiro, L. (2011). *Embodied cognition*. New York: Routledge/Taylor & Francis.

Shapiro, L. (Ed.). (2014). *Routledge Handbook of Embodied Cognition*. New York: Routledge.

Silberstein, M., & Chemero, A. (2012). Complexity and extended phenomenological-cognitive systems. *Topics in Cognitive Science, 4*, 35-50.

Sterelny, K. (2010). Minds: Extended or scaffolded? *Phenomenology and the Cognitive Sciences, 9*, 465-481.

Stewart, J., Gapenne, O., & Di Paolo, E. A. (Eds.). (2010). *Enaction: Toward a new paradigm for cognitive science*. Cambridge, MA: MIT Press.

Stotz, K. (2014). Extended evolutionary psychology: the importance of transgenerational developmental plasticity. *Frontiers in Psychology, 5*, 908.

Susswein, N., & Racine, T. P. (2009). Wittgenstein and not-just-in-the-head cognition. *New ideas in psychology, 27*, 184-196.

Thelen, E., & Smith, L. (1994). *A dynamic systems approach to the development of cognition and action.* Cambridge, MA: MIT Press.

Thompson, E. (2007). *Mind in life: Biology, phenomenology, and the sciences of mind.* Cambridge, MA: Belknap Press/Harvard University Press.

Thompson, E., & Stapleton, M. (2009). Making sense of sense-making: Reflections on enactive and extended mind theories. *Topoi, 28*, 23-30.

van Geert, P. (2012). Dynamic systems. In B. Laursen, T. D. Little & N. A. Card (Eds.), *Handbook of developmental research methods* (pp. 725-741). New York: Guilford Press

Varela, F. J. (1979). *Principles of biological autonomy*. New York: North Holland.

Varela, F. J. (1997). Patterns of life: Intertwining identity and cognition. *Brain and Cognition, 34*, 72-87.

Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind: Cognitive science and human experience.* Cambridge, MA: MIT Press.

Vernon, D. (2014). *Artificial cognitive systems: A primer*. Cambridge, MA: MIT Press.

Weber, A., & Varela, F. J. (2002). Life after Kant: Natural purposes and the autopoietic foundations of biological individuality. *Phenomenology and the Cognitive Sciences, 1*, 97-125.

Wheeler, M. (2005). *Reconstructing the cognitive world: The next step.* Cambridge, MA: MIT Press.

Wheeler, M. (2014). *The revolution will not be optimised: enactivism, embodiment and relationality.* Paper presented at the 50th Anniversary Convention of the Society for the Study of Artificial Intelligence and Simulation of Behaviour (AISB).

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review, 9*, 625-636.

Witherington, D. C. (2011). Taking emergence seriously: The centrality of circular causality for dynamic systems approaches to development. *Human Development, 54*, 66-92.

Witherington, D. C. (2014). Self-organization and explanatory pluralism: Avoiding the snares of reductionism in developmental science. *Research in Human Development, 11*, 22-36.

Witherington, D. C. (2015). Dynamic systems. In W. F. Overton, P. C. M. Molenaar & R. M. Lerner (Eds.), *Handbook of child psychology and developmental science* (7th ed., Vol. 1, pp. 63-112). New York: Wiley.

Witherington, D. C., & Margett, T. E. (2011). How conceptually unified Is the dynamic systems approach to the study of psychological development? *Child Development Perspectives, 5*, 286-290.