Commentary

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Beyond Principles and Programs: An Action Framework for Modeling Development

Commentary on Fields

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We are in strong agreement with many of the conclusions of Fields's discussion [this issue], and would like to expand the theoretical context for his arguments in order to offer some further interpretations. Accordingly, in our commentary, we will introduce some historical and developmental considerations in an effort to situate Fields's position within developmental theory more broadly. Such contextualization will help clarify how Fields's arguments relate to extant frameworks for modeling development – including our own action-based framework.

There are many things to commend this paper and it is a welcome contribution to developmental theory. Fields highlights some of the issues and complexities involved with object representation and object re-identification in an effort to demonstrate the inadequacy of a core aspect of nativist theory; specifically, that the appeal from nativists to a principle of object persistence is theoretically empty and fails to provide researchers with an explanation of *how* children are able to actually segregate and re-identify objects. Fields applies the modeling power of programs and their data structures to account for object persistence from within a computational framework – a framework that is generally shared by nativist researchers. If Fields's conclusions are correct, this means that nativist arguments for the necessity of *innate* object representations (and thus the persistence principle) are unsound. We agree that internal inconsistencies in nativist theory are particularly damaging [Allen & Bickhard, 2011a], but we disagree with Fields about the implications of such criticism. In particular, programs are a marked improvement over principles, but we suggest the need to go beyond *both* principles *and* programs in order to adequately model cognitive and developmental phenomena. Epistemic agents are open systems that must interact with their environment to exist, and modeling their ontology and development from

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within a computational framework is inherently at odds with these dynamical interactive systems considerations. Instead, we suggest that an (inter-)action-based dynamical framework is required [Bickhard, 2009a, b].

Nativism

The idea that innate principles provide a necessary foundation for development has been at the core of nativist theory for the last half a century [Chomsky, 1965]. In developmental psychology, nativist researchers have used looking paradigms to support two related strands of nativism: *constraint* nativism [Gallistel & Gelman, 1992; Keil, 1981; Spelke, Breinlinger, Macomber, & Jacobson, 1992] and *content* nativism [Baillargeon, 1987a, b; Carey, 2009; Wynn, 1992]. While the first of these maps most closely onto Chomsky's [1959, 1965] poverty of the stimulus argument, the second has found its most powerful arguments in the work of Fodor [1975].

Constraint nativism, as advocated by developmentalists, is characterized by the argument that learning (as unconstrained induction) cannot account for actual developmental performances; therefore, innate principles provide a *necessary* foundation that narrows the space of possible inductions such that it is possible for infants to learn. In contrast, content nativism is characterized by the argument that learning (as hypothesis construction) *must* presuppose the representational contents that constitute the building blocks for the hypotheses in the first place. Therefore, content nativism is primary because it provides the combinatorial building blocks that form the foundation for subsequent learning. Whether the construction of those building blocks into hypotheses also takes place within an innately constrained space of possibility is secondary. Thus, constraint nativism presupposes content nativism, and so it is the innateness of representational content that will be the focus of our subsequent analyses.

Developmental Origins and Foundationalism

Fields avoids issues concerning the "provenance" of knowledge because he assumes that neuroscientific implementation is the crucial explanatory criterion that is needed in order to understand and model development. While we agree with his efforts to integrate neuroscience into developmental theory, we disagree with his assumption that this is the crucial explanatory criterion. Further, to *require* that a neuroscientific account be provided in order for an explanation of knowing to have theoretical substance is at odds with Fields's own computational framework: One of the "virtues" of computationalism is supposed to be that functional states can be implemented by a brain, a computer, or the population of China, and therefore, that neuroscience is not necessary for explaining cognition. Whether or not this is the case,[1]

[1] Actually, we reject the possibility of a hard distinction between brain as hardware and mind as software but that is because we strongly disagree that information processing and computation is the proper framework for trying to model developmental systems that are thermodynamically far from equilibrium [Allen & Bickhard, 2013b].

we think it is a crucial mistake to focus on neuroscientific *implementation* to the *exclusion* of the developmental issues regarding *origins*.

A consequence of sidestepping the developmental issues concerning origins is that it makes it difficult to fully appreciate the nativist's appeal to innate principles. Nativism is a response to a question about the origins and development of knowledge. Specifically, nativism purports to be a necessary consequence of the failure of empiricism to provide an adequate explanation for how we could learn all that we know about the world through perceptual experience alone. In developmental psychology, nativists understand their research program as attempting to "empirically" characterize the "core" parameters of the *innate starting state* such that learning and development are possible [Carey 2009; Spelke & Newport, 1998]. Although nativists differ from empiricists in terms of the size and richness of that innate starting state, they share with empiricists in their commitment to a representational foundationalism – a foundation of representational atoms in that starting state [Allen & Bickhard, 2011a]: Foundationalism is the assumption that knowledge is built up from a base set of representational primitives.[2]

Nativists tend to claim that a foundationalism of *object level* representations is necessary while empiricists tend to claim that *perceptual level* "feature" representations are sufficient to account for subsequent learning of such object representations [Allen & Bickhard, 2013a]. Part of the reason that the "property" of object persistence has been a central focus for the debate between nativist and empiricists is because that property does not seem to be perceptually available in a way similar to other properties (e.g., color or shape). Further, nothing about the associations (no matter how non-linear and complex) between the perceptually available feature representations would seem to account for the "property of persistence." In this sense, nativist theory is intrinsically tied to what empiricism cannot account for. Nativists argue by elimination that, because empiricist models do not account for aspects of mind that are not available to perception, those aspects cannot be learned – those aspects must be innate primitives that are part of the foundational starting state.

Fields's argument is important because it suggests that nativist conclusions regarding object persistence are premature, not because standard association style empiricism works, but rather, because "programs" are more powerful than associations as an ontology for modeling the nature of representation and learning. That is, Fields goes beyond associations (and principles) to demonstrate the power of programs to account for object persistence. If object representations can be constructed as "object files," then programs can construct object representations out of feature representations (unlike associations), and innate "object" representations are not necessary. So, taking programs seriously would seem to undermine nativist arguments. Developmental nativists would still have left as grounds for their position(s) their "empirical"-based arguments about how knowledge of object properties seem to be present from very early ages, but those, as has been pointed out, turn on rich interpretations of data

[2] Fields describes as "somewhat paradoxical" Spelke's statement about a theory's explanatory value not being dependent on the content it assigns to the initial state; however, in the context of foundationalism, her claim makes more sense. If all researchers are committed to the assumption of a base set of representational primitives, then Spelke is correct that theoretical differences about the particular size or richness of those contents do not demarcate the basic legitimacy of subsequent explanation.

and design that beg the question [Allen & Bickhard, 2013a; Haith, 1998; Müller & Overton, 1998].

Fields's computational approach to the problems of object segmentation and re-identification forces a more sophisticated appreciation of what sorts of issues those problems involve. For example, the original frame problem has been around for more than 40 years, but developmental researchers have rarely considered it an issue that is relevant to their interests [Bickhard, 2001; Heal, 1996]. Fields uses the frame problem to highlight that the "possible causal histories" relevant for object re-identification are unbounded and cannot be specified a priori. As a consequence, humans *must* deploy heuristics that themselves have to be learned through experiences with particular types of situations and circumstances. Accordingly, the development of object knowledge becomes a matter of learning about the "best" heuristics for successful segmentation and re-identification, and persistence is understood as a *computational* phenomenon: Persistence is a property of the computational system.

Although Fields demonstrated that nativist arguments miss some of the important power of programs over empiricist associations – in effect, he argues that nativists try to squeeze "program" power into "principles as axioms" – he does not go beyond programs. Most important from our perspective, he is still left with feature "empirical bits," but with no model of them beyond information semantics, which does not work [Bickhard, 1993, 2009b]. In general, there is a common underlying empiricist framework among "empiricists," nativists, and Fields, but, as Fields's argument points out, with underappreciated and poorly explicated notions of how those empirical pieces are organized. Historically, the organizational means were originally associations and now the "powerful" organizational means are programs, but with little understanding of how much and what sort of differences that move makes. For our purposes, the crucial difference between these positions and our own is that they do not, and cannot, address the issue of representational emergence.

Action as an Alternative to Nativism and Empiricism

Accounting for the nature and origins of representation has always been at the core of the nativist-empiricist debate. Although nativists continue to interpret Piaget's model of object representation as being empiricist [Carey, 2009], Piaget consistently argued against such approaches in an effort to transcend both empiricism and rationalism by arguing for a "tertium quid" or "third way" [Müller, Carpendale, & Smith, 2009]. The key to understanding Piaget's action-based alternative is emergence. Nativism and empiricism both presuppose some form of foundationalism and thereby do not address how any such foundation could emerge and we argue that the models of representation on offer cannot, in principle, model representational emergence [Bickhard, 2009b]. Thus, it is the possibility of emergent representation that provides the crucial contrast for how Piaget's model transcended the foundationalism of both nativists and empiricists.

An (inter-)action-based approach to cognition and development is the only known framework that is able to account for representational emergence. From this perspective, knowledge is constituted by interactive competence, and learning about

the world means learning how to interact with it competently. While Piagetian theory is the major example of such an action-based approach, we will draw from the interactivist model of representation [Bickhard, 2009a, b][3] in order to briefly outline some contrasts with Fields's assumptions about the nature of object representation and re-identification.

For interactivism, representation is fundamentally constituted by anticipation. Anticipations are functional indications of possible future interactions given appropriate environmental conditions. If a system engages in one of the indicated possibilities, then it implicitly predicates that the current environmental conditions are, in fact, appropriate to support the interaction. If, however, the environmental conditions are not appropriate, then the interaction will fail, and the implicit predication about the environment will have been shown to be in error – i.e., the anticipation is falsified. In this sense, the interactivist model captures two essential epistemological properties of representation: *truth value* and *aboutness*. However, in all cases, "detection" of the environmental conditions does not require that they be represented, let alone represented as particulars.

Interactivism draws on the notion of implicit definition to demonstrate how detection can be separated from representation [Bickhard, 2009b]. Consider that the internal outcome state of a system (after interacting with an environment) will differentiate those types of environments that leave the system in *that* internal outcome state from those that leave it in some other outcome state. For example, for a system with only two internal outcome states, A and B, interactions with certain environments will leave the system in outcome state A while other environments will result in B. These internal outcome states serve to differentiate A-type environments from B-type environments. Importantly, the differentiation process is inherently abstract, unbounded, and implicitly defined by the internal organization of the system. The system has no explicit knowledge of the environments that it has differentiated, and consequently, detection does not need to involve representation.

The interactivist model of representation opens up the possibility that an infant could detect and/or track an object without that necessarily indicating "persistent objecthood." It also means that infants could successfully re-identify objects (and people) prior to the capacity to represent the world in terms of objecthood. Infants do eventually come to represent the world in terms of persistent objects, but that is a developmental accomplishment that unfolds over the first 2 years [Piaget, 1954]. For interactivism, the development of object representation is a matter of learning to organize the interactive possibilities afforded by objects such that they form an invariant web of mutually reachable anticipations.[4] For a toy block, the interaction possibilities will include visual scans, hand manipulations, and mouthing explorations. However, full object representation also requires that children have learned the class of transformations under which such webs remain invariant (i.e., recoverable). These transformations will include visible and invisible displacement [e.g., Piaget, 1954] as

[3] For interactivism, the emergence of representation from action takes place within the broader normative context of dynamical interactive systems that are able to functionally contribute to their own self-maintenance [e.g., Allen & Bickhard, 2011b].

[4] The interactivist model of object representation borrows heavily from Piaget's model. Such borrowing is possible because both models share a commitment to an action framework for modeling representation.

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well as occlusion and containment "events" [e.g., Baillargeon, 2008]. However, not all transformations will maintain the web of interactive possibilities. For example, if the block is burned or pulverized, the collection of interactive possibilities that previously existed is no longer recoverable.

In short, object representation is constituted by a web of mutually reachable interactive possibilities that remains invariant with respect to a large class of transformations. Persistence is manifest in the invariance of the web of interactive possibilities and in terms of that web being recoverable through appropriate intervening steps (e.g., I must first open the box to recover the toy).

Summary

Fields focuses on implementation not origins, but the origins of nativism are located in issues about the origins of representations. His narrower focus is on organization of empirical atoms – nativism argues that object representations must be innate. In contrast, Fields argues that persistence is a computational phenomenon and that programs can construct "object files," thus, nativism about object representations is not necessary. All such positions, however, assume basic empiricist atoms.

Action-based approaches provide a powerful alternative to the foundationalist assumption common to both nativist and empiricist frameworks. Only an action-based framework is able to account for the emergence of representation from a base that is not itself already representational. Accordingly, an action-based approach to representation in general and object representation in particular has implications for understanding persistence. In convergence with Piagetian theory, the interactivist model outlined above suggests that object persistence is itself a developmental phenomenon that involves increasing representational complexity over the first 2 years of an infant's life.

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