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Stepping off the pendulum: Why only an action-based approach can transcend the nativist–empiricist debate☆

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ABSTRACT

We argue that the nativist–empiricist debate in developmental psychology is distorted, both theoretically and methodologically, by a shared framework of assumptions concerning the nature of representation. In particular, both sides of the debate assume models of representation that make the emergence of representation impossible. This, in turn, distorts conceptions of cognitive development by forcing developmentally new representation to be constructed out of some already available (innate) foundation of atomistic representations – it forces a foundationalism. Contemporary nativists and empiricists differ with respect to the size and scope of such foundations, but are equally committed to some form of foundationalism. In further consequence, this foundationalism distorts methodologies by rendering any form of developmental emergence of representation impossible, and, thus, renders control conditions in experiments for such kinds of development (and their precursors) crucially irrelevant. We end by outlining an approach to modeling representation that is not committed to foundationalism because it explicitly models representational emergence. This is an action-based approach, with similarities to Piaget's model.

We argue that contemporary attempts to resolve the nativist–empiricist debate have not succeeded and that an alternative framework – an action-based framework – is necessary. Over the course of almost two decades, a number of proposals have attempted to address the limitations inherent to nativist and empiricist proposals regarding the nature, origins and development of our

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knowledge (Carey, 2009; Cowie, 1999; Elman et al., 1996; Kagan, 2008; Karmiloff-Smith, 1992; Keil, 1998; Mandler, 2004; Newcombe & Learmonth, 1999; Spelke & Kinzler, 2007; Spencer et al., 2009; Thelen & Smith, 1994). These proposals tend to share one of two conclusions: that the positions in the nativist–empiricist debate are misguided or that the debate is altogether incoherent; accordingly, attempted resolutions take the form of proposing some sort of eclectic "middle ground" or outright dismissal respectively. We argue here that all parties fail to adequately diagnose the fundamental problem with nativist and broadly empiricist positions – viz., their inability to account for representational emergence – and therefore they do not fully succeed in their respective treatments of the debate. Complete transcendence of the debate will require adopting an alternative action-based framework for understanding the nature, origins and development of human knowledge.

Nativism and empiricism constitute two opposing spheres on a continuum of proposals regarding how to account for the source, development, and nature of our knowledge. While differing with respect to the source of basic representations, both share a problematic commitment to *foundationalism* – the assumption that knowledge is built up from a representational base – as well as a strong tendency to preclude *emergent constructivism* – the assumption that representational knowledge can be emergent in the construction of action systems. We argue that these foundationalist commitments frame the nativist–empiricist debate, and therefore, that rejecting them undercuts the debate altogether.

A major reason for caring about these problematic commitments is that they impact and frame developmental research and research design across multiple levels of analysis and across multiple theoretical approaches. The particular experimental research examined serves as a case study that illustrates how conceptual issues in general (and foundationalism in particular) can manifest themselves in problematic ways and that these problems cannot be fully resolved through additional experimentation alone. Therefore, our second major aim is to demonstrate the significance of foundationalism for both methodological and conceptual issues for making progress in developmental research.

Toward that end, the current article is divided into four major sections. Section 1 is intended to provide a brief historical contextualization for the rise, rationale and prominence of nativist research and methodology in developmental psychology. This section serves two purposes: first, to clarify what is at issue in the nativist–empiricist debate; and second, to lay out the conceptual and methodological foundations of the nativist research programme.

Section 2 critically reviews some of the *empirical* stalwarts for contemporary nativist (and non-nativist) infant research. Having received sustained empirical criticism, the focus of this review concerns Baillargeon's 'drawbridge' procedure and Wynn's 'calculation' procedure. The core of this critical review is that nativist research: (1) often failed to adequately control for perceptual-level variables; (2) made use of "rich" interpretations of the data; and, (3) incorrectly ignored the inherent dynamics of habituation processes. This section serves two related purposes: first, to offer a new and integrated treatment of the wealth of empirical criticisms of some of the original nativist infant research; and, second, to illustrate one of the particular ways in which unaddressed conceptual problems can manifest at the level of experimental research and design.

Section 3 provides a broader *theoretical* critique of the nativist research programme in terms of its commitment to the competence–performance distinction, foundationalism, and a problematic notion of representation. The outcome of this critique then provides the context for the claim that the nativist research programme is seriously problematic in the sense that it precludes alternative interpretations a priori (thus the lack of a particular class of relevant control conditions). Further, the fundamental problems that constitute the conclusions of the theoretical critique of nativism have not been fully addressed or entirely avoided by other, non-nativist perspectives that may broadly be considered empiricist. While there will not be the same detailed review of empiricist research and positions, we aim to demonstrate that the in-principle failure of *any* position to account for the emergence of new knowledge is a crucial limitation in trying to account for the nature of representation, learning, and development whether in empiricist or nativist frameworks. That said, the broader emphasis of generally empiricist approaches on learning, developmental change, and process will help motivate our move towards action as the basis of cognition.

Specifically, in Section 4, an alternative action-based framework will be briefly introduced and used to highlight how the emergence of cognition from action is the key to transcending the inherent limitations of the nativist–empiricist debate.

1. The rise, rationale and prominence of nativist research

1.1. The rise of nativist thinking

Chomsky (1959, 1965) and Fodor (1968, 1975, 1980) provided much of the broader theoretical framework of ideas within which developmental nativism took hold during the late 70s and early 80s. Accordingly, they also constitute two major currents within nativistic thought (Cowie, 1999). The core of Chomsky's critique of Skinner's model of language acquisition (Chomsky, 1959) concerned what could not be learned (in-principle) given the theoretical resources of behaviorist psychology. Chomsky's Poverty Of the Stimulus (POS) argument demonstrated that there were relatively simple linguistic examples that could not be learned from associations of what is available to us in our language environment. That is, language input (in conjunction with behaviorist modeling resources) was not *sufficient* to account for language acquisition. Something more was required to account for the 'facts' of language acquisition and that something more was to be found in our genetic inheritance.

With the onset of the "cognitive revolution", Chomsky's particular argument against behaviorism became progressively less relevant; however, while the general information-processing framework that took over did not require a nativist turn, it provided no reason for its exclusion either. Within developmental psychology it was the theoretical and rhetorical use of the competence–performance distinction (Chomsky, 1965) that largely contributed to the emergence of a nativist research programme. Specifically, the competence–performance distinction was easily the most productive conceptual resource used by developmental nativists in their purported refutation of Piagetian theory; and given that Piagetian constructivism was the primary available alternative, the way was now clear for a nativist research programme.

The second major strand of nativistic thought during the latter half of the 20th century finds its progenitor in the work of Fodor (1975, 1980). Fodor's "pessimistic" brand of nativism differs from Chomsky's in that for Fodor *no* cognitive learning is possible unless there is already innate representational content. Fodor's argument is basically that, if learning is constituted by hypothesis-generation and confirmation, then the content of the basic concepts used to generate the hypotheses must already be available to the organism – they must be innate. The radical "mad-dog" scope of Fodor's argument derives from his further claim that most lexical concepts are non-definitional (they do not admit of necessary and sufficient conditions) and therefore do not have internal structure, thus, they must be foundational. That is, if most concepts cannot be learned (because they are already basic) then they must be innate.

1.1.1. What are nativists and empiricists arguing about?

Contrary to some common characterizations, the nativist–empiricist debate has substantive content. Our purpose in establishing that there is a meaningful difference between nativist and empiricist positions is to guard against what will be argued to be false resolutions of the debate based on oversimplifications of the opposing positions. While the differences between Chomsky and Fodor already suggest that nativism is not a unitary position, both brands still share several core features. For empiricism, the situation is even more variable because "empiricist" positions are often grouped implicitly as those positions that are not nativist. In this article, the term empiricism is being used broadly to include any position where association or similarity, or some building block model of constructions out of perceptual representational primitives, is the focus for learning and development – connectionism, feature nativism, several versions of information-processing accounts, several versions of constructivism. Thus, while nativist and empiricist collections of positions may have more of a family resemblance structure than a definitional one, there are still substantive differences between the families.

At its core, the nativist–empiricist debate is an *epistemological* distinction about the origins of knowledge. Nativist and empiricist positions differ because they provide contrasting solutions to

account for the source of that knowledge. The nativist's proposal, made clear during the 1975 debate between Piaget and Chomsky, was that "all structure comes from within. Environment *reveals* this structure; it does not imprint its own patterns on the system" (Piattelli-Palmarini, 1980, p. 12), alternatively "forms . . . preexist . . . and are forced to materialize under appropriate conditions" (p. 13). For both of these renditions of nativism the environment plays a necessary role in the (perhaps non-linear and complex) series of interactions that must take place between innate and environmental factors; but the crucial point is that the structure is intrinsic to the nature of the organism. In developmental psychology, Spelke and Newport (1998) have suggested that in asking whether knowledge is innate, one is asking whether it is independent of learning, not whether it is independent of environmental influences altogether.

In contemporary research, explicit challenges to empiricism per se are less common than those to nativism. Part of the reason for this is that empiricism is often the taken-for-granted starting point of a materialist natural science (Carey, 2009; Gelman & Kalish, 2006) and so it is, in some sense, a common presupposition for both nativists and empiricists (i.e., nativists argue by elimination that empiricism alone is insufficient to account for *certain* aspects of what we know but agree that accounting for *other* aspects is unproblematic). Contemporary empiricist assumptions about the origins of knowledge are not fundamentally different from classic empiricism. For the classic empiricist, structure comes from the environment and imprints itself upon us (consider Aristotle's signet ring imprinting in wax). While modern accounts of such imprinting involve technological updates such as "transduction" for in-the-moment representation or "abstraction" and "induction" for longer-term learning, the function of such processes is still, ultimately, to transfer the structure of the external world into the mind (Bickhard & Richie, 1983) such that mental content reduces to experiential content. However, as Fodor (1998) succinctly states, "that there is usually more in the content of a concept than there is in the experiences that prompt us to form it is the burden of the traditional rationalist critique of empiricism" (p. 150). This idea that there is something more than what is given by experience is precisely the point that Chomsky was trying to make with respect to language – our experiences with a language environment are not sufficient to account for the linguistic competence that all normal members acquire, therefore, there must be something more than what is given from experience alone.

While we have focused on the original arguments by Chomsky and Fodor with respect to their nativist conclusions, these arguments were also major contributors to the broader movement in psychology towards the information-processing framework of the cognitive revolution. With respect to the broader information-processing framework, nativist and empiricist positions converge in their commitment to the notion of representation as encoding. Thus, the nativist–empiricist debate concerns the *origins* (source) of those encodings not whether encoding relationships capture the foundational *nature* of representation. Within developmental psychology, one of the historical consequences of this shared information-processing framework was that Piagetian theory was assimilated into that framework and misinterpreted accordingly (Chapman, 1988; Lourenco & Machado, 1996; Smith, 1993). However, Piaget's attempt to provide a third way, distinct from both nativism and empiricism, has fundamental contrasts with the very information-processing paradigm used to interpret his work. As a consequence of forcing Piagetian theory into the information-processing landscape (where nativist and empiricist positions are considered exhaustive), nativists arguing against Piaget have tended to assume that he was an empiricist (e.g., Carey, 2009). Therefore, within this zero-sum distortion, the decline of Piagetian theory has entailed the rise of nativism.

1.1.2. Developmental nativism as a consequence of anti-piagetianism

In contrast to Fodor and Chomsky, nativist researchers of infant developmental psychology did not typically begin with theoretical arguments about what can and cannot be learned; instead, they built on the existing strategy then being used in developmental psychology for purported demonstrations that Piagetian theory was false. The general structure of this *Anti-Piagetian* strategy was to show that some *competency* developed earlier than Piagetian theory had claimed (Borke, 1975; Braine, 1959; Bryant & Trabasso, 1971; Gelman, 1969). However, the general problem with this strategy has

always been the debatable claim that the *same* competencies were under examination in the different tasks. This is especially the case for applications of this strategy to infancy. At its core, the logic of this strategy contains a commitment to a distinction between underlying competence and actual performance.

An explicit corollary of Chomsky's (1965) argument for the innateness of our language faculty was the introduction of the competence–performance distinction. His competence model was an idealized abstraction that required a performance model if it was going to claim any psychological reality. The general consequence is that actual performance need not be a direct window on true competence because a variety of potentially limiting performance factors (e.g., motivation, memory, speech apparatus, etc.) would always be involved with any actual linguistic interaction. Thelen and Smith's (1994) discussion of the competence–performance distinction suggests that Gelman's classic (1969) paper established the "modus operandi" for how researchers should apply the competence–performance distinction to developmental research:

> Define the *essence* of some knowledge structure, do a thorough task analysis, strip away the supporting process and performance variables that could limit successful use of the essential knowledge structure, and see if children possess the "essential" knowledge (Thelen & Smith, 1994, p. 26).

A major problem with applying the competence–performance distinction in this way is that it involves a "natural bias" toward earlier and earlier claims about the presence of a given competency (Chandler, 1991; Sophian, 1997). The reason for this bias is that positive results are interpreted as evidence of true "competence", while negative results are relegated to extraneous performance factors.

With the seminal application of looking methodologies to the notion of object permanence (Kellman & Spelke, 1983), the Anti-Piagetian strategy was applied to infant populations in an effort to demonstrate the "presence" of certain competencies so early in development that no (non-nativist) account could explain the findings, including Piaget's (Fischer and Bidell, 1991 refer to this strategy as the "Argument from Precocity"). The conclusion from this line of research was that the competencies being studied were innate (or innately constrained). It is now that we begin to see a methodological version of one of the signature elements of the nativist family of positions – namely, that experience (i.e., learning as *unconstrained* induction) is not sufficient to account for current acquisition.

To the extent that explicit conceptual arguments are introduced to motivate nativist positions in developmental psychology, researchers have typically appealed to Quine's (1960) riddle concerning the indeterminacy of translation (Thelen & Smith, 1994). The general point being made by Quine was that a stranger in a foreign land would be unable to learn the native language unless there was some commonality between them that reduced the number of possible inductions. In turn, developmental nativists have used the problem raised by Quine to argue that the failure of learning (as unconstrained induction) compels nativism because sense experience underdetermines what is to be learned: if all we have access to is sense experience, then the number of possible inductions consistent with "the stimuli" is too large to ever learn any particular one (i.e., a variant of Chomsky's Poverty of the Stimulus argument).

The anti-Piagetianism of the 70s that evolved into the nativism of the 80s resulted in two brands of nativism that map (roughly) onto those exemplified by Fodor and Chomsky: innateness of representation and corresponding inferences (Baillargeon, 1987a, 1987b; Wynn, 1992) and innateness of constraints (Gallistel & Gelman, 1992; Keil, 1981; Spelke, Breinlinger, Macomber, & Jacobson, 1992) respectively. However, despite being separate, they are intimately related in the sense that constraint nativism presupposes some form of representational (or concept) nativism. Fodor's impossibility argument demonstrates why this is the case: constraint nativism attempts to limit the space of possible (un-constrained) inductions so that learning can settle on the correct solution; however, specifying any hypotheses at all requires the innateness of the representations that make up/constitute those hypotheses. The current point is that the fundamental issues concern representational nativism and any principled problems apply equally to constraint nativism (as well as the more recent use of the term innate "learning" mechanisms).

1.2. The foundation for looking methodologies in "cognitive" development

The original use of the preferential looking procedure concerned research on infant perception (Fantz, 1964). The basic logic (Schöner & Thelen, 2006) of the paradigm is derivative from the empirical fact that, with repeated exposure, animals will typically decrease their reactivity to a "stimulus" and reengage that activity with the introduction of sufficient novelty. In the habituation phase of looking paradigms, participants are repeatedly exposed to some display or event until their attention (looking activity) decreases to some set criteria (i.e., they are habituated). During the testing phase, infants are exposed to a new display or event that is altered according to some dimension of interest (e.g., type of pattern, color, number of objects) and if infants reengage their attention (dishabituate) to the altered display or event then they must be *sensitive* to that change.

While habituation is fundamentally grounded in the ability to differentiate aspects of the world in terms of perception, the "rich" interpretive stance of nativist researchers assumed that *conceptual* habituation was possible, that it operated according to analogous principles to that of *perceptual* habituation, and that any potential effects of *perceptual* habituation were either irrelevant or overwhelmed. That is, to explore infant's conceptual knowledge, nativist researchers attempted to design experiments such that the *only* relevant difference between displays concerned the conceptual content of interest. If infants showed differential looking during test, then they must be sensitive to that difference in conceptual content. Further, because perceptual aspects of the display will always vary with the conceptual differences of interest, researchers designed their experiments so that negative results (according to the conceptual dimension) were paired with positive results (according to the perceptual dimension). That is, they pitted perceptual novelty against conceptual familiarity and perceptual familiarity against conceptual novelty. This aspect of the design was intended to control for the possibility that infants were responding on the basis of perceptual aspects of the display instead of the conceptual dimension of interest.

In contemporary research, the use of looking methodologies is ubiquitous across domains of infant development. While nativists originally used looking methodologies to investigate object representation and physical reasoning, and later numerical knowledge and spatial knowledge, looking procedures have more recently been used in the exploration of goal attribution, action parsing, intention reading and false-belief understanding (Baird & Baldwin, 2001; Onishi & Baillargeon, 2005; Woodward, 1998, 1999). However, very little of the extensive conceptual and methodological criticisms of nativist looking procedures has had any impact on contemporary uses of the general paradigm (Blumberg, 2005). Part of the reason for this failure is the lack of a comprehensive account of the systemic limitations of nativist research that implicitly forms the basis of methodology and interpretation for contemporary investigations of infant development in general. While contemporary infant researchers often claim to be agnostic about possible nativist conclusions, they employ much of the same methodological and conceptual machinery that has been previously criticized (Jackson & Sirois, 2009; Sirois & Jackson, 2007).

1.3. Summary of Section 1

The cognitive revolution ushered in the information-processing framework as the new conceptual background for how to do psychology. For researchers concerned with the origins of knowledge, the cognitive revolution also provided the groundwork for the resurgent interest in nativist brands of thinking. Nativism differs from empiricism in that they offer contrasting perspectives regarding the *origins* of knowledge (the organism versus the environment) but they share in their information-processing assumptions regarding the representational *nature* of that knowledge. Piagetian theory attempted to offer an alternative to both nativism and empiricism in the sense that the *nature* of knowledge was constituted by competent interaction with the world and in the sense that the *origins* of representation were emergent out of (inter)action. However, Piagetian theory was assimilated into the information-processing framework shared by both nativists and empiricists. Further, the more fervent opposition by nativists meant that Piagetian theory was forced into the empiricist sphere of that framework. Therefore, the decline of Piagetian theory was directly related to the rise of the

nativist research program in developmental psychology. Finally, by incorporating the logic of the competence–performance distinction into their research methodology, developmental nativists proceeded to demonstrate that existing explanations for how a given competence could have been learned through experience alone were inadequate.

2. Critical review of the "empirical" foundations of the nativist research programme: the experiments and their critics

2.1. Overview

There have been a series of criticisms arrayed against some of the classic nativist studies for their limitations on both methodological and conceptual grounds. Of course the conceptual framework utilized and the methodology employed are reciprocally related and consequently so are the criticisms. With respect to methodology, it has been empirically demonstrated that many of these studies failed to *adequately* control for perceptual-level variables in their original research designs (Mix, Huttenlocher, & Levine, 2002; Rivera, Wakeley, & Langer, 1999). Others have pointed to the lack of consideration given to the dynamic complexities involved in the procedures used to study infant development (i.e., the process of habituation itself; Kagan, 2002; Schilling, 2000; Schöner & Thelen, 2006). The point is that there are important "content free" dynamics involved in looking (and looking away) that must be taken into account when conducting this type of research. With respect to the conceptual issues, it is argued that these classic nativist studies indulged in what has been termed "rich" interpretations of the data (Bogartz, Shinskey, & Speaker, 1997; Haith & Benson, 1998; Reznick, 2000), the general point being that the experimental design and empirical evidence from these studies requires fairly charitable interpretations to achieve the rich cognitive conclusions that nativist researchers were attempting to demonstrate.

More specifically, in the domain of object research, Baillargeon's "drawbridge occlusion" (1987a), "car rolling down a ramp" (1986) and "short rabbit–tall rabbit" (Baillargeon & Graber, 1987) procedures have all been subject to alternative perceptual-level interpretations. In addition, Kellman and Spelke's influential "two-rods" procedure (1983) has also been reinterpreted in non-conceptual terms. With respect to number research, Wynn's (1992) calculation procedure (see also, Wynn, 1995, 1998, 2002) has received attention both from critics who promote an object enumeration perspective as well as from those who argue for perceptual-level alternatives.

While there have been multiple other critical reviews of the nativist infant literature (e.g., Bremner, 2001; Haith & Benson, 1998; Kagan, 2002, 2008; Mix et al., 2002) and while we discuss content similar to these reviews, we aim to provide here an account of how underlying theoretical assumptions have guided and constrained methodological design. Consequently, in contrast to providing a methodological prescription for the symptomatic ills of nativist infant research, we attempt a more permanent solution. We argue that it is precisely the underlying theoretical assumptions of the nativist framework that ultimately constitutes the problem with nativist infant research design and interpretation. Further, it is these underlying theoretical assumptions that need to be addressed in order to adequately analyze and transcend the nativist–empiricist divide more broadly. Thus, our critical review of the literature serves as an illustration for our argument that the numerous methodological concerns regarding nativist infant research are actually symptomatic of problems with underlying theoretical assumptions. Here we focus primarily on the two procedures that have received the major share of attention from critics, Baillargeon's (1987a) drawbridge procedure and Wynn's (1992) calculation procedure.

2.2. Object representation

2.2.1. The drawbridge procedure

One of the most influential sets of nativist studies concerns Baillargeon's drawbridge procedure (Baillargeon, 1986, 1987a, 1987b, 1991; Baillargeon, Spelke, & Wassermann, 1985). In the canonical

version of the task (Baillargeon, 1987a), infants were habituated/familiarized[1] to a display in which a hinged paddle moved in a 180° arc; after habituation, a block was placed directly in the path of the paddle; finally, during the test phase infants saw alternating trials in which the paddle traveled either all 180°, seeming to smoothly crush the block (a physically impossible event) or only 112°, seemingly coming to rest on the edge of the block (a physically possible event). In a control condition, infants received the same habituation and alternating test procedures but without the presence of the block in order to rule out the possibility that infants had an inherent preference for one or the other of the test displays. Average looking times were greater for the "impossible" event (accompanied by equal looking time during the control condition). As a result of these findings, Baillargeon concluded that, contrary to Piaget, infants as young as 4-months understood that the box continued to exist (object permanence) and that the screen could not rotate through the space occupied by the box (inference).

2.2.2. Methodological criticisms

The literature is replete with alternative, non-conceptual, interpretations of Baillargeon's findings. The implications from these criticisms differ with respect to their breadth of application. At the narrow end is Rivera et al. (1999) whose primary critique applies to the specifics of Baillargeon's drawbridge procedure, whereas Schilling (2000), Cashon and Cohen (2000) and Bogartz, Shinskey, and Schilling (2000) provide an analysis that spans certain aspects of the habituation paradigm in general. Schöner and Thelen (2006) extend and elaborate on that work by providing an explicit model of habituation dynamics that incorporates all of the known behavioral consequences of the procedure. Finally, Meltzoff and Moore (1998) and Fischer and Bidell (1991) provide more of a conceptual analysis concerning developmental nativist theory and its interpretive stance regarding infant methodology.

2.2.2.1. Failure to adequately control. Rivera et al. (1999) point out a fairly straight-forward methodological confound involving amount of motion. The two test displays in the drawbridge procedure systematically differ in terms of the amount of motion involved (180° of paddle arc versus 112°). Recall that Baillargeon (1987a) included a condition to control for this possibility and found no difference in looking time. However, Rivera and colleagues note an inconsistency in the overall logic of Baillargeon's experiment: accepting the *possibility* of a (perceptual) novelty preference for the experimental condition but failing to consider it in the control condition, thus creating ambiguity in the results from the control condition. Specifically, according to the logic regarding habituation, in the control condition there should have been a novelty preference for the newly displayed 112° paddle arc (not equal looking to both as was found).

Rivera et al. (1999) suggest that the reason infants in Baillargeon's control condition did not differ in terms of their looking response at the two test displays was because their habituation-induced (perceptual) novelty preference for 112° was pitted against their hypothesized (perceptual) preference for more motion (180°), resulting in equal looking to the two displays (i.e., the two perceptual factors cancelled each other out). To disentangle novelty from motion, Rivera et al. modified Baillargeon's control condition by omitting the habituation trials. The results indicated that infants looked significantly longer at the display involving more motion (180°) than at the display with less motion (112°) even though there was no "impossibility" manipulation (i.e., no block was involved). Further, the magnitude of looking at the 180° test display for the modified control condition was the same as the magnitude of looking at the 180° test display for a modified (no habituation trials) replication of Baillargeon's original experimental condition. This suggests that the same preference for more motion that was clearly at work in the modified control condition was likely to have been operating during their modified replication of Baillargeon's original experimental condition. Taken together these findings were suggested to indicate that longer looking to the "impossible" rotation was "due only to simple perceptual preference for events that display more motion" (p. 433).

[1] The word "familiarization" is used when the number of "habituation" trials is minimal, approximately 1–4, (Aslin & Fiser, 2005); however, any amount of familiarization to events prior to the test trials are probably best thought of as varying degrees of habituation (Schöner & Thelen, 2006).

The two experiments by Rivera and co-authors can be collectively understood as a rebuttal that is wholly on Baillargeon's own terms. That is, they accept both the theoretical and methodological framework from within which the drawbridge procedure is operating and exploit an inconsistency in the original work (i.e., recognizing the possibility of a perceptual novelty preference for the experimental condition but failing to consider it in the control condition). Further, the decision not to provide habituation prior to test is entirely consistent with Baillargeon's (1987a) own discussion that it was not theoretically relevant with respect to the results of the procedure. The critique by Rivera and colleagues is both powerful and limited: it is powerful in that it followed both the test procedures[2] and logic used by Baillargeon herself; however, it is also limited by those same two factors in that it only establishes that the original experiment confounded amount of motion (via disregarding perceptual novelty preferences in the control condition) and ignored potentially important complexities involved in the habituation process itself (via removing that aspect of the experiment altogether) without providing any insight as to what those important complexities might be. Finally, while the particular inconsistency regarding Baillargeon's interpretation of her control condition is specific to this procedure, it is nevertheless symptomatic of a general (and theoretically motivated) tendency of infant researchers to take a confirmatory approach to science. A confirmatory approach is one in which theories only need to be *consistent* with select data and therefore, research often fails to use adequate control conditions with the potential to rule out many of the interesting alternatives (more on this below). In sum, despite its limited scope, Rivera and colleagues exposed both methodological and conceptual failures that are expanded and elaborated by other critics.

In particular, a series of other experiments have applied the well-documented (Hunter & Ames, 1988; Hunter, Ames, & Koopman, 1983) perceptual processes involved in the preference for familiarity to reinterpret results from the drawbridge procedure (Bogartz, Shinskey, et al., 2000; Cashon & Cohen, 2000; Roder, Bushnell, & Sasserville, 2000; Schilling, 2000). The earlier set of findings on familiarity established that infants prefer perceptually familiar displays after brief habituation exposure and that the novelty preference emerges only after longer exposure times. Further, they demonstrated that the familiarity to novelty shift occurs faster if the display is "simple" or if the infant is older. Kagan also highlighted the importance of familiarity and novelty preferences (in general) some time ago (1970) by arguing that infants attend optimally to events that are not too "different" or too "similar" from what has been processed before. The methodological point made by the more recent group of researchers is that the drawbridge experiments confounded a perceptual familiarity preference with the "impossibility" of the display. This confound leaves open the alternative interpretation that infants were responding on the basis of familiarity rather than impossibility. Recall that habituation experiments were specifically designed to avoid confounding a perceptual *novelty* preference with the "impossible" event; but in so doing, they neglected to consider the earlier emerging familiarity preference and created the opposite confound between perceptual *familiarity* and "impossibility".

In response to these concerns, Wang, Baillargeon, and Brueckner (2004) have suggested that the properties of the habituation process involved in these critical experiments might belong to a different functional system from the properties of the habituation process involved in their experiments because they each tap different abilities. However, the claim that there are different systems involved begs the question because the only criterion used to differentiate which "functional system" is involved is based on how the researcher interprets the experiment (in terms of possibility or in terms of familiarity). Further, given that perceptual aspects are always present, it is unjustified to suggest that perceptual habituation dynamics are not involved in their "conceptual" display.

[2] Despite their explicit attempt to replicate the procedure (i.e., similar stage like enclosure, identical yellow boxes decorated with clown faces, striped walls, same sound cues, etc.) a recurrent theme in Baillargeon's response to critics is to point out that some aspects of the procedure were different (dark versus brightly lit rooms, infants positioned 100 cm (from the pivot of the screen) versus 65 cm from the screen, 10 s versus 2–3 s inter-trial interval). Unfortunately, these differences detract from others that are potentially more interesting, though in all cases there is little argument as to why an infant that possesses these putative conceptual cognitive capacities should be so affected by modest to minor perceptual differences.

2.2.2.2. The familiarity to novelty shift. To investigate the possibility that familiarity was responsible for looking behavior in the drawbridge procedure, Schilling (2000) systematically varied the infant's degree of habituation via the manipulation of the number of familiarization trials (7 or 12) and differences in age (4 or 6 months). His results indicated that looking behavior at test was a function of those two factors. Bogartz, Shinskey, et al. (2000) and Bogartz, Cashon, Cohen, Schilling, and Shinskey (2000) adapted the standard Event Set × Event Set design (ES×ES) using 5.5-month-old infants to statistically test the competing perceptual (familiarity/novelty) and conceptual (impossible/possible) hypotheses at issue. The standard ES×ES design is presented in Bogartz et al. (1997). The basic idea is to habituate three different groups of infants to one of the three events involved in the original procedures (i.e., the original familiarization event, the possible test event or the impossible test event) and then to alternate testing them on the other two events. This 3 × 3 design enables the authors to evaluate the amount of variance that can be attributed to each of the factors (e.g., impossibility/possibility, familiarity, amount of motion, presence or absence of the block, etc.) and thus test possible alternative interpretations. Bogartz and colleagues' analysis indicated that infants did not respond on the basis of impossibility but rather that their looking behavior was the product of familiarity/novelty preferences that were themselves a function of the number of habituation trials, changes in screen rotation, and the presence or absence of the block, all of which were interpreted as perceptual-level variables.

Cashon and Cohen (2000) used 8-month-old infants and as many as 20 habituation trials to examine the time-course of novelty preferences. To ensure thorough habituation, these researchers used an infant-controlled procedure in which the number and duration of habituation trials is determined by the looking behavior of each individual infant. Their results indicated that fully habituated infants prefer the perceptually novel/possible test display versus the perceptually familiar/impossible test display. Further, those infants who did not habituate (even after 20 trials) produced the opposite pattern of behavior thus replicating Baillargeon's standard findings. These results are consistent with those of Schilling (2000) and Bogartz, Shinskey, et al. (2000) and Bogartz, Cashon, et al. (2000) and further strengthen the criticism that the original research did not control for the perceptual-level processes involved with familiarity and novelty preferences.

Finally, Roder et al. (2000) examined the individual time-course for the emergence of a consistent novelty preference in 4.5-month-old infants so as to avoid any ambiguities resulting from individual differences in processing speed and artifacts of averaging data across infants. Their results indicated that infants selectively attended to familiar stimuli prior to their novelty preference and thus provide support for a non-linear model of memory formation during infancy. Individually and collectively these results demonstrate the relevance of the perceptual-level processes involved with the familiarity to novelty shift for the original experiments (see Baillargeon (2000), Munakata (2000), and Aslin (2000) for comments sympathetic to the original studies as well as Bogartz, Cashon, et al. (2000) for their reply to these comments).

While Rivera et al. (1999) exploited an inconsistency intrinsic to Baillargeon's specific study, they accepted the underlying logic and methods of the general habituation procedure. In contrast, the alternative perceptual-level interpretations of Bogartz and his colleagues' was broader in that it systematically explored the confounding of (perceptual) familiarity with (conceptual) impossibility and highlighted the relevance of habituation prior to test. In so doing, their analysis has demonstrated the general value of understanding at least one of the important dynamic complexities involved in the habituation process itself – the familiarity to novelty *shift*. The most immediate consequence from this collection of studies is that, contrary to earlier assumptions (Baillargeon, 1987a), the process of habituation itself has important systematic non-linear intrinsic dynamics that influence subsequent looking behavior. The historical fact that the original set of studies neglected to consider these dynamics as relevant constitutes a methodological limitation to adequately control for perceptual-level processes. At a deeper level, this failure derives from the anti-constructivist assumption that if it is a world of objects and their properties that the infant is looking at then it is a world of objects and their properties that they are seeing (in a way similar to how an adult sees them).

While the empirical demonstration that looking behavior at test is, at least in part, a function of the dynamic complexities of the habituation process, any particular modeling of those dynamic complexities is going to differ among researchers. With their focus on familiarity and novelty effects, studies operating from within an information-processing perspective have understood habituation

dynamics to result from the processes involved in "completing the representation" (Bogartz et al., 1997; Sokolov, 1963). The idea here is that infants need a certain amount of time to fully encode what they are seeing in order to form a complete representation. With few habituation trials encoding is incomplete and thus the familiarity preference; with sufficient habituation the representation is completed and thus the novelty preference (for a version of the same idea in terms of schemata see Kagan (2002)). Because simple stimuli are encoded faster and because older children are quicker information-processors, novelty preferences appear with fewer habituation trials in both cases. While this model provides an explanation for phenomena focused on familiarity and novelty, Schöner and Thelen (2006) point out that it is unclear what exactly is meant by 'encoding' or at what level the 'representations' are built, as well as why infants need to complete them. There would seem to be additional difficulties concerning the very idea of 'completing a representation'. Complete relative to what? The obvious answers are either: the world – but that is what we are trying to represent in the first place; or memory – but these are new representations which is why they need time to be encoded.

2.2.2.3. A dynamical systems model of habituation. Schöner and Thelen (2006) provide their own model of habituation that incorporates and expands on all of the known empirical results: (1) declining interest with repeated trials; (2) an initial increase in response prior to the decline; (3) more complex stimuli slow the rate of habituation; (4) dishabituation is a function both of the dishabituating stimulus as well as its intensity/complexity; (5 and 6) a familiarity preference with few habituation trials and a novelty preference with many; (7) order effects from test stimuli produce asymmetric preference responses; (8) dishabituation to novel stimulus can reinvigorate interest in the familiar stimulus; (9) non-specific activation boost can reinvigorate interest in the familiar stimulus; (10) individual differences in the rate of habituation determine rate of dishabituation. In so doing, Schöner and Thelen are able to successfully provide a comprehensive account of *all* of the empirical findings surrounding Baillargeon's drawbridge procedure.

Schöner and Thelen's habituation model is a particular instance of the more general class of models from within Dynamic Field Theory (DFT): "Field theories are based on the assumption that actions are the dynamic (and often non-linear) function of both the immediate stimuli in the environment and both the recent and longer-term history of the system in similar situations" (p. 277). Given the empirical demonstration that the perceptual processes involved in familiarity and novelty preferences depend on the infant's recent habituation history and the assumption that perceptual aspects can be modeled by a metric space of varying activation strengths, DFT would seem ideally suited for investigating the alternative perceptual interpretations proposed for nativist habituation research.

The DFT model simulated visual inputs through two coupled and interacting fields: the first is an activation field that drives looking. This field represents two metric properties of the stimuli – their perceptual similarity and their activation strength. The second field is the inhibition field which drives looking away. It receives input from the activation field and thus represents the level of habituation for each type of stimuli. Importantly, it is the non-linear interaction of these two fields driven by some perceptual properties of the stimulus along with timing that determines the level of habituation that takes place and subsequently the looking behavior associated with dishabituation during test.

After successfully modeling the looking behavior associated with basic habituation (e.g., initial increase in looking followed by attenuated interest, role of inter-stimulus interval, and fast and slow habituators) and dishabituation (e.g., novelty and familiarity effects, and order effects) processes, the model was applied to, and accounts for, virtually all of the findings from the drawbridge procedure as used by both nativists and non-nativists. Importantly, based on two empirically supported assumptions about the perceptual properties of the events – that while habituation and test events share some overlap, the 180 rotation provides more input (Rivera et al., 1999) and that the block boosts activation (Bogartz, Shinskey, et al., 2000; Bogartz, Cashon, et al., 2000; Cashon & Cohen, 2000) – Schöner and Thelen have, arguably, answered Baillargeon's (2000) challenge to provide a coherent and comprehensive account of all the data.

Baillargeon (2000) actually claims that a researcher would have to show that all 30 experiments from a list of putative demonstrations of object representation are better accounted for by a single coherent perceptual interpretation to overturn her interpretation. However, we would argue that the

logic of this claim is incorrect. First, perceptual confounds are confounds whether or not the theoretical apparatus needed to unify the results is available. Further, Baillargeon's position presupposes that these putative demonstrations all concern a single unitary phenomenon, but that is precisely what is at issue. Finally, systematic conceptual and methodological errors do not require an exhaustive enumeration of their instances. Chomsky's (1959) in-principle rejection of behaviorism did not proceed by re-interpreting the vast literature of experimental studies.

The dynamic field model of habituation provided by Schöner and Thelen directly informs their deeper analysis of the systemic biases present in nativist studies. Their model demonstrates explicitly how subtle changes in the stimuli or in timing can alter whether the infants' behavior accords with familiarity or novelty preferences. Further, they point out that the number of potential displays that can be construed by an adult as being about containment or support or object permanence is probably unbounded. That is, the different types of situations in which a display can be construed as manifesting the violation of some physical principal is limited only by the imagination and resources of the researcher. Given that the habituation methodology used to explore conceptual knowledge has its own dynamic complexities, it follows that the stimulus displays can be adjusted to produce virtually any outcome one is looking for. This isn't to suggest that researchers are intentionally engaging in such practices but rather that, through piloting, null results, and previous studies, they have unknowingly set the relevant perceptual display and timing parameters such that they find whatever result that they are looking for.

Ironically, this conclusion seems to be supported by one of the main features of Baillargeon's standard reply to critics. Specifically, that subtle methodological differences in perceptual aspects of the display (including habituation parameters) are responsible for the differences in outcome found by other researchers (Baillargeon, 2000; Wang et al., 2004). However, this type of explanation creates somewhat of a problematic situation for nativist researchers because not only are the empirical results of their critics convincing (in terms of their non-conceptual conclusions regarding object permanence) but they have, incidentally, demonstrated the potentially ad hoc character (Schöner & Thelen, 2006) of experiments that don't have theoretically driven constraints on the (thought-to-be-irrelevant) habituation parameters. This potential limitation encompasses most nativist studies given that habituation parameters have rarely been considered theoretically relevant to the "essential" knowledge structures (competencies) being studied by these researchers.

In sum, given some rather modest assumptions about *perceptual* activation and inhibition, Schöner and Thelen have been able to model results that were designed to demonstrate *conceptual* knowledge. Further, they have been able to account for the subsequent results from critics of the original experiments as well as interpret other robust findings (e.g., order effects) that were either dismissed as "theoretically uninteresting" (Baillargeon, 1987b) or left unexplained (Rivera et al., 1999; Cashon & Cohen, 2000). Finally, they have been able to accomplish all of this through an understanding of the non-linear content-free dynamics involved in the habituation process itself.

2.2.3. *Depth of critique and divergence of the alternative are reciprocally informative*

The three sets of criticism discussed so far provide a progressive elaboration of the extent to which a classic nativist procedure systematically failed to adequately control for perceptual-level variables in their design methodology. In each case, the depth and nature of their criticism importantly influenced, and was influenced by, the scope and nature of their alternative resolution.

In particular, the criticism from Rivera et al. (1999) was limited to some specifics concerning amount of motion and the logic of what to expect in control conditions. Consequently, their solution was to eliminate an aspect of the procedure (i.e., remove habituation altogether). For Bogartz and colleagues, the nature of the problem was a systematic confound derived from failing to incorporate one of the dynamic complexities involved in the habituation procedure itself (i.e., the familiarity to novelty shift) and so their alternative was a model of habituation that could accommodate what they took to be the relevant properties (familiarity and novelty preferences). Consequently, their analysis concluded that the failure by nativists to consider the dynamics of habituation processes was most directly the result of designing the original experiments within the context of possibility/impossibility rather than one of familiarization and novelty.

By providing a more robust model of habituation, Schöner and Thelen (2006) exemplify more clearly the bidirectional influence between critique and alternative. Similar to Bogartz and co-authors, they also developed their habituation model on the basis of an analysis that nativist studies were in error for not looking at the dynamics involved in habituation and that model was then used to examine how and in what specific ways failing to consider habituation processes mattered. The results of their simulations further informed their critique regarding the specifics on how habituation dynamics can produce the sometimes ad hoc character found in looking-time research.

2.2.4. Conceptual criticism

2.2.4.1. The developmental approach. At a more conceptual level of critique, Fischer and Bidell (1991) point out that it is from the fully competent adult perspective of an external observer that the events are characterized as possible or impossible. The implicit forced choice between these two categories entails that the looking methodology is intrinsically committed to a dichotomous present/absent conclusion regarding the concept of interest (e.g., object permanence, number, etc.). However, using the looking paradigm in this way presupposes a non-developmental perspective that ignores (emergent) constructivist alternatives a priori. Fischer and Bidell (1991) highlight their point by arguing that the variability and gradual nature of cognitive developments means that behavioral findings cannot be taken out of the context of: (1) the developmental *sequence* before and after the ability of interest; (2) the developmental *synchronies* found in other domains; and, (3) the *cluster* of behaviors that "move" together with the target behaviors, without also removing the necessary constraints on generalizations concerning the abilities that such behavior is taken to represent. Only by designing dichotomous yes–no experiments that ignore developmental variability and are isolated from the context of sequence and synchrony are nativists able to presuppose that they know the meaning, for the infant, of the behavior under study and conclude that they have refuted Piaget's model of the object concept (see an unpublished dissertation by Warbin (1995) for an empirical demonstration of the relevance of the particular "conceptual" issues raised by Fischer and Bidell for infant looking procedures).

Irrespective of the failure to adequately control for perceptual-level variables, Fischer and Bidell share with Rivera et al. (1999) in reminding us that Piaget's model (Piaget, 1954) of the object concept consisted of six developmental stages; as such, the findings from the drawbridge procedure are not inconsistent with his model at all. Infants in stage two of object permanence are already capable of expecting a disappearing object to reside at the location in which it vanished (Piaget, 1954 as cited in Rivera et al., 1999). Further, Haith, Hazan, and Goodman (1988) investigated the development of visual-perceptual expectancies of dynamic spatial-temporal events in 3.5-month-old infants and established that they are able to rapidly develop expectations of visual events that are independent of their own actions. So the obvious alternative interpretation of the preferential looking in the drawbridge procedure is that it represents an earlier stage of object development. Only by collapsing (implicitly and a priori) the six developmental stages into the end-state were nativists able to use their yes–no procedures to "reject" Piaget's model. That is, even ignoring all of the issues surrounding the intrinsic dynamics of the habituation process itself, Fischer and Bidell argue that the drawbridge procedure probably only requires that infants know that objects exist (stage 3) and while this information is necessary for object permanence, it is not synonymous with it.

More recently, Baillargeon (2008) has reviewed findings concerning object representation from a number of studies that all used the standard looking-time methodology. The overwhelming pattern to emerge from her review is that the violations (of various object properties) that infant's detect is extremely context dependent. That is, infants' sensitivity to various object properties (location, height, color, etc.) differs depending on the type of task being used (occlusion, containment, covering). For example:

> Although infants are surprised at 3.5 months to see a tall object become fully hidden behind a short *occluder*, they are not surprised to see a tall object become fully hidden inside a short *container* until 7.5 months, under a short *cover* until 12 months, and inside a short *tube* [emphases added] until 14 months (p. 5).

In certain respects, Baillargeon's account of these findings (Baillargeon, 2008; Baillargeon, Li, Luo, & Wang, 2006; Baillargeon, Li, Ng, & Wang, 2009) seems to be more of an empirical summary than an explanation of why the nature of infant's object representation is such that it would manifest the patterns of looking behavior that it does. However, this type of extreme context dependence is precisely what one would expect from Piaget's action-based model of object representation. One of the major virtues of an action-based approach is that it easily accommodates the partial object knowledge and extreme context dependence displayed by these "striking" decalages (more on this in Section 4).

2.2.4.2. Levels of object representation. Meltzoff and Moore (1998) argue for a variant of the preceding point made by Fischer and Bidell but in more detail. They differentiate between object representation, object identity, and object permanence. Their argument is essentially that young infants are able to represent objects before they are able to track the identity of objects, before they are able to "know" or "reason about" the permanence of objects and that "evidence" for the former has been conflated with evidence for the latter. Their ultimate conclusion is that infants are demonstrating the capacity for representational identity (that a representation of the once-visible object and its spatiotemporal parameters is maintained), not permanence, when they look longer during occlusion experiments. Meltzoff and Moore elegantly capture the issue concerning such conflation when they say, "*it is important not to collapse the distinction between the persistence of infant representations and infants' belief in the permanence of external objects*" (p. 215).

There is actually a deeper issue here that falls under a general class of errors in which a property of a representation is itself assumed to be a property of what is represented. For example, my representation of a dog presumably involves multiple bio-chemical properties of the brain, but those properties are not themselves part of the content of my representation of the dog. In the current situation, Meltzoff and Moore have argued that the property of persistence of the representation is assumed to be a property of what is represented and thus the conflation between object identity and object permanence.

Importantly, it is only from the perspective of an external observer that the apparent instantiation of some property of an epistemic system could be assumed to constitute knowledge of that property. Fischer and Bidell (1991) have referred to the external observer perspective with their use of the term adultocentrism: "if an adult looking at an infant's behavior sees it as implying a concept of number or a concept of object, the inference is made that the infant must be using the concept" (p. 210). For objects, these researchers assume that "because it is an object that the infant is seeing, therefore the infant must be seeing (it as) an object (Bickhard, in preparation)" and thus, the failure of nativists to conceptually differentiate levels of object knowledge. More generally, the failure to conceptually differentiate stages of knowledge and development is a direct consequence of assuming that the adult end-state is exhaustive of what it is to know the world (or rather, to possess the "essential" competence).

2.3. Number domain

In the domain of number, some of the most influential and controversial nativist claims have derived from Wynn's (1992, 1995) "*calculation procedure*". Although the present analysis implies that there are no fundamental presuppositional differences between nativist proposals across object and number domains, the debate surrounding the innateness of number knowledge is particularly valuable because the positions fracture in ways that are more numerous and visible than with studies concerning object knowledge. The general reason for this greater transparency is two-fold: first, numbers are inherently abstract whereas objects are concrete; and second, the age at which there is general consensus that children demonstrate unambiguous indications of numerical operations (i.e., addition and subtraction) occurs much later than for that of the full object concept. To put it in more general terms, understanding representation as an encoding correspondence relationship means that number knowledge (as inherently abstract) has nothing in the world to attach to; and second, innateness claims are more difficult to maintain when development is protracted into early childhood (i.e., there is too much opportunity for relevant experiences). Before elaborating on these two aspects, some of

the extant objections concerning strong innateness claims about numerical knowledge and reasoning will be discussed.

There are two relevant distinctions to be made with respect to number research. The first distinction is between studies that look at set size discrimination and those that look at more complex tasks (addition and subtraction – the current focus). The second distinction concerns two general classes of objections to the conclusions about numerical competence based on Wynn's calculation procedure (Wynn, 1992). The first group of objections (the current focus) consists of alternative perceptual-level interpretations while the second includes some recourse to perceptual preferences but these are understood from within a framework that already presupposes knowledge of the object concept.

2.3.1. Wynn's "calculation procedure"

In the canonical version (1992) of Wynn's task (1 + 1 = 1 or 2), infants first saw a single toy doll on stage followed by its occlusion, then a hand placed a second toy behind the occluding screen, the screen was then removed and there was either one toy (the impossible/violated outcome) or two toys (the possible/expected outcome). During test, outcomes with 1 or 2 dolls were alternated for a total of six trials across three blocks. Given the results from this procedure, Wynn (1995) concluded that: "Infants can mentally represent different numbers and have procedures for manipulating these numerical representations to obtain further numerical information" (p. 172).

2.3.2. Object enumeration alternatives to Wynn's calculation interpretation

Before examining the "strictly" perceptual processing interpretations of Wynn's results, consider the underlying rationale of the object-enumeration class of objections. These researchers (Feigenson, Carey, & Spelke, 2002; Simon, 1997; Uller, Carey, Huntley-Fenner, & Klatt, 1999; Xu & Carey, 1996) accept that the infant's longer looking is the result of a violated *conceptual* expectation, but deny that the nature of that expectation is based on number-specific information. For them, it is the violation of a conceptual expectation about the nature of physical objects that drives looking behavior: during the procedure infants create object representations for each doll and when there are fewer (or more) dolls in the current visual representation than "existed" in the infant's prior representation there is a violation, but it is based on a representation of objects not on numerical competencies per se. Notice that, in the context of number knowledge, this position highlights the same issue that was raised by Meltzoff and Moore regarding the potential conflation between the properties of a representation and the content of that representation. In the current situation this would be a conflation between the fact that *each* representation has the property of oneness with oneness being *represented*.

Along these lines, Simon (1997) points out that while the "infants' behavior is consistent with arithmetical operations based on cardinal representations of quantity, this does not mean that they possess the conceptual competence of number and arithmetic" (p. 351). This point is particularly relevant when there are other alternative possibilities that account for the number-like behavior without recourse to number-specific knowledge. To assume that number-like behavior *requires* number-specific knowledge is to preclude a developmental perspective that takes the emergence of knowledge seriously (i.e., an emergent constructivism).

Regardless of the specific concerns raised by object-enumeration critics, the basic logic and assumptions of Wynn's calculation interpretation are fundamentally no different than those of the object enumeration group itself: "since infants look longer at outcomes that violate their expectations, if they are anticipating the number of objects that should result [from the "addition" operation], they will look longer at the inconsistent outcomes than the consistent ones" (Wynn, 1995, p. 41). While for Wynn the expectation is about numbers (and their operations) per se and for the object enumeration group the expectation is about objects and their unexpected appearance/disappearance, both of these frameworks presuppose the *unitization* of the objects/events to be represented/counted.

However "entities" can be quantified in ways other than through the use of discrete unitization (Mix et al., 2002). When total quantity is presented all at once (visually), there are several continuous spatial cues (collectively called spatial extent) that are also available: surface area, volume, contour

length, and density. Again, when total quantity is presented sequentially (using audition or vision), there are other perceptual cues that co-vary with number: rate, duration, and rhythm.

2.3.3. Perceptual quantification of number

Clearfield and Mix (1999) have investigated whether the often confounded continuous variable of contour length could be responsible for looking preferences that have been taken as evidence for number knowledge. Two groups of infants were habituated to sets of squares of size two or three. During test each group saw alternating displays of either the same number of squares but with different total contour length or different numbers ($n \pm 1$) with the same total contour length. The critical finding was that infants looked significantly longer with changes in amount of contour length but not for changes in discrete number.

In a follow-up study, Clearfield and Mix (2001) replicated their earlier findings (Clearfield & Mix, 1999) and attempted to disentangle contour length from area. While it has been known for some time that when spatial extent is pitted directly against number, it is extent that determines infants looking behavior (Fantz & Fagan, 1975), the results from Clearfield and Mix suggest that infants at this age are not sensitive to number (as a concept) at all, provided that amount has been controlled across conditions. Although there are some other studies that have been more careful to control for spatial extent variables (Starkey & Cooper, 1980; Starkey, Spelke, & Gelman, 1990; Xu & Spelke, 2000), Mix et al. (2002) argued that these attempts did not fully rule out the possibility of infant's use of non-numerical cues.

Some of the strongest empirical evidence for the conclusion that infant looking behavior *must* be the result of number of entities per se, that inherently avoids spatial extent variables, are studies using event sets (Wynn, 1996). These studies involve event sequences that unfold over time (e.g., infants are habituated to a sequence of two or three jumps within a continuous stream of motion), and while spatial extent variables do not apply (it is the "number" of jumps that is manipulated), rate, duration and rhythm variables do. In fact, Mix et al. (2002) point out that despite prior research demonstrating that infants are sensitive to changes in rhythm, it was never considered as a variable of potential interest. Clearfield (2004) later demonstrated empirically that looking behavior in Wynn's (1996) task could be accounted for by amount of motion without utilizing enumeration processes.

2.3.4. Familiarization alternatives to Wynn's calculation interpretation

While many studies concerning infant's knowledge of number have been sensitive to the possibility that perceptual variables may be relevant, the calculation studies pioneered by Wynn (1992) were so much more abstract in their focus that the possibility of low-level perceptual aspects being responsible for the results was much less intuitive. Further, because the procedure itself does not attempt to induce a novelty preference via habituation, the potential impact of familiarization is left entirely unaddressed. However, having demonstrated the potential relevance of familiarization dynamics for object research, Cohen considered what possible influence that process could be having for number research (Cohen & Marks, 2002).

Cohen and Marks (2002) proposed that infant behavior in Wynn's addition and subtraction tasks could be the result of responding to perceptual familiarity rather than to conceptual novelty. In-principle, the basis of such a familiarity preference could be either the number of objects (discrete variable) or the overall quantity created by those objects (continuous variable). The authors point out that for both conditions in Wynn's task, infants are exposed more often to the incorrect/impossible result: for the addition task they receive more exposure to the single doll (incorrect result of $1+1$) and for the subtraction task they receive more exposure to the two dolls (incorrect result of $2-1$). Consequently, "the conditions would seem optimal for infants to look longer at the impossible event, not because it is impossible, but because it is more familiar" (p. 188).

To test whether infants were responding on the basis of conceptually rich computations or instead were displaying a perceptual-level familiarity preference, the authors included two additional displays during test. Specifically, infants saw 0 and 3 objects as well as the 1 and 2 objects typically presented. While the predictions from both perspectives are the same for outcomes with the standard 1 object versus 2 objects [less looking at 2 (correct/unfamiliar) compared with 1 (incorrect/familiar) for addition and the opposite for subtraction] they are exactly opposite for outcomes with 0 and 3 objects

thus enabling the possibility of *empirical differentiation* between the two interpretations. Specifically, on the arithmetic account, outcomes of 0 and 3 are equally as impossible ($1+1 \neq 0, 3$; $2-1 \neq 0, 3$) as outcomes of 1 for addition and 2 for subtraction (implying equally long looking at all three impossible conditions for either addition or subtraction). For the familiarity hypothesis, outcomes 0 and 3 are equally unfamiliar as outcomes of 1 for addition and 2 for subtraction respectively (implying equally *short* looking at all three unfamiliar conditions). The collective results from their study support a dual-process explanation in which a familiarity preference was superimposed on a preference for more items. Importantly, there was no support for an addition–subtraction plus more items hypothesis.

However, one of the standard rejoinders by nativist researchers is to reject problematic findings on the basis of procedural differences (Baillargeon, 2000; Wynn, 2002). Wynn (2002) suggests that there were two crucial problems with Cohen and Marks' study: failure to replicate fully her original results and procedural differences. Wynn suggests that the former demonstrates that the task used by Cohen and Marks is not tapping the same cognitive processes that are operating in her task and that such a failure is the result of the latter (changes to the procedure).

Interestingly, Wynn herself does not always obtain results consistent with her cognitively rich interpretation, even with very modest variations of the original procedure. For example, Wynn (1995) did not find a meaningful difference in looking time across "possible" and "impossible" test displays for the "$2+1$″ addition condition. Confusingly, Wynn accepts the significant difference found in the other (subtraction) condition ($3-1$) as evidence for the calculation interpretation but dismisses the relevance of the no-difference addition result: "Inferring the results of the addition in these experiments appears to be more difficult, for *some reason* [emphasis added], than inferring the results of the subtraction" (p. 49). Perhaps the confusion concerning such results is an artifact of assuming that the infant is calculating in the first place (for a detailed summary of conditions within different studies that did or did not conform to a calculation interpretation see Wakeley, Rivera, & Langer, 2000). The real tradeoff of trying to attribute contrary findings to small differences in procedure is that, to the extent that the subtle variations matter, the phenomena lose their generality (Cohen, 2002) and come to require all sorts of ad hoc caveats in order to maintain the rich conceptual interpretations.

Whether or not Cohen and Marks' findings (2002) pose a serious challenge to the calculation interpretation, their study has, at minimum, demonstrated the relevance of familiarization in number research. Following up on their lead, Clearfield and Westfahl (2006) have also investigated the potential role of familiarization/habituation in infant addition research; however, they have attempted to eliminate the possibility of nativist counter claims that procedural differences disqualify their criticisms. They accomplish this by using the same test display procedures as used by Wynn (1992). Consequently, the results of their first experiment replicated Wynn (1992) exactly[3] (i.e., for all three test blocks – in Cohen and Marks the replication was only for the first test block).

In experiment three infants were familiarized/habituated to either 1 or 2 dolls prior to the standard test display procedure. The results indicated that infant's looking behavior was driven by a novelty preference irrespective of the impossibility/possibility of the task. That is, they looked longer at the possible event if they were familiarized/habituated to 1 doll and longer at the impossible event if they were familiarized/habituated to 2 dolls. If taken in isolation, it could be argued that the novelty preference simply overpowered the violated expectancy of the impossible event; however, recall that it is standard in habituation studies to pair the (perceptually) novel test display with the possible event and nativists' conclusions require that the impossibility of the (perceptually) familiar event overcomes any (perceptual) novelty preference to produce longer looking to the (impossibility) violation. Regardless of the details, the power of this study is derivative from the fact that prior exposure to 1 or 2 dolls can determine infant's looking behavior to test displays irrespective of the "conceptual/numerical" content of the display. Indifference to conceptual content is precisely what one would expect if looking

[3] Technically, it cannot be determined if their replication was exact. As Wakeley et al. (2000) point out, in the original study, Wynn (1992) did not actually report the statistical differences in looking between correct and incorrect addition or correct and incorrect subtraction. Instead, Wynn compared differences in looking between correct and incorrect addition with differences in looking between correct and incorrect subtraction. In any event, the results of the statistical analysis were consistent with the rich cognitive interpretation that Wynn was attempting to demonstrate.

behavior in these situations is instead driven by perceptual-level processes. Finally, notice that the impact of this research is not limited to Wynn's numerical interpretation only, it is equally relevant for the "object enumeration" interpretation according to which these experiments involve the violation of object expectations. For both numerical and object interpretations, the outcome of the test display is impossible (despite having different ideas about the basis of that impossibility – number versus object) and it is the infants' knowledge of the impossibility aspect of this type of research that is being challenged.

2.3.5. Object nativists versus number nativists

While the previous study provides direct evidence against an impossibility interpretation of Wynn's calculation procedure (with respect to number or object), it only indirectly provides evidence that a familiarity preference was in fact driving behavior in the original task. The most direct evidence for what factor(s) was driving infant looking comes from a series of experiments conducted by Feigenson et al. (2002). These authors built on the earlier work from Clearfield and Mix (1999, 2001) to tease apart the confound between number and continuous extent variables (contour length and area) present in the calculation procedure. After replicating Wynn's original (1992) findings, Feigenson and co-authors proceeded to separate the number/extent confound by controlling for surface area such that total spatial extent was held constant across the numerically "impossible" outcomes and allowed to differ for the numerically "possible" outcomes. For example, in the 1 + 1 condition, one small doll was added to another small doll. At test, infants saw either one large doll (unexpected number – expected spatial extent) or two large dolls (expected number – unexpected spatial extent). Their results indicated that infants in Wynn's task are responding to changes in spatial extent and, importantly, they are not responding on the basis of a numerical expectation.

Consistent with other nativist attempts to reconcile perceptual-level findings in such a way as to be consistent with previous conceptually rich interpretations, Feigenson and co-authors suggest that infants are creating object-files for the objects that are involved and that the perceptual variables related to spatial extent are property information that is bound to the object-file. On this construal, what the current empirical results indicate is that infants *select* the property information rather than their complete object representations. However, they provide no additional reason for this explanation (i.e., why choose property information rather than the complete object representation) except that it is consistent with the empirical results. Part of the reason for such flexibility is that experimental nativist research tends to avoid sufficient specificity about terms like representation, knowledge, understanding, sensitivity, detection, discrimination, etc. such that there are few theoretical constraints on how to interpret empirical results (Fischer & Bidell, 1991). More broadly, their proposal is indicative of the power of any theoretically unconstrained research program to accommodate conflicting findings: if a rich interpretation is assumed to be true then virtually any empirical results from infant research can be construed in such a way that it will be consistent with that framework.

The empirical research on number illustrates even more strongly than for objects that the *idealization* required for preferential looking to succeed as a measure of *conceptual* knowledge may be a *practical* impossibility (Schöner & Thelen, 2006). Recall that the basic logic of the preferential looking paradigm (as used to probe conceptual knowledge) is supposed to be such that the only important differences between the two test conditions are with respect to the conceptual content of interest; however, the empirical results to the contrary demonstrate that, in many cases, the conceptual content was only from the observer perspective of the adult researcher.

2.4. Summary of Section 2

Our analysis and review of literature that is critical of nativist infant studies attempted to integrate previous findings in an effort to situate and give context to our broader theoretical critique of the nativist research programme. Whether or not the many experiments conducted by infant researchers within a nativist perspective failed to adequately control for perceptual-level alternatives is a historical issue. The further demonstration that in many cases perceptual-level processes can both account for and displace earlier nativist interpretations is an empirical issue. However, one of the central theses

of this article is that these "historical" and "empirical" issues are theoretically and programmatically motivated – and that that motivation needs to be fully explicated in order to establish a proper diagnosis and subsequently a complete transcendence of the ultimate limitations of this research. If valid, this critique would constitute a comprehensive and principled argument against any foundationalist approach (nativist or empiricist) while compelling an emergent constructivist, action-based developmental alternative.

3. Theoretical foundations of the nativist research program

The "empirical" displacement of Piagetian theory in developmental psychology was as much about the refutation of Piaget as it was about promoting a nativist framework. Three interrelated themes coalesced to defeat Piagetian theory as a mainstream position: (1) unfortunate misinterpretations of Piaget's account, in conjunction with (2) the competence–performance corollary of nativist arguments, that united with (3) the preferential looking methodology of developmental psychology. Together these themes squeezed Piaget's emergent-constructivism out of mainstream developmental theorizing leaving a nativist research programme as the primary benefactor.

There are three related, but distinct, layers of theoretical criticism that need to be addressed in order to fully appreciate the fundamental problems with the nativist research programme. The first of these concerns the competence–performance distinction and how it makes strong theoretical commitments while purporting to be a "common-sense" truth. The second concerns foundationalism (the assumption that knowledge *must* be built up from a representational base) and how it relates to the failure to adequately control for perceptual-level variables in infant research. Finally, the third theoretical criticism concerns the inadequacy of encoding models of representation, and the intrinsic conflation that they create between epistemic contact (detection) and epistemic content (representation). In Section 4, we conclude with a brief presentation of how action can provide an alternative framework to the foundationalism of nativist and empiricist approaches.

3.1. Layer 1 of the theoretical critique: the competence–performance distinction

The preferential looking paradigm had been used in previous decades to explore various facets of perception (Fantz, 1964; Fantz & Fagan, 1975; Hunter et al., 1983), but it was the "nativist turn" that helped to justify the exploration of infant's conceptual knowledge. With the research agenda set (eliminate performance factors to show competence 'X' as early as possible), most of the subsequent intellectual energy and creative insights concerned new *methods* for confirming the scope of what was innate (i.e., what competencies could be uncovered using more "sensitive" measures). Not only were there opportunities to demonstrate competencies earlier than predicted by Piagetian theory, but, also, the opportunity to explore the circumstances under which infants could and could not demonstrate their precocious abilities. The instrumental productivity of the looking-time methodology as a research tool was probably sufficient for subsequent generations of researchers to follow suit, but it was only able to reach such a pinnacle because of the conceptual resources provided by the competence–performance distinction and the consequent vacuum that was left by the absence of Piagetian theory.

3.1.1. Competence–performance: theoretical versus methodological distinction

A formal commitment to the competence–performance distinction is easily motivated by the casual observation that various abilities are not manifest under all circumstances. However, the shift from our intuitive grasp of competence to the standard distinction involves a crucial (but common) distortion of a basic methodological distinction [e.g. Wynn's (1997, p. 333) response to Sophian (1997)]. As a methodological distinction, controlling for extraneous factors that influence task performance is intuitive and perfectly acceptable, but as a theoretical distinction competence–performance is in error (Campbell & Bickhard, 1986). What is considered extraneous is always relative to a specific hypothesis and as such does not become theoretically uninteresting in general. Different researchers have considered memory, attention, means-ends coordination, language, etc. as 'performance'

factors; but surely other researchers are justified in taking these variables as a 'competence' of primary interest (Thelen & Smith, 1994).

In a similar vein, Lefebvre-Pinard and Pinard (1985) have suggested that the inherent ambiguity of whether some factor is ontologically in the competence class or in the performance class is the primary problem with the distinction and indicative of the more traditional problem that they reference as the Cartesian dilemma: the problem of knowing in what way the *use* of a concept is integral to the *having* of that concept. The possibility that use may *constitute* knowing is precluded by frameworks that presuppose a competence–performance distinction. For example, a methodological version of the competence–performance distinction, a version that is a consequence of the underlying information-processing framework (and the version that forms the basis of using looking methodologies to explore infant cognition), is the assumption that action is not relevant to the ontology of cognition. Instead, action is understood as the output of processes that *make use* of cognition. Consequently, if action considerations are not relevant to cognition per se, then action incompetencies are just performance issues relative to cognition and cognitive development. In contrast, from within the Piagetian framework knowledge was intrinsically related to use and accordingly Piaget explicitly rejected the competence–performance distinction because "logical form and physical content are inseparable" (as cited in Lourenco & Machado, 1996, p. 149).

The more fundamental problem with the competence–performance distinction derives from problems inherent to the ontology of competence models in general and Chomsky's (1965) model in particular (Campbell & Bickhard, 1986). It is not so much that competence models need to be able to change with development (Sophian, 1997) as that they commit to a fundamental epistemological error in which they conflate and confuse systematic *descriptions* of possible task performances with *explanations* of how those tasks are accomplished. Competence models are descriptive accounts of the classifications of possible human performances.

Capacity descriptions, if correct, (i.e., if they correctly classify possible performances), provide an important constraint on subsequent theorizing in the sense that any proposed explanation must be able to account for the set of possible performances. However, it is incorrect to assume that capacity descriptions *explain* how the performances that they classify are accomplished. This reification of capacity descriptions into explanation (in terms of internal structures) is especially tempting when considering domains with near infinite possibilities because an adequate description must itself employ generative rules (as is the case for language) and the application of these rules – as internalized structures – can then seem to imply "mental processing".

In sum, the competence–performance distinction is an ill-founded theoretical assumption that flourishes under the guise of being a methodological issue. Competence models do not explain anything about the cognitive processes that take place during performance, and, within the context of the information-processing framework, the competence–performance distinction dismisses the possibility that action could be intrinsic to cognition.

3.2. Layer 2 of the theoretical critique: foundationalism

Both nativism and empiricism assume that representations are built on and out of some foundational base. They differ in terms of their assumptions concerning the origins and nature of that base. The nativist uses arguments about the limits of learning to motivate the need for innate machinery that is either domain or content specific, while the empiricist looks more openly at the structure available in world and argues that domain/content invariant learning mechanisms are sufficient for its acquisition. Contrary to some of the rhetoric, contemporary nativists and empiricists both acknowledge the need to assume that some representational structure is innate; where they differ is in terms of the *type* and *amount* of that structure. Therefore the crucial question for researchers is taken to be: how *much* and what *kind* of innate representational structure is required to account for learning and development within a given domain? Alternatively, how rich does the representational base need to be in order to account for the learning and development of a given domain of knowledge?

Framing the debate in terms of the amount and type of innate representational knowledge is useful because it provides a context in which we can situate actual positions in the field. For example, we

might get a position that proposes a large number of innate concepts ('Mad dog' nativism – Fodor, 1975); alternatively, we might get a position that proposes only a few innate concepts (philosophical empiricism – Cowie, 1999); some positions might propose innate feature representations (developmental empiricism – Mandler, 2000; Quinn & Eimas, 2000); while others suggest that a few core principles are innate (developmental nativism – Chomsky, 1965; Spelke et al., 1992; Gallistel & Gelman, 1992); finally, we could have a couple of rudimentary innate theories (starting-state nativism – Gopnik, 2003; Wellman, 1990); or else, some very elaborate/specific innate theories (modular nativism – Leslie, 1987; Baron-Cohen, 1997).

Set within this context, contemporary nativist and empiricist positions are understood to differ with respect to the "richness" of the innate representational base that they presuppose (Carey, 2009; Keil, 1998; Fodor, 1981, 1998; Simpson, 2005; Spelke & Newport, 1998). That is, the debate between nativists and empiricists is going to center on how much of development is given in the innate representational base and how much is the product of learning. Empiricists typically want to presuppose as little initial representational structure as possible in their account of mind, hence the general learning mechanisms; while nativists take seriously the principled arguments for why such a paucity of structure is inadequate and subsequently propose a much richer set of innate structures and "learning" mechanisms.

From a foundationalist perspective, the canonical contemporary empiricist developmental psychologist is best characterized as being a "feature nativist" (Mandler, 2000; Quinn & Eimas, 2000). These researchers presuppose a base of innate representational *features* in contrast to a base of representational *concepts* and so they differ from "concept nativists" in terms of the nature of what is in the base. While particular empiricist positions in the field are going to involve varying degrees of specificity in terms of the learning mechanisms that they invoke, as well as differences in the amount and type of representational structure that is assumed to be innate; the crucial point, is that for *any* empiricist approach the foundational base is going to be representational. The most extreme versions of empiricism (that presuppose the least representational structure in their foundational base – e.g., color patches, etc.) undisputedly failed to account for the learning and development of knowledge. More contemporary versions of empiricism have involved a ratcheting up of the presupposed representational structure (e.g., features, objects, relations, hypotheses, etc.) needed to explain how learning can account for what we know: without an account of emergent representation, there must be some version of foundationalism involved, and which version, or what kind of version, constitutes the debate between nativism and empiricism.

That both nativism and empiricism presuppose a representational base in their attempts to account for the origins and development of knowledge means that both are committed to foundationalism. It will be argued next that foundationalism constitutes the fundamental error concerning our attempts to understand the developing mind: in particular, if a foundational base must be assumed, then there is no possibility of accounting for the emergence – for the origins – of that base.

3.2.1. Emergence as a theoretical constraint

Foundationalism does not provide an account of itself. That is, presupposing a representational base does not provide an explanation for the origins of that base – thus the need for it to be presupposed. The *necessity* of a representational base to account for representational knowledge and development (in general) means that the fundamental problem for any foundationalism is emergence: if representational knowledge is *required* to account for the learning and development of "new" representational knowledge, then such knowledge could not have emerged out of something that is non-representational. In that case, representation could not emerge in cosmology, phylogeny, or ontogeny, and, therefore representation could not exist. Of course representation does exist and therefore any model of representation that cannot account for its own emergence must be incorrect.

Standard notions of representation require foundationalism because their own emergence cannot be accounted for, in-principle (Fodor, 1975; Bickhard, 1991; Bickhard & Terveen, 1995): just as the Empedoclean foundational substances earth, air, fire, and water did not account for their own emergence (nor the emergence of any new substances), foundationalism about representational knowledge is equally contrary to an emergentist perspective. Further, foundationalism buttresses

positions against any consideration of emergent complexities a priori – if knowledge already exists, then there is no need to consider the processes involved in the emergence of knowledge at that level. This general point is highlighted by the criticism that nativist positions do not take the complexity of development seriously (See Spencer et al., 2009).

For foundationalist approaches, knowledge beyond the level of the representational base is, of course, still acknowledged, but the nature of the learning processes responsible for that knowledge is severely constrained by the intrinsic need for foundationalism (Allen & Bickhard, 2011a). In particular, learning is restricted to constructions[4] (including associations) amongst the already available foundational elements that can, at best, be used to explore the combinatoric spaces [of the foundational 'atoms'] involved. Exploration of these spaces can be recursive in the sense that old constructions can be used for new learning, but there is no possibility of constructive processes that generate emergent representation. That is, there is no possibility of an *emergent constructivism* in which fundamentally new knowledge is learned – knowledge that lies outside the combinatorial space that is based on the presumed innate representational atoms.

The sense in which foundationalism has systematically motivated ignoring perceptual-level variables in nativist infant research now becomes clear. If foundationalism precludes emergent constructivist possibilities a priori, then it also precludes the need to control for alternative constructivist interpretations of experimental results. In infant research, the failure to control for constructivist alternatives manifests itself as a failure to consider perceptual aspects precisely because perception is taken to be the simple evocation (e.g., sensory transductions) of innate conceptual contents with no methodologically relevant complexities; thus the lack of perceptual-level controls. Here then is an intrinsic link between foundationalism and the lack of adequate perceptual controls found in nativist experimental research as well as an explanation for the adultocentric assumption that, if it is an object the infant is *looking at*, then it is an object that the infant is *seeing*. Interestingly, Ratcliffe (2007) raises a similar general concern in the domain of folk psychology: "The assumption that adults understand each other by attributing internal propositional attitudes was written into these studies [Theory of Mind studies] from the start. It motivates them, influences their experimental design and operates as a framework for the interpretation of the results" (p. 55).

3.2.2. Foundationalism applies equally to empiricism as to nativism

If foundationalism applies equally to nativism and empiricism, then why do they disagree about the status of infant studies? While nativism and empiricism both accept the perception–conception distinction, they differ concerning whether or not concepts can be (combinatorially) constructed out of percepts. Further, the partial convergence between developmental empiricists (i.e., feature nativists) and emergent constructivists (i.e., anti-foundationalists) is a consequence of the fact that, for both, perceptual-level aspects are considered directly relevant to the infant's epistemic contact with the world: for the empiricist, *input* from the world is in terms of perceptual features; for the emergent constructivist, *contact* with the world is in terms of detections or differentiations (but not necessarily representations) of those perceptual features. It is important to note that not all contact is perceptual. Contact will be present in the course of *any* interaction but only some of those will be (primarily) for perceptual purposes. Thus, an emergent constructivist position may converge with empiricist positions in their criticism that nativist infant researchers failed to adequately control for perceptual aspects, but they do not share with empiricists their commitment to foundationalism.

3.2.3. Summary

The specific methodological and conceptual problems with nativist research discussed above constitute one particular (contemporary) manifestation of developmental nativism's commitment to foundationalism and while empiricists may disagree with nativists in the context of infant research, they do not themselves consider or resolve any of the general problems with the need to presuppose an innate representational base of some sort – i.e., foundationalism.

[4] Constructions can be understood broadly as new internal organizations that are available for future system functioning.

3.2.4. Unexplained innate foundations: previous criticisms from the literature

The problem of emergence can be understood as forming the basis for some of the major concerns (from empiricists, dynamicists and generally systems oriented researchers) regarding nativist proposals in the developmental psychology literature. For example, the suggestion that innateness claims are "vacuous" or "empty" because they do not provide any insight into the complex prior interactions that must have taken place to give rise to development (Elman et al., 1996; Spencer et al., 2009; Johnston, 2001); or, more broadly, that a developmental perspective regarding learning is essential for a proper characterization of the nature of the knowledge that is learned (Fischer & Bidell, 1991; Elman et al., 1996). The emergent constructivist perspective of the current analysis attempts to strengthen these prior concerns by pointing out that: first, current notions of the *nature* of representation require foundationalism precisely because they cannot account for representational emergence (in-principle); and second, that the only known framework able to account for the emergence of representation is an action-based framework in which the *nature* of representation looks very different.

The standard rejoinder to concerns that nativist positions are empty and or non-developmental is that evolution/biology is not part of developmental psychology and so accounting for the presupposed foundation need not concern us as psychologists (Fodor, 1980, 1981; Samuels, 2002; Spelke et al., 1992). Samuels (2002) has actually argued that innateness claims are claims that such and such should be considered *primitive* with respect to the domain in which the claim is being made. And while an explanation of a *primitive's* acquisition is possible, it is not for the scholar of that domain to determine. That is, psychology need not explain its own primitives: that is (by definition) the job of another science. The more specific variant of this argument found in the developmental psychology literature tends to be that because all theories must characterize a starting state as well as the developmental processes that transform that starting state into mature form, nativism is no more empty than any other theory (Carey, 2009; Spelke & Newport, 1998).

The general problem with this stance is two-fold. First, a genuinely developmental perspective presupposes that our understanding of how something is acquired can importantly influence our assumptions about its ontology (nature), so adopting a nativist stance would seem contrary to the spirit of the developmental perspective: it would seem to reject the relevance of understanding *origins* as central to understanding *ontology* (at least with respect to the innate starting state). Further, the subsequent attempt to model the origins of new knowledge acquired after the innate starting state (i.e., learning) will be highly constrained given the original decision not to account for the origins of the starting state. That is, the presumed nature of representation will constrain the possibilities for what might constitute learning and development (Allen & Bickhard, 2011a).

The second problem with the standard rejoinder that innateness claims form the explanatory boundaries of psychology concerns in-principle arguments against the *possibility* of being able to account for the origins of those boundaries (Bickhard, 1991). For example, Fodor's argument against learnability (i.e., that we cannot learn any basic concepts) is a logical issue (not empirical) concerning the nature of learning processes, namely, that learning processes logically require prior representation. Yet, there has been no argument concerning why the evolutionary processes of variation and selection are relevantly different from those that are involved in learning. What is it about evolutionary processes such that they are capable of accounting for knowledge that is not possible, in-principle, for learning and development to explain? Conversely, on the assumption that evolution is able to account for the emergence of representational content (as the nativist *must* assume to be the case), there is no reason to suppose that the processes involved in learning and development would not also able to account for such emergent content (i.e., if evolution can do it, then why not learning and development?).

What Fodor's argument has really demonstrated is that, if the generation of "new" representations is restricted to combinations of those that are already available, then the natural emergence of representation is not possible at all; the foundational representational base must already exist in order for any "new" representations to be constructed in *development* or in *evolution*. Consequently, if no naturally emergent origins are possible, then the nature of representational content and learning (how they are characterized) must be different than what we have assumed them to be (Bickhard, 1991). That Fodor's argument is actually a reductio ad absurdum for some of our assumptions about

the nature of knowledge and learning was acknowledged by Fodor during the 1975 debate between Piaget and Chomsky (Chomsky & Fodor, 1980).

> . . . I am inclined to think that the argument has to be wrong, that a nativism pushed to that point becomes unsupportable, that something important must have been left aside. What I think it shows is really not so much an a priori argument for nativism as that there must be some notion of learning that is *so incredibly different* [emphasis added] from the one we have imagined that we don't even know what it would be like as things now stand. (p. 269)

3.2.5. The origin of concepts: an incredibly different notion of learning?

Carey (2009) has recently proposed a notion of learning that claims to resolve the issue of how "new" representations are possible (given old representations and language). However, to the extent that this notion of learning suffices as an account of new representation, it equally undermines any arguments for the *necessity* of a nativist position (Allen & Bickhard, 2011b).

Carey's brilliantly constructed case for the nativist perspective, while not in full agreement with other nativists, has provided a comprehensive and coherent discussion of the empirical and theoretical work that is used by researchers to support nativist conclusions. One of the major breaks with other nativists concerns the issue of whether qualitatively new knowledge is possible. Through a process of "Quinian bootstrapping", language capable children (and adults) are argued to be able to learn qualitatively new representations that may be more powerful than, and sometimes even incommensurable with, the representational resources from which they were built.

However, Carey's broader defense of nativism is only as good as the alternative kinds of perspectives considered and those are limited by her own underlying conceptual framework. That framework is, we argue, false and misguiding, and leads, among other consequences, to serious misinterpretations of Piaget. Most fundamentally it renders as inconceivable the modeling possibility that we argue holds the most promise. Piaget's theory is an example of this kind of model: a model of emergently constructivist cognitive development. Further, the misinterpretations of Piaget in Carey's account (e.g., that Piaget's model is based on sensori-motor *representations*) follow inevitably from the limitations of her conceptual framework.

Carey's conceptual framework assumes that a theory of cognitive development *must* specify "the innate representational primitives that get learning off the ground", and further, that characterizing those "innate representational primitives" is an empirical question. However, both of these claims are problematic. Framing the discussion in terms of "representational primitives" is already, fundamentally, from within a *foundationalist* perspective that does not consider the possibility that representation could be emergent from action. Consequently, any "empirical" characterization of the presumed primitives is itself a "theoretical" characterization as well – the alleged "empirical characterization" is not itself theoretically neutral. Thus, the limitations in research methodology and the over-interpretations of data (as discussed in Section 2) find much of their origins in an underlying "theoretical" commitment to foundationalism.

In sum, contemporary debates regarding the nature of "innate representational primitives" take place within a context that is already committed to fundamentally problematic assumptions about the nature of representation, learning, and development.

3.3. Layer 3 of the theoretical critique: representation

The overall focus in the last sub-section (layer 2) has been with respect to the contrast between foundationalism and emergence; however, these issues draw from broader arguments against notions of representation as fundamentally constituted by encodings. Encoding models of representation have numerous conceptual problems (Bickhard, 2009b; Bickhard & Terveen, 1995) but it is their inherent conflation between epistemic *contact* (detection) and epistemic *content* (representation) that forms the primary focus for our final layer of theoretical critique and illustrates the sense in which empiricist positions recommit to new versions of the same underlying problem. However, before discussing these issues we begin with a brief discussion of encodingism.

3.3.1. Encodingism

Encodingism is the assumption that foundational representations are encodings (Bickhard & Terveen, 1995). Encodings are representational stand-ins that possess an epistemic connection with what they represent. However, they possess such connections, as well as their contents, only in so far as some epistemic agent is present to provide those connections to them. That is, an encoding requires an epistemic agent to provide both its content as well as its connection (in the world) to what it is taken to represent. A canonical example of a conventional encoding relationship is the Morse code correspondence relationship (e.g., "..." stands-in-for 's'). Morse code is useful because dots and dashes can be sent across telegraph lines while characters cannot, but in all cases the encoding relationship requires an epistemic agent to provide the representational content to the characters (e.g., 's'), the pattern of dots and dashes (e.g., "..."), and the stand-in relationship between them (e.g., "..." means 's'). "In other words, encodings change the *form* of representations, but borrow the *content* from elsewhere, which entails that, in order for encodings to have content, that content must already be available elsewhere" (Bickhard, 2009b, p. 18). Although Morse code is conventional, the same point applies for naturally occurring correspondence relationships (informational, nomological, etc.) as well. For example, the encoding relationship between the number of rings on a tree and its age holds only in so far as someone already knows about rings inside trees, annual changes in the growth of trees, and the informational relationship between the two. Technical – covariational – informational relationships are factual relationships in the world, but they require interpretation in order to constitute representational relationships.

The need for encodings to have their content supplied to them from an external epistemic agent (an interpreter) is one implication of Piaget's copy theory argument. Piaget argued that our knowledge of the world could not be understood as somehow a copy of it because one would need to already have knowledge of the original (the world) in order to make the copy; however, knowledge of the original is exactly the same problem all over again (Müller, Carpendale, & Smith, 2009). The need for encodings to be interpreted introduces a regress (of interpreters) into any attempted account of the origins of representational content. To avoid an *infinite* regress, foundationalism is necessary to halt the borrowing of content. That is, the need of encodings to borrow their content is supposed to ground out in a foundational base. Thus, one of the fatal problems for encoding models of representation is their inability to account for the emergence of that foundational base (i.e., foundationalism). In short, encodingism requires foundationalism because it precludes the possibility of emergent representation.

Notice that Fodor's nativist conclusion is itself a response to the learnability problems faced by an encodingist construal of representation. Fodor's argument turned on the idea that models of learning do not account for the generation of new representations but rather apply only to the confirmation/disconfirmation of already-present representations. What Bickhard's encodingism critique demonstrates is that Fodor's innateness conclusions (his foundationalism) follow from a characterization of representation that itself already precludes the emergence of representational content altogether (i.e., encodingism logically entails foundationalism). In the explicit context of the encodingism critique it becomes clear why Fodor's nativism (*nor any* foundationalism) does not avoid the *logical* error concerning emergence of representational content – encodingism inherently precludes such emergence.

The problems with encoding notions of representation are ubiquitous and labyrinthian and there have been many reactions and responses to various aspects of encoding assumptions depending on what exactly is taken to be the problem. In that sense, our approach is in convergence with these reactions but important differences remain (i.e., some version of foundationalism and encodingism). In the next sub-section we will consider three related responses to some of the problems of encodingism: (1) detection versus representation; (2) development of graded representations; and, (3) rejection of representation.

3.3.2. Detection versus representation: Haith and Benson's challenge to developmental psychology

A major aspect of Haith and Benson's (1998; Haith, 1998) critical stance toward nativist research turned on their recognition of problems that derive from failing to distinguish between detecting some environmental conditions and representing those conditions. For example, most psychologists

will accept that a thermostat's sensitivity to temperature constitutes an ability to detect differences (between above-set-point temperatures and below-set-point temperatures) but that the thermostat does not have representational knowledge regarding what those detections are about – temperature. That is, despite the thermostat's sensitivity to temperature there is no representational knowledge involved.

With respect to infant research, the conflation between detection and representation strongly motivates a nativist interpretation of experimental results. The fact that infant's looking behavior systematically differs between test displays indicates that they have detected *some* difference. Given that standard encoding models of representation conflate detection with knowledge of what those detections are about (i.e., correspondence constitutes representation), nativist conclusions that infants have representational knowledge regarding the content of what they detect follow naturally (i.e., they are looking at an object, therefore they see it as an object).

Although empiricist researchers have made great strides to address some of the problematic aspects of the nativist conflation between detection and representation (Mandler, 2004, 2000; Haith & Benson, 1998; Haith, 1998), there has been no resolution to the problem of emergence because empiricism also involves a commitment to encoding notions of representation (thus the need to also be foundationalist); and therefore, ultimately, to a (re-) commitment of different aspects of the "same" conflation between detection and representation. One methodological manifestation of this "same" conflation present in empiricist proposals concerns categorization research in particular (Mandler, 2000; Quinn & Eimas, 2000). The (false) assumption that detection of *abstract* categories requires conceptual knowledge of those categories is derivative from the assumption that detection or sensitivity to the world is with respect to *particular* things (as must be the case if representation is constituted by correspondence – i.e., encodingism). However, the ability to detect – to differentiate – aspects of the world is inherently abstract and to assume otherwise is to conflate detection with representation (Bickhard & Terveen, 1995).

Reznick (2000) explicitly illustrates how this conflation adversely impacts categorization research – how detection of some *abstract* category does not constitute an understanding of the conceptual basis for it:

> As a *reductio ad absurdum*, consider the category of things that causes a particular infant to develop an allergic rash or to smile. The infant responds similarly to all members of the category, there is no visual feature that category exemplars share, and the infant can emit this behavior without any cognizance whatsoever about the intension of the category. (p. 64)

This example highlights the importance of distinguishing between detection and representation (i.e., that sensitivity to or detection of a category does not constitute knowledge of the category) but it also illustrates the relevance of the infant as an *embodied* agent. The "category" is as much about the nature or properties of the infant as it is about the world because it is constituted by the nature of their potential interactions. The use of the category "allergic rash" or "smile" is a powerful counterexample for standard interpretations because the exemplars do not share any "perceptual" properties, therefore the established equivalence of category members must involve the infant's interactions with those members – the infant must be co-constitutive of the category. For example, "things I can see from my crib", "objects that can be rolled", "objects that bounce, fit in the hand", etc.

In sum, Reznick's discussion highlights one of the interpretive problems with categorization research (that established equivalences are inherently abstract and do not require knowing what the equivalence is about) that is an instance of the more general conflation between detection and representation intrinsic to encoding models of representation. Further, Reznick's example forces an appreciation of the fundamentally interactive nature of category meaning (that the mechanisms for established equivalence concern the nature of the infant as much as they do the nature of the world) that is fundamentally true for all representation and knowledge (Bickhard, 2009b; Bickhard & Terveen, 1995).

As a remedy to the nativist conflation between detection and representation, Haith (1998) suggests a distinction be made between representation as "sensory encoding" (when energy undergoes a transformation) and representation as "symbolic representation" (images or schemas used to make

inferences and create beliefs). On the basis of this distinction Haith suggests that the relevant question for infant researchers to ask is: when are they dealing with sensory encodings following occlusion events versus symbolic representations recovered from memory involving potential manipulation. Although we differ from Haith on how to remedy the conflation between detection and representation, his conclusion that confusion regarding the concept of representation is at the center of many of the issues concerning infant cognition seems exactly right.

> Now that we recognize that even fetuses "do it" [undergo energy transformations], the need for a full-scale developmental model of representation that incorporates the notion of partial accomplishment is obvious. We cannot get by with a single term whose meaning spans the full distance from energy transformations in the CNS to mental manipulations of symbols. (Haith, 1998, p. 175)

The relevant question for Haith is two-fold: (1) which form(s) of representation do infant studies reveal? And (2) what does a graded account of representation underlying partial accomplishments look like? The discussion up to this point has attempted to provide a conclusive response to the first question with the answer involving perceptual-level "representations". The second has yet to be addressed directly and will be used to illustrate explicitly the sense in which, despite making great progress, connectionist approaches to development are still committed to aspects of encodingism and some version of foundationalism.

3.3.3. *Development of graded representations: abilities appear gradually*

There are many authors who have pointed out that theories of development must account for the fact that children's abilities appear gradually over time. However, it is important to keep in mind the distinctions made by Keil (1981) regarding the different possibilities that could produce such gradual "development". Keil argues that there are at least three logical possibilities, however the current discussion need only consider two of them: first, the fully mature competence/representation/knowledge is present from an early stage and development is primarily a process that involves increasing access. Increasing access is itself cashed out in terms of *ancillary deficits* involving general processing abilities (e.g., performance memory, means-end ability, inhibitory control, etc.). Second, the competence/representation/knowledge itself undergoes non-maturational transitions resulting in partial forms. These partial forms are themselves "complete" in that they fully enable certain interactive possibilities but are talked about as partial because they still preclude other possibilities that are considered part of the adult form.

Part of the reason that nativist proposals are explicitly (or implicitly) advocating the all-or-none presence of various competencies is precisely because they presuppose the non-developmental-increasing-access possibility mentioned above. Without a developmental account of partial forms there is no possibility except complete absence or complete presence of the competency per se. Further, Aslin and Fiser (2005) point out that the looking-time methodology used in most nativist research is itself constrained to providing "a Yes–No answer to a given research question" (p. 92). This does not mean that genuinely developmental questions cannot be asked in-principle, but that the methodology employed lends itself to a construal of knowledge that is also all-or-none (present or absent).

In summary, the above difficulties do not mean that nativist positions have to deny the gradual "development" of children's ability to interact competently; however, it does mean that they are committed to an all-or-none stance on whatever specific competency they are "testing" to be innate. This commitment is ultimately a consequence of the deeper assumption regarding foundationalism. A genuinely developmental account explains the emergence of forms, which is precisely what foundationalism precludes.

3.3.4. *The adaptive process account (APA)*

With respect to graded representations of objects, the meaningful divergence between nativists and others is whether the object concept can *itself* have partial forms – not just partial expression.

Munakata and her colleagues (Munakata, 2001; Munakata, McClelland, Johnson, & Siegler, 1997) have attempted to reconcile some of the seemingly contradictory findings that have emerged from the infant literature with their notion of graded representation. They have looked at situations in which "Two tasks supposedly tap the same knowledge, but the same infants succeed on one and fail the other ... [asking specifically] Why do infants fail to retrieve hidden objects until 8 months and even then show the A∼B error, if they have a concept of object permanence many months earlier?" (Munakata et al., 1997, p. 686). After demonstrating that the standard means-ends deficit account of children's failure to retrieve hidden objects is not sufficient, they proceeded to explain the looking-reaching task dissociation (i.e., infants show signs of object knowledge for looking but not for reaching tasks) in terms of their Adaptive Process Account (APA). The central idea of this approach is that representations are graded in nature and it is this property that explains the task dissociations. Specifically, representations become stronger throughout development and it is the strengthening of these representations that enables the infant to perform competently on some tasks but not on others. For example, a weak representation of a hidden object may enable infants to succeed on various looking time procedures, while still not being sufficiently strong for them to succeed on procedures that require them to reach for an object (due to the increased complexity required for reaching).

Using and implementing the notion of graded representation to reconcile the apparent conflict between different measures of infant competence is both provocative and insightful. The authors' proposal is explicitly contrasted with what they call principle-based approaches (competence models) in which "knowledge takes the form of principles that function like propositions: that is, the principles are construed as generally accessible inputs to a reasoning system" (Munakata et al., 1997, p. 687). Convergent with our earlier discussion of Campbell and Bickhard (1986), they go on to suggest that, while the use of these principles as a description of behavior might be potentially useful, the danger of such an approach "... is the tendency to accept these descriptions of behavior as mental entities that are explicitly accessed and used in the production of behavior [i.e., conflating description with explanation]" (p. 687).

In response to these concerns, the authors offer an alternative conceptualization of knowledge that serves as the epistemic foundation for their account. Broadly speaking, this alternative conceptualization has affinities with an action-based approach. In particular the authors talk about knowledge as "evolving", "experience-based", "embodied" and guided by learned "representations". Further, their general claim that representations themselves develop and that such development enables differential interactive possibilities (sucking, looking, reaching, etc.) flirts with the core of an (inter)action-based approach. However, we suggest that the account inherits problems from its commitment to the parallel distributed processing approach that is itself set within the broader information-processing framework.

3.3.4.1. The connectionist model. The APA approach to representation can be characterized as a connectionist variant of Sokolov's (1963) notion of "completing the representation" (Bogartz et al., 1997). Recall there, that the completeness of the representation was used to explain why infants show the familiarity and novelty preferences that they do. Recall also that Schöner and Thelen (2006) raised a number of concerns regarding the very idea of 'completing a representation,' most importantly, complete relative to what? The obvious answer was the world; but that was the problem of representation all over again. Despite the time difference (perceptual time versus developmental time) notice the general parallel with the APA: weak (incomplete) representations result in looking behaviors while strong (complete) representations result in reaching behaviors. The APA is superior to the general notion of 'completing a representation' in that it attempts to provide an explicit and detailed explanation of what strong and weak representations could possibly mean as well as the mechanism for why they develop in that way. However, while connectionism is thought to have overcome the representational limitations of discrete homuncular symbols through its notion, and implementation, of distributed representations, it does not transcend the basic representational issues concerning representational content and is thus, in this regard, no better off than other information-processing models (Bickhard & Terveen, 1995).

3.3.4.2. Distributed representations are still encodings. Distributed representations are constituted by activation vectors that correspond to aspects of the world. They can be trained to "extract"[5] information (correlational correspondences) that may in fact be present in the environment (i.e., the input patterns) but their purported knowledge of what those correlations are about is necessarily from the perspective of an epistemic agent who can already interpret the correspondence relationship. That is, connectionist networks are committed to an encodingist model of representation (Bickhard & Terveen, 1995). They differ from the classic symbols of "Good Old Fashion Artificial Intelligence" (GOFAI) in that classes of input patterns can be *trained* to settle into the same output pattern which then enables them to *generalize* to novel inputs (Rumelhart & Mclelland, 1986; Seidenberg & McClelland, 1989; Plaut, McClelland, Seidenberg, & Patterson, 1996); however, the meaningfulness of any such categorization depends entirely on an external observer (both so that training results in the "correct" classification and also so that those correspondences are contentful). Connectionist networks are trained transducers that learn to differentiate classes of environments and are typically passive and non-interactive (Bickhard, 2001). To assume that connectionist networks represent what they differentiate is precisely to conflate detection with representation.

The graded representational aspect of the APA is fundamentally constrained by its commitment to the broader connectionist framework and that framework's inability to provide an adequate (non-foundationalist) model of representational content. The degree of differentiation of the input classes may occur gradually over time with increased robustness to noise, but that does not constitute a *graded representational* ontology. Further, despite the generally action-based attitude regarding the relevance of embodiment, PDP networks are typically non-interactive, passive systems that "have yet to fully meet the challenge of taking development seriously" (Elman, 2005, p. 114). Crucially, they do not consider the possibility that action is essential and intrinsic to the ontology of representation itself and thus have few theoretical resources available to explore an emergent constructivist developmental perspective.

In sum, the APA constitutes a comprehensive and coherent alternative framework for interpreting the seemingly contradictory results regarding different measures of object permanence (i.e., looking versus reaching). It is, in part, a reaction to the principle-based (broadly nativist) approach and its attempt to use the ancillary-deficit-hypothesis to reconcile the conflicting results from these measures. More deeply, the APA is also a reaction to the characterization of knowledge that was argued to underlie principle-based proposals. In contrast, the APA attempted to take seriously the idea that knowledge itself develops gradually over time but, as with any non-nativist proposal, it must ultimately answer the question of where representational content comes from throughout development. That is, rejecting nativist positions still requires some account of the source and development of representational knowledge.

3.3.5. Rejection of representation: dynamic systems theory dismisses the debate

Dynamic systems theory (DST – Port & van Gelder, 1995; Thelen & Smith, 1994) was a historically parallel reaction to the empty symbols of GOFAI (though one that was slower than connectionism to gain momentum) and has been characterized by Clark (2001) as the third revolution in cognitive science (connectionism being the second). Dynamicism can be understood as rejecting the entire space in which the nativist–empiricist debate takes place by denying the need to consider representation (as discrete symbol) altogether (see Brooks, 1991 for similar rejection of representation in the field of robotics). For the dynamicist, it is not so much that the debate is misguided or even incoherently characterized; rather the debate is irrelevant. Understanding cognition does not require the notion of representation at all: "From a broadly dynamical perspective, cognition is seen as the emergent outcome of the ongoing interaction of sets of coupled quantitative variables rather than as sequential discrete transformations from one data structure to another" (p. 12, van Gelder, 1999).

[5] "Extract"is in scare quotes because the experimenter has already done much of the epistemic work required by an actual system, in the actual world in order for the input to be as it is. That is, networks often extract correlated regularities from input classes that have already been structured by the experimenter as though that structure is trivially present in the environment. This assumption is one of the senses in which foundationalism is present in contemporary empiricist frameworks.

Accordingly, its early application in developmental psychology (Thelen & Smith, 1994) was restricted to *systems* (i.e., motor control) whose variables could be specified without recourse to the notion of representation (e.g., finger tapping, kicking, stepping, etc.) and consequently to problems that, as Clark and Toribio (1994) put it, were not "representation hungry". In an effort to address this representational limitation, Dynamic Field Theory (DFT) has been offered with the promise of 'bridging the representational gap' (Spencer & Schöner, 2003). Spencer and Schöner propose that the dynamic field approach differs from standard DST in that "dynamic fields represent information as attractor patterns of activation"; however, this is only from the perspective of the researcher. That is, the correspondences between these fields (and the attractors in them) and objects in the world are specified by the researcher and they are representational only in so far as the researcher interprets them as having any representational content at all.

This objection does not diminish the wealth of exciting research that has come from applying DFT/DST to our understanding of development (Schöner & Thelen, 2006; Thelen, Schöner, Scheier, & Smith, 2001; Thelen & Smith, 1994) but rather, suggests that the dynamic approach requires a more robust model of representation to adequately tackle the 'representation hungry' problems that DFT was intended to solve. At the center of the issue of whether or not DFT provides an adequate 'representational bridge' from "motor" systems to "cognitive" systems is the issue of emergence [for a recent discussion of DST and emergence see Witherington (2007, 2011)]. DST is intrinsically temporal and as a consequence privileges process and change over substance and stasis. Accordingly, the idea that new forms are emergent from existing system dynamics has considerable appeal to anyone interested in a genuinely developmental perspective. However, whatever theoretical traction the general framework has for understanding some sort of general emergence, the inadequacies of the DFT model of representation per se (i.e., the need to have an interpreter) means that the specific attempt to model the emergence of representation is fundamentally problematic as well. For Spencer and Perone (2008), emergence is constituted in the creation of new attractor states (i.e., local stabilities in the system dynamics). If these attractor states are interpreted as representing aspects of the world, then the emergence of new representations would be possible within a DFT framework. However, if the system is only representational from the perspective of the researcher, then the "emergence" of new representations (of new attractor states) is necessarily going to be derivative from that researcher which is the problem of accounting for emergent representation all over again.

While dynamic systems approaches avoid the foundationalism of a nativist or empiricist perspective (at least to the extent that they avoid issues concerning representation), they also (incidentally) avoid the possibility of an emergent constructivism (at least to the extent that they do not incorporate an action-based model of representation into their framework). The relevance of an adequately robust notion of representation is evident from the lack of progress regarding what learning might be as a representational process (Spencer & Schöner, 2003; Spencer et al., 2006). Further, dynamicists may be correct that we should no longer "abide" the nativist–empiricist debate, but trying to dismiss the debate without properly diagnosing and ultimately transcending it enables developmental research to begin yet another oscillation between the two spheres of nativism and empiricism. As with all contemporary scientific approaches to learning and development, the dynamic systems framework is not complete; in our judgment, adopting the theoretical resources of an action-based perspective could be mutually beneficial (Allen & Bickhard, 2011c).

3.4. Summary of Section 3

We have argued that there is a strongly constrained structure of conceptual possibilities involved in the nativism–empiricism debate:

(1) Developmental approaches that do not address and make no assumptions about cognition and representation – e.g., pure motor or skill development (if such exists) – can avoid the problems concerning representation that we have outlined;

(2) However, simply ignoring or rejecting representation is not an option: e.g., error guided behavior and learning do occur and must be accounted for;
(3) Approaches that do address or make assumptions about cognition and representation must make assumptions about the nature and origins of those representations;
(4) If those representational assumptions permit representational emergence, then there need not be a commitment to foundationalism;
(5) But, if those assumptions, as is almost universally the case, presuppose that representation is constituted as encodings, then no account of emergence is possible, and there is a commitment to foundationalism, either nativist or empiricist (or both);
(6) In turn, the encodingist conflation between detection and representation corrupts design methodology;
(7) The only framework on offer that can account for representational emergence is an action based, pragmatic framework;
(8) But the theoretical competence–performance distinction has been used to relegate action to representational irrelevance, thus blocking the one alternative that can account for emergence.

4. Action as an alternative framework to the foundationalism of nativism and empiricism

Action-based approaches – with precursors in pragmatism – provide an alternative framework to the foundationalism that is at the core of both nativism and empiricism. For foundationalist approaches, knowledge is a matter of passive input processing and action is a matter of output; in contrast, an action-based perspective places (inter)action at the core of what it means to know the world and representation is an emergent of functional interactive organizations that are appropriate for engaging with the environment. These interactive organizations cannot be impressed into a passive mind; but rather, they must be constructed "de novo" (Bickhard, 2001). That is, an action-based approach forces a constructivism, and because representation is emergent in the organization of (inter)action systems, it enables the possibility of an emergent constructivism.

Piagetian theory is the major example of an action-based approach. However, its distortions and misinterpretations (Gelman & Baillargeon, 1983; cf. Chapman, 1988) meant that researchers failed to appreciate the relevance and power of action as an alternative framework to nativism and empiricism. Piaget allowed for innate structure but the key was that this structure was non-representational, and from action alone he attempted to account for the emergence of the representational mind. As Papert (1980) commented during the debate with Piaget and Chomsky, the real issue is "not whether something has to be there from the beginning, but rather how much and what *kind* [emphasis added] of something" (p. 268). While this observation is superficially similar to the earlier discussion concerning the difference between nativists and empiricists, the key is to note that the type of *stuff* for Piaget was not representational. For Piaget, the innate starting state is comprised of certain goal oriented motor capabilities[6] and representational knowledge is an emergent product of constructions that use them (Piaget, 1954). Crucially, it is the emergence of representation from a non-representational starting state that constitutes the fundamental difference between Piaget and the foundationalism of both nativism and empiricism. What made Piaget's 'third way' qualitatively different from foundationalist attempts to understand the mind was precisely his action-emergent orientation.

The central role of emergence and the relationship between action and emergent constructivism were not the focus (nor the language) of Piaget's work, though they are present in it. The next sub-section provides a summary of some of the relevant aspects of another action-based model of representation and knowledge that is more explicit in its contrast with foundationalism and the consequences that can follow from it.

[6] Another common misinterpretation of Piaget was to assume that these were reflexes (Gelman & Williams, 1998).

4.1. Interactivist model of representation

The interactivist model (Bickhard, 2009a, 2009b; Bickhard & Terveen, 1995) is an action-based approach to representation and cognition that converges with Piagetian theory in a number of respects, but also has important differences (Campbell & Bickhard, 1989). Further, the interactivist model arguably avoids or resolves the fundamental problems faced by nativist approaches and does so without appealing to empiricism. These problem resolutions include: (1) rejecting competence–performance as a theoretical distinction; (2) avoiding the need for foundationalism; (3) avoiding the intrinsic conflation between detection and representation; and (4) providing an account of implicit and partial/graded knowledge.

First, if action is essential to cognition rather than just instrumental for obtaining new information, then the competence–performance distinction as used by developmental nativists simply begs the question (i.e., action incompetencies are not just performance limitations). Further, the standard sensory-input, compute, motor-output cycle is not going to hold because "motor-output" (action) is intrinsic to "computation" (cognition) and sensory-encoding models of "input" are false (Bickhard & Richie, 1983). For any action approach knowledge just *is* competent (inter)action with the environment.

Second, emergent constructivism obviates the need for foundationalism (the need to presuppose a representational base) because the nature of representation is anticipation rather than correspondence: anticipations can be constituted functionally and do not necessarily require an already available representational base – anticipations can be constructively emergent. The different forms of anticipation and where they come from are important questions that must be answered (Bickhard, 2009a, 2009b) but for our current purposes we will simply take for granted an aspect of anticipation that is crucial for emergent representation. Specifically, anticipations are future oriented in the sense of how the agent's interaction *would* proceed, given its current context, if that interaction were selected. In turn, this future orientation enables two essential properties of representation: *aboutness* and *truth-value*. Anticipations are *about* the world in the sense that they presuppose environmental conditions appropriate to successful interaction. For example, my anticipation that I can kick the can presupposes appropriate environmental conditions: that the can is empty, that the ground is not too slippery to balance on one foot, that the can is not covering a rail-road spike, and so on. If these environmental conditions do not hold, then the interaction will fail and the anticipation will be incorrect. In general then, anticipations have *truth-value* in the sense that an interaction may or may not proceed as expected and therefore the interaction may or may not be successful. If an interaction fails to proceed as expected, then the anticipation upon which it was based is falsified: conditions in the environment were not appropriate for the interaction possibility that was indicated by the anticipation. Conversely, if the interaction is successful, then the anticipation is correct: conditions in the environment were appropriate with respect to the indicated anticipation.

Third, recall that encoding models are assumed to possess their representational content in virtue of a correspondence relationship with what they are taken to represent. It makes no fundamental difference what type of correspondence relationship is assumed (e.g., informational, causal, nomological, structural, isomorphic, etc.). In Psychology, these correspondences often take the form of a causal relationship between the object in the world and neural activity in the brain (via "sensory encoding"). However, assuming that causal correspondences constitute representations of what those correspondences are with conflates the causal capacity to *detect* with normative ability to *represent* what those detections are *about* (recall the thermostat example above). For humans, the potential to *also* have representational knowledge of what some detection is about is of course possible, but for encoding models, representational knowledge is assumed to be constituted by the detection itself. That is, encoding models inherently conflate a crucial distinction between epistemic contact (detection/differentiation of objects and properties in the world) and epistemic content (knowledge/representations of those objects and properties; Bickhard, 2009b).

The separation of epistemic contact and epistemic content is at the core of the interactivist model of representation. Anticipations about future potential interactions must be appropriately *sensitive* to the environment, but such sensitivities need not be representational. That is, an agent must be

able to differentiate environmental conditions appropriate for subsequent anticipations about how to engage the world, but those conditions do not themselves need to be represented. One perspective on this point is to note that such sensitivities to the environment can be informational in the technical covariational sense without having to be "informational" in the semantic or representational sense (e.g., Bickhard & Richie, 1983). For example, a frog might differentiate the environment such that it anticipates an opportunity to flick its tongue and eat. While the interaction may or may not succeed, there is no need to assume that the prior differentiation upon which the anticipation was based also constitutes a representation of the environmental conditions for that differentiation. That is, the frog does not necessarily *represent* flies and then on the basis of that representation flick its tongue and eat. The frog may *differentiate* situations in which it can flick its tongue and eat from other types of situations in which other interactions are possible. That frogs do not actually represent what they differentiate helps to explain why they will try to eat pebbles tossed across their visual field – they do not differentiate between flies and pebbles (presumably the need for such sensitivity to the environment – differentiation – was not relevant during frog evolution).

Finally, explicating the nature of partial or implicit knowledge is trivial from an action perspective. If knowledge is constituted by competent interaction then partial knowledge is constituted by partial interactive competence. From an action perspective, the "paradox" of why "infants looks so smart and toddlers look so dumb" only exists because nativist researchers assume a foundationalism that ignores perceptual complexities and further, that action can only *reveal* underlying competence (not *constitute* it). However, anticipations about the world are based on interactively learned relevancies (that are always incomplete and in some sense partial) and the "striking" decalages found *within* looking time procedures (Baillargeon, 2008) are best understood as the progressive differentiation and coordination of different types of situations that are learned with appropriate experience.

4.2. An action-based model of object representation

Extant criticisms of Baillargeon's drawbridge studies have already pointed out that her empirical findings were consistent with the middle stages of Piaget's model of object representation (Fischer & Bidell, 1991; Rivera et al., 1999). Further, we have suggested above that the extreme empirical decalages found within looking time procedures has made the case for an action-based model of representation even more appealing. The reason these "striking" decalages, found *within* looking time procedures, are well suited to an action-based explication will be given in terms of the interactivist version of Piaget's (1954) model of object representation:

If what it is to represent an object is to know how to competently interact with it, then object representation is going to be a matter of knowing about object affordances (interactive possibilities). Importantly, these affordances are going to change depending on the situation (e.g., the affordances of water are going to change depending on the temperature) and children will have to learn about both the affordances and the situations in which they do or do not change. For a sufficiently developed infant, the representation of small manipulable objects might include anticipations for various visual scans, hand manipulations, mouthing explorations, etc. and the types of situations in which this collection of anticipations is maintained. Something like the A not B error is considered to be a transition in the infant's understanding of whether the collection of anticipations indicated when the object is visible is maintained (can be recovered) after occlusion or displacement. As adults, we certainly know that occlusion and visible or invisible displacement does not change the collection of interactive possibilities for small manipulable objects but we also know some of the situations in which the object affordances are not maintained (are not recoverable). For example, if you crush a bottle or burn a wooden block the collection of interactive possibilities that previously existed, changes (does not remain invariant).

In general, if object representation is *constituted* by a web of interactive possibilities that remains constant under some other class of transformations, then the prior development of this invariant web is going to involve both co-ordinations between the different types of possible interactions (in this case visual but also proprioceptive, kinesthetic, tactile, etc.) as well as changes in the class of transformations that are known to maintain that invariant web (i.e., occlusion, displacement, containment,

cover, etc.) and those that do not (e.g., burning, crushing, dissolving, etc.). That is, knowing which object interactions are possible and then which of them remain possible (invariant) despite other changes (transformations) is going to involve learning from relevant engagements with the world. Thus, the wealth of decalages found within looking time procedures (as well as those between looking and physical manipulation) are not only consistent with an action-based model of object representation, but they are precisely what is to be expected. There is a certain irony then that these types of results were used to "refute" Piagetian theory.

4.3. Summary of Section 4

An account of representational emergence permits a transcendence of the foundationalist oscillations between nativism and empiricism that encoding conceptions of representation induce. Action/pragmatist models in general, such as Piaget's, can account for the emergence of representation, and the interactivist model in particular makes a natural distinction between detection/differentiation and representation, thus permitting an escape from methodological distortions and confusions. More generally, an interactivist model of representation satisfies multiple additional desiderata for understanding representation and cognition (Bickhard, 2009b).

5. Conclusion

We have attempted to make a case for why developmental psychology should be concerned with the theoretical issues concerning foundationalism. As a fundamental epistemological assumption, foundationalism precludes emergence, and by so doing prevents a realistic view of the developing mind. A major portion of this article has attempted to explore the specific manifestations of foundationalism for nativist research methodology (i.e., research design and interpretative stance). However, the lessons from this analysis, if correct, are broader than just nativism in that they apply to any foundationalist framework, and that includes various versions of empiricism.

Consequently, the arguments presented here have suggested that understanding foundationalism is crucial for transcending the nativist–empiricist debate; however, developmental nativist assumptions and research have systematically precluded the only framework (Piaget's emergent constructivism) that was potentially able to offer it a "third" way. That is, the developmental nativist research programme has begged the question with respect to Piaget's action-based approach (rather than just influencing research as all frameworks do) precisely because it precluded relevant emergent constructivist alternative possibilities a priori.

Once it is recognized that methodological considerations (i.e., research design and control conditions) are intrinsically tied to the theoretical positions that ought to motivate them (Anisfeld, 2005; Spencer et al., 2009), it becomes clear that the potential circularity of precluding alternative interpretations a priori is going manifest itself with regard to both conceptual and methodological aspects. Conceptually, nativist proposals are problematic because of their necessary commitment to foundationalism. Methodologically they are problematic because of their "a-theoretical" construal of habituation and their failure to control for perceptual-level variables. And cutting across both, is their application of the competence–performance distinction.

While the main classical alternative to nativism is some version of empiricism, both are equally committed to foundationalism and simply suffer from different manifestations of the same fundamental issues. Similar to Chomsky's (1959) critique of Skinner, the arguments against foundationalism are in-principle and do not require an enumeration of all of the instances in which foundationalism is problematic. One of the main theses of this article has been to argue that the reason recent attempts to transcend the nativist–empiricist debate have failed is precisely because they do not recognize the deeper commitment to foundationalism and its reciprocal entailment relationship with encodingism.

The difficulty in ever discovering that foundationalism and encodingism may underlie many of the debates in developmental psychology is three-fold: (1) foundationalism is self-maintaining in the sense that it precludes the very conceptual and methodological frameworks that can help demonstrate its inadequacies; (2) attempting an analysis of foundationalism (or encodingism) requires accepting

that conceptual level explication is a legitimate part of scientific psychology; and (3) manifestations of foundationalism and encodingism are labyrinthine and relate to the issues of psychology in non-obvious ways.

In the last section we have set forth the outlines of an action-based emergent constructivism, along the lines pioneered by Piaget, as the "cure" for foundationalism. If adopted, it would revive the developmental side of developmental psychology and open the field to pioneering efforts in both empirical and theoretical work.

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