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Abstract of the original article: Let’s start from scratch in thinking about what memory is for, and consequently, how it works. Suppose that memory and conceptualization work in the service of perception and action. In this case, conceptualization is the encoding of patterns of possible physical interaction with a three-dimensional world. These patterns are constrained by the structure of the environment, the structure of our bodies, and memory. Thus, how we perceive and conceive of the environment is determined by the types of bodies we have. Such a memory would not have associations. Instead, how concepts become related (and what it means to be related) is determined by how separate patterns of actions can be combined given the constraints of our bodies. I call this combination “mesh.” To avoid hallucination, conceptualization would normally be driven by the environment, and patterns of action from memory would play a supporting, but automatic, role. A significant human skill is learning to suppress the overriding contribution of the environment to conceptualization, thereby allowing memory to guide conceptualization. The effort used in suppressing input from the environment pays off by allowing prediction, recollective memory, and language comprehension. I review theoretical work in cognitive science and empirical work in memory and language comprehension that suggest that it may be possible to investigate connections between topics as disparate as infantile amnesia and mental-model theory.

The problem of content in embodied memory

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Abstract: An action-oriented theory of embodied memory is favorable for many reasons, but it will not provide a quick yet clean solution to the grounding problem in the way Glenberg (1997t) envisages. Although structural mapping via analogical representations may be an adequate mechanism of cognitive representation, it will not suffice to explain representation as such.

Content and grounding. Glenberg’s (1997t) arguments that the analogical embodied representations he postulates “do not need to be mapped to the world to be grounded because they arise from the world” (sect. 1.3). We argue that Glenberg’s concept of analogical embodied representations does not eliminate the grounding problem in the way he envisages.

This is an important issue because, in the growing literature on embodied cognition, advocates of this approach often misconstrue the consequences of their theory for the grounding problem. One reason for this misconstrual is that, whereas Haugeland (1998) poses the grounding problem addressing the idea of formal symbol systems as criticized by Searle (1980), memory theory addresses the general problem of cognitive content or aboutness (how can states of a memory system be about anything at all?) which can be stated before any commitments concerning symbol systems are made. We will therefore refer to the problem of content to indicate that the symbol grounding problem is just one version of that general problem.

When discussing the problem of content in memory, it is misleading to distinguish symbols from embodied representations exclusively in the context of a narrower symbol grounding problem, as Glenberg does in section 1.1, because any representation is symbolic in that it realizes a detonation; that is, it stands for some other entity or state of affairs (Newell 1980). Embodied representations and meaningless symbols (sect. 1.1) are both symbolic in this sense, and because of their common symbolic character they are both tangled in some version of the problem of content.

Grounding and embodiment. In Glenberg’s approach, a representation is embodied if it is constrained by how one’s body can move itself and manipulate objects (sect. 2.2 of the target article). This view seems to be in accordance with the prevailing concept of embodiment in current cognitive science (Feldman 1997, p. 746; see also Ballard et al. 1997), but the assumption of an analogical structure of cognitive representations does not follow from the fact that cognition is somehow constrained by bodily features. The thesis of analogical structures is derived from mental model theory, according to which the structure of cognitive representations corresponds to the structure of what is represented (sect. 6.1). Regardless, it is not true that analogical representations do not need to be mapped onto the world; on the contrary, every representation – whether analogical or amodal – requires some sort of mapping in order to represent adequately. When the representation is supposed to be analogical, then there is a structural mapping mediated by certain physiological (and other) mechanisms. But this case differs only in degree from the scenario of an arbitrary symbol theory of cognition such as Fodor’s “Representational Theory of Mind” (cf. Fodor 1987) in which there is no structural mapping but rather a functional-causal one, likewise mediated by certain (perhaps insufficient) mechanisms.

Hence, analogical representations are no less symbolic than those of the Representational Theory of Mind; the latter representations are arbitrary only in the relatively weak sense that they are not structurally mapped to their external causes (their formal or syntactic features and their causal-functional relationships are by no means arbitrary). This is just a question of mechanisms of representation and their theoretical plausibility, not one of arbitrariness versus direct grounding (sect. 1.3).
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Furthermore, even if structural mapping should be the favored mechanism (as there are good reasons to assume), mapping alone will not suffice to establish representation as a cognitively relevant relation (Bickhard & Terveen 1995), for mapping merely establishes correspondence. But representation in a cognitive sense requires that this correspondence be (consciously or unconsciously) recognized by the cognitive system of which the corresponding item is a part. In less mentalistic terms, within the cognitive system a representational item will need to be processed as corresponding to something. What makes a correspondence a cognitive representation is that it is a correspondence for the cognitive system of which it is a part (this introduces a teleological component into the approach, a fact that Glenberg himself approves in section R1.1 of his response to the original commentaries; Glenberg 1997r).

Analogue representation may well be the adequate mechanism of embodied cognition as part of a theory that will finally solve the problem of content. But it is important to see that the analogue character of the supposed representations is not the key feature that renders any mapping superfluous and solves the problem of content by a more direct grounding of these representations. Analogical representational mechanisms can only transport content, not generate it. They merely provide correspondence as such, not correspondence for the cognitive system.

Meshing Glenberg’s embodied memories with negative priming research on suppression

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Abstract: This commentary examines Glenberg’s characterization of “suppression” in light of negative priming and related phenomena. After offering a radically different slant on suppression, an attempt is made to weave this alternative version into Glenberg’s provocative discussion of embodied memories.

Citing Lakoff and Johnson (Johnson 1987; Lakoff 1987; Lakoff & Johnson 1980), Glenberg argues in his 1997 BBS target article, “What memory is for,” that memories are not meaninglessly propositionally related symbols found in many cognitive theories, but instead “arise from bodily interactions with the world” and thus represent embodied, analogically related representations. In Glenberg’s view, suppression is the key to free the mind to engage in the internal processing required for memory operations, and such reflective thought processes as prediction, recollection, and language comprehension. Suppression thus functions as a kind of filter that blocks external input from the environment so that internal processing can occur. From this perspective, suppression is quite similar to strict, early selection, filtering models of attention (Broadbent 1958). The problem with this notion of suppression is that it fails to take into account research findings indicative of more sophisticated suppression mechanisms that function both on internal and external stimuli (e.g., Neumann & DeSchepper 1992; Tipper & Driver 1988).

Glenberg contends that suppression is an “effortful,” “dangerous,” and “risky operation” because “it loosens the tie between reality (the current environment) and conceptualization” (Glenberg 1997r, sect. 3.4). This pronouncement reflects a longstanding bias against suppression (or inhibition) as an explanatory construct in psychology (Anderson & Spellman 1995). It can be argued, however, that suppression is an elementary processing mechanism integral to the functioning of human memory and is not more dangerous or effortful than activation. In this account, suppression and activation operate synchronously on both internal and external stimuli and play an equal and central role in self-regulatory processes with each capable of operating on a continuum from more automatic to effortful, depending on the current goals of the perceivers (Neumann & DeSchepper 1991; 1992). Because Glenberg proposes that memory’s primary role is to serve perception and the guidance of action, his framework would benefit by not characterizing suppression as something dangerous, instead elevating it to a central position in the core operations of memory. This more benign characterization of suppression emerges from phenomena studied under the rubric of negative priming.

Negative priming occurs when ignoring an object hampers a subsequent response to it, presumably on account of its prior suppression. The mechanism of suppression posited to account for negative priming is typically conceived as a form of active inhibition. In this situation, multiple stimuli compete for processing priority, with some being selected, while others are suppressed. The philosopher Herbart (1834/1891) originally proposed this concept of inter-representational competition as a mechanism to explain the unity and coherence of conscious experience. For Herbart, an inhibitory mechanism existed for the purpose of forcing momentarily irrelevant representations “out of consciousness,” thereby preventing the contents of consciousness from becoming disorderly or muddled. Accordingly, suppression is integral to the orchestration of high-level thought processes.

Although investigations of negative priming are currently deemed the best available index for observing the operations of suppression (see e.g., Fox 1995, for a review), observations about the role of suppression have been postulated in other cognitive domains as well. These domains include, but are not limited to, retrieval processes in arithmetic (Campbell & Tarling 1996), memory retrieval (Anderson & Spellman 1995), and language processing (Gernsbacher 1990). In language processing, for example, it appears that a suppression mechanism serves a central regulatory function in processing anaphors, cataphors, and metaphors (Gernsbacher & Jeschenik 1995; Gernsbacher & Keysar 1995); in resolving lexically ambiguous words (Simpson & Kang 1994); and in shifting from one language to another by multilinguals (Neumann et al. 1999). Taken together with studies of negative priming, these findings suggest that suppression is utilized when one mental entity is in a position to conflict with another one, in order to resolve the competition. Through the simultaneous use of activation and suppression processes, perceivers can apparently amplify a target signal while momentarily suppressing unwanted distracting material, thereby enhancing their ability to pull the competing representations (i.e., signal and noise) apart (Houghton & Tipper 1994). Activation and suppression may thus be seen as two basic, ubiquitous, information-processing mechanisms.

If these conjectures regarding suppression have psychological reality, they should be able to generalize to Glenberg’s embodied memory framework if it also has psychological reality. If it is shown that suppression can play a functional role in his framework, then these hypothetical constructs may be deemed mutually reinforcing. What is intriguing is that negative priming studies emphasize the body position and spatial sensibilities demonstrate the “embodiment” of the processes of suppression. An example of this is provided by Tipper et al. (1992).

Tipper et al. (1992) asked subjects to reach for and depress target keys adjacent to red lights while ignoring distractors adjacent to yellow light. Negative priming was produced when the red light landed on a position previously occupied by a yellow light; indicating that in this task suppression was associated with an action-based representation of a three-dimensional environment. Moreover, the magnitude of negative priming depended on the spatial relationship between the distractor and the responding hand; distractors nearest and ipsilateral to the responding hand on the priming trial produced more negative priming on the subsequent trial than distractors in other locations. This supports Glenberg’s notion of action-based embodied memories. In this case, it appears that the guided action that makes it possible to avoid obstacles is carried out, at least in part, through suppression of a distracting location. The embodied memory of this action is revealed by subsequent responding, which was clearly constrained by characteri-
zation of the body’s (specifically, the hand position’) interaction with the environment. Tapping such regularities in immediate response performance provides insight about how patterns of action mesh with those based on previous experience.

It can be argued that Glenberg’s central contention “that perceptual systems have evolved to facilitate our interactions with a real, three-dimensional world” (Glenberg 1997i, sect. 1.3) holds for suppression mechanisms as well. Our evolutionary ancestors spent much of their time navigating forest canopies. In such an environment, efficient branch selection required acute spatial sensibilities and qualitative judgments about color, texture, and form, in order to choose a sound branch and avoid those that were brittle or too thin, and could lead to a precipitous tumble to the ground below. The efficient selection of appropriate branches within the canopy, necessitated rapid initial parallel processing of many branches. Because momentarily unwanted branches are likely to remain so, there would also be an adaptive advantage to implicitly encode and preserve an “unwanted” tag (Neumann & Treisman 1996; Treisman & DeSchepper 1996) so that such branches are more likely to be avoided in the future. These examples may be seen “natural” analogs to selective attention tasks in the laboratory, DeSchepper and Treisman (1996; Treisman & DeSchepper 1996) have documented implicit long-term negative priming effects that are clearly indicative of this type of suppressive tagging process in humans. Such studies provide exciting possibilities for fleshing out Glenberg’s embodied memory framework.

Clamping and motivation
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Abstract: Arthur M. Glenberg omits discussion of motivation and this leads him to an underestimation of the part played by pleasure and pain and desire and fear in both the clamping and the updating of percepts. This commentary aims at rectifying this omission, showing that mutual correction plays an important role.

One can readily start with Glenberg’s frank admission that he has left out “hedonic valence and motivation to act” (Glenberg 1997i, sect. 7.2, p. 17). Meanings are what is embodied and meanings are centrally intentional, whatever portions of the flux, internal or external to the body, are involved in the actions they embrace. As William Epstein, from whom Glenberg has drawn his key distinction of “projectable” and “nonprojectable” properties, has insisted, “an event can only assume symbolic status when it is assigned that status by an agent or process that is endowed with intentionality” (Epstein 1993, p. 705). Both kinds of properties are therefore “endowed with intentionality.” This raises an apparent problem because of two of Glenberg’s claims (sect. 5.1, p. 10): (1) that the clamped environment is not changed by the embodied memories, and (2) that the promptness of embodied memories in contributing to the conceptualization of the current environment is automatic. The problem is, where does intentionality come in for these two features? I address that issue here, particularly with regard to the clamping of the percepts. The same question arises in Karl F. MacDorman’s criticism that Glenberg has failed to “mesh memory with affect” (BBS, 20:29) and in Norman H. Anderson’s commentary (BBS, 20:19–20), which, without pursuing the link with pleasure and pain, notes the omission of goal-directedness of cognition.

With regard to the projectable properties, Glenberg rightly notes that they are habitual — that is, having been established in an evolving manner to serve a purpose, they are maintained as long as that purpose is felt to be sustained. Their “automatic” nature is only an aspect of habit, and, should a clamping register itself with the organism to be maladaptive, then it is immediately subjected to re-jigging; so, though the environment may remain unchanged, the clappings may not. This is, of course, a re-jigging of the memory that is embedded in the perceptual clappings themselves. Glenberg drew attention to the fact that it is precisely because we, like other animals, do not wish to be subjected to “freezing, burning, drowning, falling” (sect. 2.1, p. 4) that the clamping was done in the first place. He therefore wonders what part pleasure and pain have to play (sect. 7.2, p. 17).

What is it that shows a clamping to be maladaptive? The answer, implied in the remarks about freezing, burning, and so forth, is pain. Percepts evolve to their clamping under a regime of value (Edelman 1989; Wright 1985). What clamps a percept is pleasure or pain: these are the motivations that excite the gestalt process, registering in memory whatever is so unified, which may be multiple. Pain marks the percept-memory with fear. Mutatis mutandis for adaptive reward: Pleasure excites the gestalt-embedding system, in this case marking the percept-memory with desire.

This marking in both cases is certainly automatic, in that one cannot prevent such a memory-embedding from taking place: One cannot stop immediately beginning to desire a repetition of pleasure or to fear the repetition of pain — that is indeed automatic. The clamping itself, however, once established, frequently becomes so habitual by repeated confirmations that it can be said to be automatic, as Glenberg says, but only in the sense of being prompt. As Glenberg centrally argues, updates are continually necessary wherever a problematic situation occurs; a new meshing (to use his own term) becomes imperative. And what is it that renders the problem imperative? In the case of aversion it is pain, whether the threat is present or to come. The clamping often emerges as a result of the discovery of a new significance in a context not previously thought to be relevant. The changing of a clamped gestalt thus comes about as in a narrative with the emergence of a contextual clue that effects a realignment of a key conceptualization (as in a comedy, a tragedy, a joke, a pun any transformation, indeed, that partakes of an ironic analysis; Wright 1993). Here is a pointer to the answer to Arthur C. Graesser’s question “Where in the body is the mental model for a story?” (BBS, 20:25). The mesh is with action precisely because of the binding of drive to percept; it is this that secures the embodiment, but the ironies, the tropes, the narrative transformations, occur because of the inescapable — and evolutionarily valuable — fact of perceptual relativity. It creates the opportunity for a mutual correction (or a lie).

A further philosophical point arises out of that very embodiment Glenberg speaks of: the clamping to particulars (sect. 3.2, pp. 6–7). If Glenberg accepts the full implications of individual embodiment he should accept that what we have is a mutal coordination of differing gestalt selections that have to be repeatedly readjusted in a cooperative act. The method we adopt is that we have to speak, out of linguistic convenience, as if there is a numerically singular logical particular before us, just in order to effect the needful fuzzy superimposition of our numerically multiple selections (Gregory 1993, p. 259; Wright 1992, pp. 42–50; 1993, pp. 192–93). To use Harnad’s terms, there is a never-to-be-achieved perfect “convergence” of each agent’s “approximations” to the putatively common categorization (Harnad 1987, p. 538). This being so, there is strictly no common “referent,” no single Gibsonian “invariant” to provide given “affordances,” only a multiplicity of individually chosen referent selections from the flux which may or may not produce a coinciding of purposeful action. The Gibsonian Richard A. Carlson asks Glenberg to mesh Piaget with his theory (BBS, 20:21), but Piaget regarded knowing as an assimilation of reality into “systems of transformations” (Piaget 1970, p. 15) and saw the roots of logic in the “coordination of actions” viably maintained together (ibid., p. 17). Glenberg (1997i), in his answer to those who accused him of neglecting affect, still places his analysis at the ordinary-language level in referring to given overlapping selections, about which we have to talk conti-
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usually to improve the degree and success of that superimposition of our differing clampings, to update the concepts of each other in a narrative manner – all of which negotiation is fraught throughout with motivation.

Authors’ Response

Embodied meaning and negative priming

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Abstract: Standard models of cognition are built from abstract, amodal, arbitrary symbols, and the meanings of those symbols are given solely by their interrelations. The target article (Glenberg 1997t) argues that these models must be inadequate because meaning cannot arise from relations among abstract symbols. For cognitive representations to be meaningful they must, at the least, be grounded; but abstract symbols are difficult, if not impossible, to ground. As an alternative, the target article developed a framework in which representations are grounded in perception and action, and hence are embodied. Recent work (Glenberg & Robertson 1999; 2000; Glenberg & Kaschak 2002; Kaschak & Glenberg 2000) extends this framework to language.

Kurthen et al. and Wright argue that grounding is not sufficient to make symbols (embodied or not) be about something – that is, to make them intentional or meaningful. We will address both commentaries by discussing the power of embodied representations and how they become intentional representations. Neumann comments on a different point. He suggests that the account of embodied cognition developed in the target article is deficient in that it does not provide a role for what we will call internal suppression. Part of Neumann’s commentary seems to reflect a misconstrual of what was intended in the target article. Nonetheless, he is correct to point out that the target article did not consider negative priming data that are consistent with internal suppression. Here, we will sketch an account of negative priming based on the mesh of embodied representations.

According to the framework developed in the target article (Glenberg 1997t), an individual’s conceptualization of a situation consists of the set of actions that a person can take in that situation. Those actions arise from the mesh of affordances (Gibson 1979), action-based goals, and experiences. Affordances are interactive properties that arise from projectable (roughly, directly perceptible) features of the environment (Epstein 1993). In brief, affordances are how an organism with a particular type of body can interact with a particular object. A chair, for example, affords for an adult the options of sitting on, standing on, or even hoisting as a defense against snarling dogs. For a small child, the chair may afford sitting, but not hoisting for defense. In the Glenberg (1997t) framework, affordances differ from Gibson’s formulation in that affordances are not necessarily directly perceived, and they may become internal representations (as will be discussed shortly). In addition to affordances, some knowledge (such as that indicating ownership) must come from memory because the knowledge is not projectable. Nonetheless, the meaning of nonprojectable properties is action-based. For example, we know that a person owns an object from the way that person interacts with it, and the fact of ownership constrains our own interactions with the object.

Mesh is the process by which affordances, goals, and experiences are combined into a coherent conceptualization. The most important property of mesh that distinguishes it from association formation, concatenation, convolution, and many other forms of combination is that mesh respects intrinsic constraints on action. That is, given constraints of biology and physics, some actions can be smoothly combined and coordinated (they mesh), whereas other actions cannot be combined. Consider the situation in which you have the goal of changing a bulb in your kitchen ceiling fixture. In this case, the action-based goal (lifting the body), the projectable affordance (the chair affords standing on), and the nonprojectable knowledge (you own the chair) can be meshed into a coherent (that is doable) set of actions and thus a coherent conceptualization of the situation: Stand on the chair to change the bulb. However, if the chair is so rickety that it does not afford standing on, one cannot mesh the goal and the affordances. We offer this as an embodied account of the meaning of situations.

If one were reading about a situation, then understanding must arise from words. The Indexical Hypothesis (Glenberg & Robertson 1999; 2000) specifies how language about a situation becomes meaningfully embodied. Words and phrases are indexed or mapped onto objects or perceptual, analogical symbols (Barsalou 1999); affordances are derived from the objects or perceptual symbols, not the words themselves; the affordances are meshed under the guidance of intrinsic constraints, context, and syntax (Kaschak & Glenberg 2000). Consonant with this hypothesis, Glenberg and Kaschak (2002) have demonstrated that literal action in one direction will interfere with the comprehension of a sentence implying action in an incompatible direction. Thus, language understanding makes use of the same neural systems that plan and guide action.

Kurthen et al. suggest that embodied representations need to be grounded much like abstract symbols. We agree, although the problem is simpler for embodied representations such as perceptual symbols than for abstract, amodal, arbitrary symbols. Consider first the problem of grounding abstract symbols. Until they are grounded, content can only be represented by relations to other abstract symbols. This must be so because the symbols themselves (being abstract, amodal, and arbitrary) are stripped of any perceptual or motor qualities. In contrast, Searle’s (1980) Chinese Room argument demonstrates that content cannot arise solely from relations among such symbols. Furthermore, Putnam (as discussed in Lakoff 1987) demonstrated the impossibility of finding the correct mapping from a set of abstract symbols to the correct objects of the world. That is, the set of relations among the symbols does not provide enough constraints to get the mapping right. Therefore, by Searle’s argument, abstract symbols need to be grounded, but by Putnam’s argument there are insufficient constraints to do so.
Embodied representations that are perceptually based have at least four advantages over abstract symbols. First, they provide at least the beginning of a solution to finding the correct mapping between world and representation. For example, Barsalou (1999) defined perceptual symbols as records of the neural states that underlie perception; they are by no means anodal and arbitrary. Thus, when perceptual symbols are used in thinking (as in: Can I stand on the chair in my kitchen?), the results of that thinking can be compared to perceptual input to check on the veracity of the conclusion. The comparison is not problematic (as Putnam demonstrated it is for abstract symbols), because the embodied representations are of the same stuff as the perceptions.

A second advantage of embodied representations compared to abstract symbols is that embodied representations correspond nicely to data from functional magnetic resonance imaging (fMRI). The fMRI data indicate that when a concept is thought of, there is activation in those areas of the brain involved in the perception of the objects underlying the concept (e.g., Martin et al. 2000). For example, when a tool is thought of, motor areas of cortex are activated, and when the color of an object is thought of, visual areas are activated. This sort of correspondence is expected on an embodied account, whereas it is sheer coincidence if cognition is based on abstract symbols stripped of perceptual qualities.

Third, if representations are analogical, new features, affordances, and meanings can be derived. In contrast, when using abstract symbols, only prewired features are possible. Two types of data demonstrate that people can derive new features. First, Schyns et al. (1998) demonstrated that people create new visual features depending on how the objects are used in categorization tasks. As they discussed, this feature creation requires analogical representations at some level. Second, Glenberg and Robertson (2000) and Kuschak and Glenberg (2000) demonstrated that language often requires the derivation of new affordances. Consider, for example, the differential sensibilities of the endings of subjects are used in categorization tasks. As they discussed, this feature creation requires analogical representations at some level. Second, Glenberg and Robertson (2000) and Kuschak and Glenberg (2000) demonstrated that language often requires the derivation of new affordances. Consider, for example, the differential sensibilities of the endings of

A fourth advantage of embodied representations over abstract symbols is related to proposals for how perceptually based representations can be endowed with content beyond grounding. Following Dretske (1988), Ellis and Tucker (1999) made the distinction between indicator states (Kurthen et al.’s “correspondence”) and representational states (Kurthen et al.’s “content”). Indicators arise from causal effects in sensory pathways and reliably correspond to states of the world. But which states? Dretske notes, for example, that the needle on a fuel gauge indicates the amount of fuel in a car’s tank, but it also indicates (more reliably) the torque on the needle and (less reliably) the number of miles traveled since last fueling. What makes the needle a fuel gauge rather than a torque meter is its role in the car/driver system: The needle signals to the driver when to refuel. Similarly, what changes a neural indicator into a representational state with content is that the indicator comes to play a causal role in the actions taken by the system. Ellis and Tucker proposed that the transformation from indicator to representation comes about from incorporating affordances into indicators by a type of reentrant processing (e.g., Edelman 1978); that is, the neuronal group acting as an indicator is associated with a neuronal group affecting action. In support of this idea, Ellis and Tucker demonstrated experimentally that the simple perception of an object results in the activation of some of its affordances. In one experiment, participants classified pictures of objects (e.g., a coffee cup) as upright or inverted. When the handle on the cup was portrayed on the right, participants found it easier to make the correct response (e.g., upright, when the cup was upright) with the right hand, whereas when the handle was portrayed on the left, responding with the left hand was easier. Apparently, the affordances of a cup (how to interact with it) affected responding, even when the affordance was irrelevant to the classification (upright or inverted).

Wright suggests that affect is also an important component of meaning, and we agree. We see two ways in which affect can influence meaning and action. The first was described in the target article and previous reply to commentators. A strong affective response to a situation literally changes the body through a wash of chemical and neuronal signals. Because of these changes in the body, there is a change in the affordances of the situation (how the body can act in the situation), and hence a change in meaning. This mechanism corresponds to Damasio’s (1994) body-loop for emotional responsivity. The second manner in which affect can change conceptualization makes use of a reentrant mechanism such as the one mentioned above; that is, the neural representation of the body’s state while experiencing an affective response is combined with the representation of the situation itself. Thus, the meaning of the situation takes on an emotional tone that modifies affordances, action, and hence meaning. This mechanism (similar to Damasio’s “as-if” loop) influences meaning both in the present and in future encounters with similar situations.

Neumann’s commentary focuses on suppression. The target article describes a type of external suppression. Normally, cognition is controlled by the affordances of a situation. To gain control over cognition in the service of planning, remembering, or language (none of which need pertain to the current situation), people may block out external stimuli by, for example, closing their eyes or looking at a blank sky. Blocking of external stimuli increases with the difficulty of the planning, remembering, or language task, and the blocking enhances performance of the task (Glenberg et al. 1998). It is this sort of suppression of the external environment that the target article characterizes as “dangerous,” because continuing to act overtly without regard to the affordances of the environment is clearly risky.

Neumann’s concern is with what may be characterized as internal suppression: reducing the competition between...
activated responses by suppressing one of them. This construct is widespread in the cognitive literature, forming important parts of theories of cognitive development (e.g., Diamond’s [1985] account of errors on the Piagetian A-not-B task), language comprehension (e.g., Gernsbacher 1990), and intelligence (e.g., Dempster 1991). Support for an internal suppression mechanism comes from the negative priming phenomenon. This support notwithstanding, an embodied account of cognition can address the negative priming literature without the introduction of internal suppression.

To frame our approach to negative priming, consider the situation Neumann describes in the last paragraph of his commentary. He suggests that an evolutionary ancestor might have spent time navigating the forest canopy. Furthermore, in choosing branches to use in locomotion, that ancestor might have (internally) suppressed inappropriate branches, such as those too weak to support the animal’s weight. According to Neumann, “Because momentarily unwanted branches are likely to remain so, there would also be an adaptive advantage to implicitly encode and preserve an ‘unwanted’ tag . . . so that such branches could more likely be avoided in the future.” We think that this analysis is misguided in several respects. First, on an embodied account, a more efficient selection mechanism is available that does not depend on storing and later retrieving “unwanted” tags. Instead of tags, the animal perceives affordances for its action: one branch will afford locomotion, another will not. Second, an “unwanted” tag is likely to be inappropriate under many circumstances. For example, a branch that does not afford locomotion might well afford a snack or camouflage. Internal suppression renders that stimulus useless when in fact the stimulus has myriad uses other than for locomotion. This last point will motivate a prediction in an experiment to be described shortly.

Support for the idea of internal suppression comes from experiments on negative priming, such as that by Tipper et al. (1992) described by Neumann. Participants were seated in front of a panel of nine response buttons and each button was paired with a red light and a yellow light. Participants were to press the button signaled by a red light (the target button for that trial) as soon as possible. They were to ignore any button signaled by a yellow light (the distractor button for that trial). When a distractor was near a target, responding to the target was slowed. Supposedly, the response to the distractor needed to be suppressed before responding to the target. The suppression was revealed by negative priming, an effect that involved two successive trials. The trial just described can be considered a prime trial, and the trial following is the critical trial. Negative priming occurs when the prime trial distractor button becomes the critical trial target button. In this case, responding to the critical trial target is slow relative to responding to a critical trial target at a location not used on the prime trial.

An embodied account of negative priming is based on affordances and a reentrant mechanism much like that described above. A projectable property of all of the buttons is that they afford pressing. Neither the red nor the yellow light differentially afford action, but they are represented in memory with the nonprojectable information “approach-with-hand” and “avoid-with-hand.” In selecting the correct response, the participant must mesh the projectable affordances of the button with the nonprojectable information from memory. Hence, on the prime trial, the button with the red light is interpreted as a meshed combination of “press” affordance and “approach-with-hand,” whereas the button with the yellow light is interpreted as a combination of a “press” affordance and “avoid-with-hand.” Using the reentrant terminology, the indicator button-with-yellow-light that had the pre-experimental content “press” is now updated with the “avoid-with-hand” information to have the updated content “avoid.” On the critical trial, what had been the distractor button becomes the target button. Thus, the just-meshed “avoid-with-hand” information must now be meshed with the nonprojectable “approach-with-hand” information, and resolving the conflict results in negative priming.

One might object that we have simply replaced “suppression” with the more cumbersome terminology: “nonprojectable avoid-with-hand information.” But, the two accounts make several different predictions. As noted in the tree canopy discussion, a problem with suppression is that it slows all responding, even when responding is now appropriate (e.g., using the branch for eating rather than locomotion). The embodied account of negative priming need not suffer from this problem. Consider the following adaptation of the Tipper et al. (1992) experiment. The target and distractors are not indicated by lights, but by pictographs projected onto the buttons. The target pictograph is shaped like a barbell that is on a 45° angle slanted from upper left to lower right. The distractor pictograph is the same except that it slants up from lower left to upper right. Ellis and Tucker (1999) have demonstrated that the target pictograph is perceived with “right-hand” affordances. That is, because of the slant it is easier to grasp the target shape with the right hand than with the left hand.

Finally, imagine two scenarios: (i) the array of nine buttons is on a table in front of the participant and the target button is pressed with the right hand (as in Tipper et al. 1992), or (ii) the array of nine buttons is placed on the floor in front of the participant and the target button is pressed with the right foot. Consider three types of negative priming conditions: hand/hand: responding to the prime and critical trial is with the right hand; foot/foot: responding to both trials is with the right foot; and foot/hand: the prime trial is responded to with the foot and the critical trial is responded to with the hand. In the hand/hand condition there is no need to mesh projectable affordances with nonprojectable information from memory (e.g., “avoid-with-hand”) in order to respond. Instead, the participant can respond on the basis of the perceived affordances of the pictograph: Press the button that more readily affords interaction with the right hand. Because there is no need to mesh projectable affordances with nonprojectable information from memory, the embodied account predicts little negative priming. The suppression account might find this result a bit uncomfortable, but it could explain the finding too: The two pictographs are so distinctive that they do not compete. Therefore, there is no need for suppression on the prime trial and there is no negative priming on the critical trial. Now consider the foot/foot condition. The barbell shapes do not differentially afford responding with the right foot. Hence, when selecting the button to press with the foot, the participant will have to mesh the target button “press” affordance with the nonprojectable “approach-with-foot” information from memory. Similarly, the participant will have to mesh the distractor button’s “press” affordance with the nonprojectable “avoid-with-foot” infor-
ation from memory. On the critical trial, the distractor button is now the target, and hence the “avoid-with-foot” information must now be meshed with the “approach-with-foot” information, and resolving the conflicting information results in negative priming. Whereas the suppression account could explain negative priming in the foot/foot condition (the distractor button must be suppressed), it is difficult for the suppression account to simultaneously predict negative priming in the foot/foot condition and no negative priming in the hand/hand condition.

Finally, consider predictions for the foot/hand condition. Responding with the foot on the prime trial should result in suppression (on the suppression account) and mesh with the “avoid-with-foot” information on the embodied account. On the critical trial, the participant is to respond with the right hand. The suppression account predicts negative priming – that is, slow responding because the target button is suppressed. The embodied account predicts no negative priming for two reasons. First, the participant can respond on the basis of projectable affordances without the need to mesh information from memory: Press the button that most readily affords interaction with the right hand. Second, even if mesh with memory takes place, the “avoid-with-foot” information from the prime trial is irrelevant to the hand movement, and hence the “avoid-with-foot” information should not affect performance.

Our responses to Kurthen et al. and Wright on the one hand, and to Neumann on the other hand, are connected by the idea of affordances. By incorporating afforded action (and affect) into perceptual symbols, those symbols take on the character of intentional representations. That is, the symbols become meaningful by playing a causal role in the behavior of the system. Affordances also obviate the need for a mechanism of internal suppression: When affordances (e.g., this branch affords locomotion) and goals (I need to get from here to there) can be meshed to guide action, there is no need for internal suppression to aid in selecting among responses. On this account, negative priming arises only when action needs to be guided by nonprojectable information from memory.

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Note: The letter “r” before author’s initials stands for continuing commentary. Glenberg 1997t refers to the original BBS target article.

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Race, brain size, and IQ: The case for consilience

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Abstract: Data from magnetic resonance imaging (MRI), autopsy, endocranial measurements, and other techniques show that: (1) brain size correlates 0.40 with cognitive ability; (2) average brain size varies by race; and (3) average cognitive ability varies by race. These results are as replicable as one will find in the social and behavioral sciences. They pose serious problems for Rose's claim that reductionistic science is inadequate, inefficient, and/or unproductive.

Rose (1999) clearly doesn't like much of today's behavioral and brain sciences, which he characterizes as filled with "reductionism," "reification," "arbitrary agglomeration," "ultra-Darwinism," and "neurogenetic determinism." However, his proposed alternatives, auto poiesis and homeodynamic lifelines - inasmuch as they actually involve anything different - are unlikely to generate testable predictions the sine qua non of science. That is why I associate myself with those commentators (like Alcock 1999) who argued that, based on its long track record of success, to assume some sensible degree of reductionistic determinism is the way of science. That is also the view of E. O. Wilson (1998, pp. 30–31), in whose "sociobiological footsteps" I am proud to follow, and who is one of those "ultra-Darwinists" that Rose dismisses. Still, I was surprised that only one of the commentators (Martindale 1999) brought up the relationship between brain size and IQ, and he made mention of a review by Jensen and Sinha (1994) only in passing. No one referred to the remarkable Magnetic Resonance Imaging (MRI) studies showing a correlation of 0.40 existing between brain size and IQ among humans. There are now well over a dozen MRI studies (e.g., Gur et al. 1999; Tan et al. 1999; see Rushton 1995 and Jensen 1998 for reviews). The MRI brain-size/IQ correlation provides a challenge to Rose's anti-reductionism. Brains have evolved via natural selection for behavioral complexity (i.e., intelligence), they show substantial heritable variance and, worst of all from Rose's perspective, they show racial variation at birth, 4 months, 1 year, 7 years, and adulthood (see Fig. 1; Rushton 1997).

Rushton's (1997) study, based on the enormous (N = 35,000)
Collaborative Perinatal Project, also found that at age 7, brain volume estimated from external head size measures correlated 0.20 with IQ scores in the East Asian subsample, just as it had earlier been shown to do in the white and black subsamples (Broman et al. 1987). Although the more accurate MRI measure of brain size yields correlations much higher than the 0.20 in other samples, the head circumference correlation r of 0.20 is still significant. Moreover, the Asian subsample in the study averaged a higher IQ (110) at age 7 than did the white (102) or the black subsamples (90).

The pattern of increasing mean brain size from Africans to Europeans to East Asians is not based on a single isolated study or comparison (sexes combined) from recent studies. Using brain weight at autopsy, volume estimated from external head size measures correlated 0.20 is still significant. More...