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**Multimodal Priming of Abstract Constructs**

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Abstract

Abstract constructs such as morality, warmth, and competence are the bread and butter of social psychology. Their antecedents and consequences have been explored frequently using semantic priming, in keeping with early models of memory representation as a semantic network of concept nodes. Contrary to what these models would predict, sensorimotor experiences in multiple modalities have proven capable of activating abstract constructs, even if they are no more than metaphorically related. In this paper, I review illustrative evidence for multimodal priming of abstract constructs through embodied metaphors. This work has implications for debates about the activation of mental content and the form of mental representation. It also highlights the need to address several thorny issues for theoretical advances.
Social psychologists entertain abstract constructs. Morality, warmth, competence, power, valence—all are meaningful yet not very imageable; they are applicable across various instantiations rather than tied to fixed manifestations [1-4]. To study their antecedents and consequences, priming has become a standard method [5], thanks to the importation of influential cognitive paradigms into social psychology in the 1970s. In its most basic sense, “priming refers to procedures that stimulate or activate some stored knowledge” [6, p.134]. This raises two fundamental questions: (1) What procedures can stimulate or activate abstract constructs? (2) How are these abstract constructs stored or represented?

**Semantic vs. Multimodal Priming of Abstract Constructs**

How abstract constructs are activated depends partly on how they are represented. Early models conceptualize memory representation as a semantic network of concept nodes. To activate a node, one needs to stimulate it, or its associated nodes (from which activation spreads [7]), using semantic stimuli, which were presented mostly in linguistic forms in social psychology, like trait terms [8] or stereotypical concepts [9]. This approach gained tremendous momentum, with countless studies attesting to the consequences of semantic priming [6,10-12].

But does the activation of abstract constructs require linguistic, semantic primes? Or can they be primed by something non-linguistic and much more basic, like low-level sensorimotor cues of perceptual experience? Classic views on priming would predict not, given the dissociation of perceptual representation from semantic and other memory systems [13]. Contrary to this prediction, numerous basic sensorimotor manipulations have been shown to activate abstract constructs [14]. Because sensorimotor experiences in
multiple modalities (e.g., tactile, olfactory, gustatory) can function as effective primes, I call this process *multimodal priming* of abstract constructs.

How can multimodal experiences activate abstract constructs? Through embodied metaphors, according to a rapidly growing body of experimental evidence. To understand this process, two common confusions require clarification.

1. **Conceptual vs. Linguistic Metaphor**

   By metaphor, I mean conceptual metaphor, not linguistic metaphor. “The essence of [conceptual] metaphor is understanding and experiencing one kind of thing in terms of another” [15, p.5] such that “metaphorical entailments can characterize a coherent system of metaphorical concepts and a corresponding coherent system of metaphorical expressions for those concepts” [p.9]. A linguistic metaphor is the surface-level manifestation of a deeper conceptual system of “cross-domain mapping” [16, p.203], typically from sensorimotor experiences (e.g., clean, warm) to abstract constructs (e.g., moral, affectionate).

   Empirically, to study a linguistic metaphor, it obviously has to be present in language. But a conceptual metaphor—if it really exists in the conceptual system—can exert its influence without language [17], through sensorimotor cues like touch, taste, smell, sound, location, and movement [14]. A conceptual metaphor lends itself to multimodal priming.

2. **Metaphorical vs. Nonmetaphorical**

   A metaphorical relation involves cross-domain mapping; a direct, nonmetaphorical relation involves within-domain mapping [15,18,19]. This distinction appears easy enough. But what circumscribes a domain is vague, subjective, context-dependent. For example,
physics and biology are different domains of science. But in the context of university
structure, they may fall within the same domain of natural sciences, as opposed to social
sciences. And natural and social sciences may be jointly considered in the broad domain of
sciences, as opposed to arts. A domain’s scope is anything but fixed.

So how do we tell if two things are in the same or different domains, “directly” or
“metaphorically” related? I propose a two-dimensional space for characterizing different
psychological relations between a bodily domain and an abstract domain (Figure 1). One
dimension reflects the extent to which people find the bodily domain’s
relational/inferential structure to be projectable to the abstract domain. Another
dimension reflects the extent to which people find the bodily domain to be a salient
attribute of the abstract domain.

Both dimensions—structure projectability and attribute salience—are continuous,
conceptual, subjectively construed, and context-sensitive parameters. They are continuous,
not categorical, in that metaphorical and nonmetaphorical relations vary on a continuum
rather than constitute two clear-cut categories. They are conceptual, not linguistic, insofar
as linguistic patterns only inform but do not determine conceptual relations. They are
subjectively construed and context-sensitive, not objectively out there and fixed across
contexts, because which object-attributes are salient and which relational/inferential
structures are projectable depend on the person and the situation. It is tempting to think
that the projectability of relational/inferential structures across domains is an objective
fact, an observer-independent aspect of reality. It is not, because any two domains share an
infinite number of features and between-features relations/inferences. Projectability is
thus not a parameter of what is objectively projectable, which is logically intractable.
Projectability is a parameter of what people find subjectively projectable in specific contexts, which is psychologically tractable, for example, by assessing how many features, relations, and inferences of one domain people spontaneously use in reasoning about another domain, or how easily or fluently they do so.

[Figure 1 here]

In this two-dimensional space, we see four quadrants of effects; these are simplifications of course, given the continuous dimensions. If structure projectability is high, the bodily domain is likely to metaphorize the abstract domain, whether it is a salient attribute of the abstract domain (quadrant 2) or not (quadrant 1). Multimodal primes in the bodily domain should produce full-blown, multifaceted effects on the abstract domain, i.e., embodied metaphorical effects. For example, the relational/inferential structure of bodily disgust (e.g., contamination, purification, rejection) is highly projectable to moral intuition, even though it is a more salient attribute of sexual morality (quadrant 2) than of nonsexual morality (quadrant 1), so disgust exerts embodied metaphorical effects on moral judgments across sexual and nonsexual issues [20,21].

If structure projectability is low, the bodily domain is unlikely to metaphorize the abstract domain. Still, nonmetaphorical effects may result from manipulating the bodily domain if it is a salient attribute of the abstract domain (quadrant 3). For example, head nodding is a salient attribute of mental agreement, so incidental activation of head nodding increased people’s agreement with persuasive messages [22]. While bodily activation of a salient attribute increases its effect, bodily inhibition decreases its effect. For example, smiling is a salient attribute of affective amusement, so unobtrusively inhibiting the facial muscles responsible for smiling decreased amusement with cartoons [23].
If both structure projectability and attribute salience are low (quadrant 4), no effect is expected.

**Multimodal Priming of Abstract Constructs through Embodied Metaphors**

Experimental work on embodied metaphors has grown rapidly in the past 10 years. It shows that sensorimotor cues prime abstract constructs to produce coherent systems of metaphorical effects. Conversely, processing abstract constructs changes metaphorically related sensorimotor experience in multiple modalities [24]. For example, given the metaphorical relation between cleanliness and morality, physical cleansing reduced moral guilt from past transgressions [25] and moral condemnation [26]. Conversely, recalling one’s immoral (vs. moral) experience activated cleansing-related thoughts [25].

Supporting the role of modality in multimodal priming, moral cleanliness has shown modality-specific effects: After doing something immoral with their hands, people favored hand sanitizer, but after doing something immoral with their mouth, they favored mouthwash [27; see also 28]. Effects of moral cleanliness thus appear strongest on whichever modality is momentarily salient. They also appear strongest on whichever modality is chronically salient: In a face culture, where the facial modality has sociomoral significance and chronic salience, immoral behavior specifically potentiates desires for a face-cleaning product and increases spontaneous face-cleaning behavior [29].

Numerous sensorimotor cues across modalities have been found to produce metaphorical effects (Table 1). Tactile and kinesthetic experiences of warm vs. cold, smooth vs. rough, and heavy vs. light elicit changes consistent with their metaphorically related abstract constructs of affectionate vs. aloof, agreeable vs. disagreeable, and important vs. unimportant. Olfactory and gustatory cues of fishy, clean, bitter, and sweet
evoke suspicion, morality, condemnation, and agreeableness. Visual cues of spatial
distance, font size, and vertical location influence judgments of temporal duration,
psychological distance, conceptual similarity, social power, valence, divinity, and
rationality. Motor and interoceptive cues of approach vs. avoidance, forward vs. backward,
and firm vs. loose activate or facilitate processing of transfer of ideas toward vs. away from
oneself, good vs. bad memory, future vs. past, and strong vs. weak self-control.

As is typical in stage 1 of the scientific cycle (loosening), effects abound after a
decade of prolific experimentation, but are open to different interpretations. These deserve
attention [30,31], together with a few thorny issues identified below, as we enter stage 2
(tightening) now.

**Thorny Issues**

**“One-to-Many” Problem**

Most experiments have focused on one-to-one mapping between a sensorimotor cue
and an abstract construct. What about cases where one sensorimotor cue has metaphorical
relations to many abstract constructs? For example, verticality (up) primes such diverse
meanings as good, happy, powerful, dominant, divine, moral, and rational (Table 1). Why is
one bodily domain metaphorically related to multiple abstract domains? Is it because there
are far more abstract meanings our minds can comprehend than physical states our bodies
can actualize [15,32] so some bodily experiences get recruited to scaffold many abstract
meanings?

If so, a given sensorimotor cue may prime several abstract constructs, and which of
them exerts influence on an outcome should depend on personal and situational factors.
For example, if a task requires attention to one abstract construct (e.g., power) over
another (e.g., valence), then a sensorimotor cue (e.g., up) is more likely to exert influence through the attended than the unattended construct [33]. A sensorimotor cue (e.g., clean) is also more likely to exert influence through an abstract construct that is chronically accessible (e.g., face [29,34]). I suspect traditional principles of knowledge activation and use (e.g., accessibility, applicability, salience [6]) may characterize multimodal priming effects in context [24]. This context-sensitive view may shed light on ways to resolve the one-to-many problem in embodied metaphorical effects.

**Explanations for Multimodal Priming**

Theoretical predictions about moderating variables are emerging [24,35-37]. Testing them with facilitatory and inhibitory paradigms holds promise for revealing proximal mechanisms underlying multimodal priming. In so doing, what look like different effects may be unified by a single mechanism; what look like the same effect may be mediated by multiple mechanisms, in which case they can be teased apart by testing their signature predictions against each other.

For example, if an embodied metaphorical effect occurs by activating goals (vs. concepts), then it should increase (vs. decrease) with time, because unsatisfied goals become more motivating over time, whereas concepts become less accessible over time [38]. If an embodied metaphorical effect is driven by feelings-as-information, then it should be weakened by attributing the bodily feeling to a plausible source, because attribution undermines the feeling’s informative value [39].

Beyond these proximal mechanisms, developmental, evolutionary, and functional explanations [40] for multimodal priming remain crude and need fleshing out [41-43].

**How are Abstract Constructs Represented?**
Seeing how many abstract constructs are primeable by multiple sensorimotor modalities, it is tempting to assume that abstract constructs are represented in multiple sensorimotor modalities [18]. The evidence is compatible with, but does not lend unequivocal support to, this strong claim.

Consider three perspectives on cognition (Figure 2). In the traditional view of semantic priming (perspective 1), linguistic or pictorial stimuli activate knowledge, which is represented in a semantic network of amodal symbols, with spreading activation from one node to another. In the weak embodied view of multimodal priming (perspective 2), multiple sensorimotor modalities are channels for activating knowledge, which is still represented as amodal symbols but associated with sensorimotor processes [42]. In the strong embodied view of multimodal priming (perspective 3), multiple sensorimotor modalities are used in simulating knowledge, which is represented in sensorimotor systems [41], and metaphors predict which abstract constructs are grounded in which sensorimotor activities [15,18].

Multimodal priming is predicted a priori by perspectives 2 and 3, but not 1 (unless post hoc assumptions are added). As such, the evidence favors perspectives 2 and 3 but does not distinguish between them. Hybrid perspectives involving both amodal and modal representations have also been offered [44] but lack parsimony.

Evidence of multimodal priming, when considered in conjunction with other issues, nudges me toward the strong embodied view (perspective 3). First, it predicts that linguistic and motoric processes influence each other, as borne out by social and cognitive experiments [9,45-50]. Second, it resolves the symbol grounding problem [44]; the other perspectives do not. Third, it assumes cognitive representation in sensorimotor systems,
for which there is neural evidence, whereas the other perspectives assume the existence of an additional layer of mental representation (amodal symbols), for which there is no clear evidence [41].

While these considerations are important in their own right, they are not incompatible with social psychologists' concern with contextual influences on thinking, feeling, and doing, which motivated social priming research. As far as this is concerned, the reviewed work unequivocally shows that diverse sensorimotor experiences in multiple modalities can prime abstract constructs of social interest.

**Acknowledgements**

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References


- This book contained contributions from social, personality, and cognitive psychologists. They reviewed the burgeoning research on embodied metaphors and their pervasive influence on memory, thought, action, emotion, judgment, and decision making. Effects are manifest in contexts of culture, morality, politics, intergroup relations, and public opinion.


- This paper applied the social cognitive principles of knowledge activation and use to embodied metaphorical effects. It argued that contrary to common assumptions, metaphorical effects should run bidirectionally between bodily states and abstract constructs (e.g., clean <-> morality, fishy <-> suspicion). It predicted that metaphorical effects are mediated by the accessibility of metaphorically associated concepts and moderated by their applicability in context.


- This empirical paper reported four elegant experiments demonstrating that threats to the moral self elicited thoughts about and desires for physical cleansing and that physical cleansing weakened the emotional and behavioral impact of threats to the
moral self. It sparked interest in moral cleansing and many other embodied metaphors.


[38] Förster J, Liberman N, Friedman RS: **Seven principles of goal activation: A systematic approach to distinguishing goal priming from priming of non-goal constructs.** *Pers Soc Psychol Rev* 2007, **11**:211-233.


- This paper rejected prevailing amodal theories of cognition and proposed a formal perceptual theory of knowledge and thought for cognitive science and neuroscience. It sparked a vigorous debate about the role of perceptual processes like bodily states in cognitive functions like abstract thought.


- This paper highlighted a fundamental problem of purely symbolic models of the mind. The problem is that amodal symbols, which are arbitrary tokens, by themselves cannot give rise to any meaning. They have to be grounded in nonsymbolic representations. This problem is resolved by embodied models to the extent that they ground abstract constructs in nonsymbolic, nonarbitrary bodily states.


Table 1. Examples of multimodal priming of abstract constructs through embodied metaphors.

<table>
<thead>
<tr>
<th>Modality</th>
<th>Manipulation</th>
<th>Effect</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tactile</td>
<td>Briefly holding a warm (vs. cold) beverage or therapeutic pack</td>
<td>Increases perception of a target as interpersonally warm; increases likelihood of making a prosocial choice</td>
<td>Williams &amp; Bargh, 2008a</td>
</tr>
<tr>
<td>Tactile</td>
<td>Briefly holding a warm (vs. cold) beverage or being in warm (vs. cold)</td>
<td>Increases the sense of interpersonal overlap</td>
<td>IJzerman &amp; Semin, 2009</td>
</tr>
<tr>
<td>Tactile</td>
<td>Briefly holding a warm (vs. cold) therapeutic pack</td>
<td>Increases monetary investment in a trust game</td>
<td>Kang, Williams, Clark, Gray, &amp; Bargh, 2010</td>
</tr>
<tr>
<td>Tactile</td>
<td>Playing a puzzle with rough (vs. smooth) pieces</td>
<td>Increases perception of a social interaction as difficult and adversarial; increases monetary offers in an ultimatum game</td>
<td>Ackerman, Nocera, &amp; Bargh, 2010</td>
</tr>
<tr>
<td>Tactile</td>
<td>Touching rough sandpaper (vs. smooth paintbrush)</td>
<td>Increases perception of a social interaction as difficult and adversarial, which is strongly associated with activation of somatosensory brain regions</td>
<td>Schaefer, Denke, Heinze, &amp; Rotte, 2013</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Filling out a survey presented on a heavy (vs. light) clipboard</td>
<td>Increases judged importance of information in the survey; increases elaborate processing of the information</td>
<td>Jostmann, Lakesn, &amp; Schubert, 2009; Ackerman, Nocera, &amp; Bargh, 2010</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Carrying a heavy (vs. light) shopping bag</td>
<td>Increases judged importance of information in the survey</td>
<td>Zhang &amp; Li, 2012</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Filling out a survey presented on a heavy (vs. light) clipboard</td>
<td>Increases judged importance of information in the survey, especially if it concerns a near (vs. far) event</td>
<td>Maglio &amp; Trope, 2012</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Inserting concealed weight into a book</td>
<td>Increases judged importance of the book if people have enough knowledge to form a judgment about it</td>
<td>Chandler, Reinhard, &amp; Schwarz, 2012</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Inserting concealed weight into a book</td>
<td>Increases judged importance of the book if people have done enough thinking about it</td>
<td>Hauser &amp; Schwarz, 2015</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Holding a heavy (vs. light) clipboard</td>
<td>Increases estimated seriousness of diseases and estimated effectiveness of drugs</td>
<td>Kaspar, 2013</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Holding a heavy (vs. light) clipboard or heavy (vs. light) pillow boxes</td>
<td>Increases judgment of one’s own learning of information</td>
<td>Alban &amp; Kelley, 2013</td>
</tr>
<tr>
<td>Olfactory</td>
<td>Incidental exposure to fishy (vs. non-fishy bad or neutral) smells</td>
<td>Decreases monetary investment in a trust game or a public goods game</td>
<td>Lee &amp; Schwarz, 2012</td>
</tr>
<tr>
<td>Olfactory</td>
<td>Incidental exposure to fishy (vs. neutral) smells</td>
<td>Increases sensitivity in detecting trick questions; increases performance on Wason rule discovery task</td>
<td>Lee, Kim, &amp; Schwarz, 2015</td>
</tr>
<tr>
<td>Olfactory</td>
<td>Clean scents (vs. no scent) in a room</td>
<td>Increase moral behaviors such as reciprocating money and volunteering time</td>
<td>Liljenquist, Zhong, &amp; Galinsky, 2010</td>
</tr>
<tr>
<td>Gustatory</td>
<td>Bitter (vs. sweet or neutral) tastes</td>
<td>Increase gustatory disgust response and moral condemnation, especially among conservatives</td>
<td>Eskine, Kacinik, &amp; Prinz, 2011</td>
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<tr>
<td>Gustatory</td>
<td>Both bitter tastes and immoral behaviors</td>
<td>Increase activation of facial muscles responsible for oral-nasal rejection (levator labii)</td>
<td>Chapman, Kim, Susskind, &amp; Anderson, 2009</td>
</tr>
<tr>
<td>Gustatory</td>
<td>Sweet (vs. nonsweet) tastes</td>
<td>Increase self-reported agreeableness and helping behavior (&quot;sweeter personalities&quot;)</td>
<td>Meier, Moeller, Riemer-Peltz, &amp; Robinson, 2012</td>
</tr>
<tr>
<td>Gustatory</td>
<td>Sweet (vs. nonsweet) tastes</td>
<td>Increase favorable evaluation of hypothetical relationships and interest in initiating a romantic relationship</td>
<td>Ren, Tan, Arriaga, &amp; Chan, 2014</td>
</tr>
<tr>
<td>Visual</td>
<td>Seeing lines grow in length to be much (vs. a little) longer within a fixed amount of time</td>
<td>Increases judgment of their duration on screen</td>
<td>Casasanto &amp; Boroditsky, 2008</td>
</tr>
<tr>
<td>Visual</td>
<td>Marking off two points that are far apart (vs. moderately apart or close together) on a paper grid</td>
<td>Decreases strength of social bonds with one's family and hometown; decreases estimated caloric content in unhealthy food; decreases negative affect from reading a violent story; increases enjoyment of an embarrassing story</td>
<td>Williams &amp; Bargh, 2008b</td>
</tr>
<tr>
<td>Visual</td>
<td>Seeing two abstract nouns presented far apart (vs. close together)</td>
<td>Decreases judgment of their similarity</td>
<td>Casasanto, 2008</td>
</tr>
<tr>
<td>Visual</td>
<td>Seeing big (vs. small) font sizes</td>
<td>Increases speed and accuracy of judging groups as powerful (vs. powerless)</td>
<td>Schubert, Waldzus, &amp; Giessner, 2009</td>
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<tr>
<td>Visual</td>
<td>Seeing powerful groups presented at the top (vs. bottom) and powerless groups at the bottom (vs. top) of the screen</td>
<td>Increases speed of finding both groups and judging their power</td>
<td>Schubert, 2005</td>
</tr>
<tr>
<td>Visual</td>
<td>Seeing an organizational chart with greater (vs. less) vertical separation between the manager and subordinates</td>
<td>Increases judgment of the manager's leader power</td>
<td>Giessner &amp; Schubert, 2007</td>
</tr>
<tr>
<td>Visual</td>
<td>Seeing positive words presented at the top (vs. bottom) and negative words at the bottom (vs. top) of the screen</td>
<td>Increases speed of evaluating their valence</td>
<td>Meier &amp; Robinson, 2004</td>
</tr>
<tr>
<td>Visual</td>
<td>Seeing God-related words presented at the top (vs. bottom) of the screen</td>
<td>Increases speed of categorizing them as related to God rather than to the Devil</td>
<td>Meier, Hauser, Robinson, Friesen, &amp; Schjeldahl, 2007</td>
</tr>
<tr>
<td>Visual</td>
<td>Seeing unfamiliar stimuli (Chinese characters) presented at the top (vs. bottom) of the screen</td>
<td>Increases judgment of Chinese characters as fitting for a statistical website, which has rational connotations (vs. a dating website, which has emotional connotations)</td>
<td>Cian, Krishna, &amp; Schwarz, 2015</td>
</tr>
<tr>
<td>Motor &amp; intero-</td>
<td>Moving index finger from a</td>
<td>Increases speed of judging sensibility of sentences that describe abstract transfer of ideas toward (vs. away</td>
<td>Glenberg &amp;</td>
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<td>ceptive</td>
<td>middle to a close (vs. far) key from) oneself</td>
<td>Increases speed of retelling and amount of retrieval of positive (vs. negative) memories</td>
<td>Kaschak, 2002</td>
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<tr>
<td>Motor &amp; interoceptive</td>
<td>Moving marbles upwards (vs. downwards)</td>
<td>Increases judgment of proximity of three weeks in the future (vs. past)</td>
<td>Casasanto &amp; Dijkstra, 2010</td>
</tr>
<tr>
<td>Motor &amp; interoceptive</td>
<td>Forward (vs. backward) spatial movement</td>
<td>Increases behaviors that require firming one’s willpower (e.g., donating money to an unpleasant charity appeal, drinking a healthy by awful-tasting tonic)</td>
<td>Caruso, Van Boven, Chin, &amp; Ward, 2013</td>
</tr>
<tr>
<td>Motor &amp; interoceptive</td>
<td>Firming one’s muscles (e.g., hand, calf, biceps)</td>
<td></td>
<td>Hung &amp; Labroo, 2011</td>
</tr>
</tbody>
</table>
Figure 1. A two-dimensional space, with examples, for characterizing different psychological relations between a bodily domain and an abstract domain. Structure projectability reflects the extent to which people find the bodily domain’s relational/inferential structure to be projectable to the abstract domain. Attribute salience reflects the extent to which people find the bodily domain to be a salient attribute of the abstract domain.
**Figure 2.** Three perspectives on cognition (denoted by the ellipse), varying on how abstract constructs are activated (by what stimuli) and represented (in what form).

(1) Traditional view of semantic priming

(2) Weak embodied view of multimodal priming

(3) Strong embodied view of multimodal priming

(1) vs. (2 & 3): Debate about the activation of mental content

(1 & 2) vs. (3): Debate about the form of mental representation