Narrative Review Article

Theories of Distributional Models, Embodied Cognition and Hybrid Approaches on Acquisition of Abstract Concepts in Human Cognition

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ABSTRACT

Understanding human comprehension of the origin and purpose of lexical words beyond their mere sensory features (e.g. how they look when they are written or how they sound when they are pronounced), also known as the "symbol grounding problem" remains one of the most profound challenges in cognitive sciences. It is particularly challenging for abstract concepts because they lack tangible references in the surrounding world for intuitive and universal understanding of their true meaning. In cognitive science, there are two major theories: the distributional model and embodied cognition model. However, the distributional model struggles with how words become meaningful, and the embodied approach is limited in explaining highly abstract ideas. Since both major approaches have critical gaps in their explanations of abstract concept comprehension, an alternative approach is needed to bridge these gaps and provide a more comprehensive understanding of human concept acquisition. This review examines how the distributional model, the embodied approach, and the hybrid model explain abstract concept acquisition, by referencing relevant empirical evidence. The review also discusses the strengths and limitations of both models, explaining why it is important to adopt an alternative approach.

Keywords: Abstract Concepts; Distributional Model; Embodied Cognition; Sensorimotor; Language; Metaphors; Familiarity

INTRODUCTION

How do humans construct, obtain, and communicate meanings of abstract words, such as "justice" or "freedom"? This profound question lies at the heart of one of the major theoretical debates in cognitive sciences: the symbol grounding problem, which questions how symbols acquire meaning beyond just being meaningless symbol tokens (1). To address this problem, two dominant frameworks have emerged: the distributional model and embodied cognition.

The distributional semantic model posits that abstract concepts' meanings are determined by the frequency of their co-occurring words in a specific or altered context. Words infer their meanings through association with other words and through measuring the similarity of the contexts in which words appear (2). For example, the representation of the word *authority* has lexical connections with *king*, which are associated with words like *man, power, rules*. These words are associated with one another due to their frequent co-occurrences in a similar context. In contrast, the embodied approach suggests that the meanings of abstract concepts, at least to an extent, emerge through sensorimotor simulation. Meaning is grounded in our lived experiences within our environment, along with the introspective states and

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emotional systems when the concept was acquired.

While each approach provides compelling explanations for the process of concept acquisition, both contain limitations when applied to abstract concept comprehension.

The theoretical gaps in the two mainstream models leads to the necessity of an alternative approach which suggests a synthesis of the distributional model and embodied cognition to explain abstract concept comprehension. This review therefore examines how distributional and embodied models address and explain abstract concept acquisition, and evaluates their strengths and weaknesses with the support of empirical or scientific evidence. The review argues that abstract concept acquisition should consider an integration of both approaches.

ABSTRACTNESS OF ABSTRACT CONCEPTS

Concepts and meanings are crucial components for nearly all aspects of human cognition, and are broadly categorized based on their sensorimotor accessibility: concrete and abstract concepts. Concrete concepts refer to concrete objects that are directly accessible through sensory interaction via sensory modalities, i.e. the five senses: vision, audition, olfaction, gustation, and tactile (3, 4). This is because they have direct corresponding physical features such as tables, chairs, and coffee. In contrast, abstract concepts are intangible ideas, emotions, or social constructs, devoid of direct reference to the external environment; they lack direct sensory correlation with the world. In other words, unlike concrete concepts, abstract concepts lack “obvious physical referents” (5). This is what Dove called the problem of disembodiedment of abstract concepts due to the difficulty of sensory grounded representations (4, 6).

The problem of disembodiedment is tightly associated with the explanation provided by the Sensory Model of Meaning’s explanation of how concepts are encoded in cognition. The perceptual experiences (including visual details, tactile information, and auditory information) occurring during the encoding stage of a new word are stored in sensory modalities in the brain and become part of our long-term memory (3). When the word is recalled, the perceptual representation that is stored in the same neural networks as the sensorimotor circuitry originally involved in the encoding process is reactivated (7). This demonstrates the importance of sensory accessibility of a concept in the process of encoding and storing for long-term uses in the real-world.

However, abstract concepts are not completely divorced from sensory inputs since they are at least partially experienced through the senses or have internal introspective states that correspond to them (e.g., thoughts, emotions, or perhaps memory). Therefore, the abstractness of abstract concepts is better understood as a continuum rather than a strict dichotomy in psycholinguistic perspectives (2).

In psycholinguistics, abstract concepts are determined by two psycholinguistic variables called “abstractness” and “imagery”. “Abstractness” is the degree to which a concept can be perceived directly through direct access to sensory modalities (8–10). “Imagery” is the measure of the extent to which subjects can trigger the retrieval of images of instances of the respective category or scenario (triggering episodic memory that might associate a relevant emotion or sensorimotor pattern derived from that episodic memory, i.e. grounded; (9, 11)). “Imagery” variable is further clarified by Paivio’s dual-coding theory, where lexical abstract concepts rely on two systems: verbal representational system (direct linguistic symbols) and the nonverbal representational system (elicit associated imagery/episodic memory). Specifically, a word (verbal system) activates the nonverbal system, pulling up imagery or past episodic memories. This helps to make sense of the concept by linking past sensory experiences, thereby understanding the word’s meaning with stronger attachment to the external environment (8). Therefore, the input or stimulus elicits a verbal representational system, and the consequential activation will always lead to the activation of non-verbal systems that utilize imagery-related episodic memory to grasp a concept, highlighting the importance of “imagery”.

To exemplify the continuum of abstractness and imagery, one may consider “gratitude” in comparison to “justice”. The concept of “gratitude” evokes emotional experiences, such as feeling thankful and warm-hearted, giving it a low abstractness level. It also has a high imagery level because it triggers associated episodic memories, such as the action of saying “thank you” that is highly relevant to “gratitude”. These memories might vary based on the specific individual’s personal connection that is grounded in sensory modalities. In contrast, the abstract concept “justice” might be more abstract due to the absence of a direct, linear emotional state that can be triggered, rather, triggering multiple emotional states due to the complexity and low intuitiveness of the concept itself. Often, a wide range of objects/experiences are associated with “justice”: a symbolic gavel stimulating the visual cortex, recalling a courtroom, triggering spatial senses via the somatosensory cortex, or even allegories/scenarios that imply justice. Therefore, the abstractness of "justice" is relatively high compared to "gratitude" due to the complex emotions elicited and associations inducing ambiguity. This same complexity accounts for its ("justice") lower, more fragmented imagery level. This comparison demonstrates the dynamic and flexible boundary of abstract concept categories defined by "abstractness" and "imagery" as two critical determining variables.

DISTRIBUTIONAL MODEL

The Distributional Model offers significant insights into the solution to the problem of abstract concept acquisition. This model assumes that a word's meaning is derived as a function of the "company it keeps", i.e. the linguistic context and frequency of co-occurrences between lexical representations (12). This approach is fundamentally important for abstract concept acquisition, as language provides the mediational pathway for expressing and learning concepts through symbolic representations.

The distributional model exemplifies an amodal approach to semantic representation. In an amodal symbol system, the concepts are represented by perceptually-free and modality-free symbols that do not resemble the physical characteristics of the concept or object they are describing in the real-world (13, 14). For example, the symbol for a table (as a real-world entity that physically exists) has no resemblance to the texture, shape, or structure of the actual object itself. Similarly, for abstract concepts like *justice*, the symbol contains no perceptual content. Therefore, amodal representation is independent of the perceptual or sensory format exhibited by the described object, thus, operates equivalently for both concrete and abstract concepts.

The distributional model operationalizes the amodal framework into computational analysis and measurable statistical patterns of word co-occurrences. By measuring lexical similarity based on contextual overlaps, the meaning of a word is determined based on its functional role in linguistic context. Essentially, the model holds that words with similar meanings appear in similar contexts, and co-occurrences provide the natural basis of semantic representations (15). For example, in the distributional model, books have lexical associations with *learning, knowledge, libraries,* and *genres* because these words often occur together (co-occur) in similar language contexts. This creates semantic representation through linguistic patterns rather than perceptual features or physical referents. For abstract concepts that lack sensory correlates, which are less directly accessible through modality pathways, in the distributional model, their meaning is largely constituted by their position in the network of linguistic associations and contexts.

While the core principle remains consistent, a concept's meaning derives from statistical, distributional co-occurrence patterns– the specific approaches to extracting and analyzing these patterns vary across sub-models. Latent Semantic Analysis is one of the subtheories of distributional models that demonstrates the computational validation of distributional principles. This count-based model analyzes and computes word co-occurrence frequencies across large corpora (2). The model applies a specific reductionist technique, emphasizing how words with similar meanings appear in similar contexts, creating amodal representations from text corpora and word's contextual functions. Implementation of this principle allows this count-based system to excel in the synonym section of the Test of English as a Foreign Language (TOEFL), showcasing the power of distributional statistics in capturing the relationship between words and contexts. The Latent Semantic Analysis program designed by Bullinaria and Levy in 2007 achieved 85.0% accuracy (12), surpassing the average 64.5% scored by actual non-English speaking applicants (16). This successful result reflects the model's sense-making effectiveness, using statistics to capture semantic relatedness, exemplifying the computational strength of the distributional model.

The successful performance on the TOEFL demonstrated the Latent Semantic Analysis model's ability to simulate human semantic reasoning without having real-world experiences. Landauer argues that if a machine could pass a language test designed for humans while relying solely on word-context co-occurrence statistics, the "meaning of words" in the human mind is partially contained within these statistical patterns of language (Latent Semantic Analysis: A Theory of the Psychology of Language and Mind, Thomas K Landauer).

On a biological basis, Hebbian cell assemblies provide the neurological mechanism that explains how the human brain performs the statistical "count" of co-occurrences simulated by models like Latent Semantic Analysis. Psychologists found that widespread cortical areas in the brain activate when humans engage in language-related tasks. The Hebbian approach assumes that the synaptic connections strengthen between neurons from different but adjacent cortical regions, if frequently activated simultaneously (17). Over time, these cortical connections lead to the co-activation of neurons, strengthening the synaptic connection and forming Hebbian cell assemblies. The strong internal connections between neurons enable neuronal assemblies to activate as a unified whole when a critical proportion of constituent neurons fire (18). Therefore, the Hebbian cell assembly is a functional unit of memory for the concepts that often appear together in information processing. This implies that co-occurring words activate cortical regions, frequent co-occurrence leads to frequent co-activation, thus strengthening the neural connections, which mirrors the idea of statistical counting of co-occurrence patterns.

These assumptions have been validated in a recent experiment by Carota *et al*. 2021 (19) , using functional magnetic resonance imaging technique (fMRI) to provide strong neuroscientific evidence for Hebbian cell assemblies underlying distributional model. The study showed a similar correlated activity pattern between the computational model's semantic comprehension and a distinct fMRI pattern in a network of fronto-temporal and inferior parietal regions, specifically the Left Inferior Frontal Gyrus (19). This observation suggest that the Left Inferior Frontal Gyrus is a higher-order region in representing semantic similarities based on statistical co-occurrence patterns, establishing "word-word" associations, where its activity does not fit into traditional taxonomic models but is well-predicted by the distributional model, tested via Word2Vec, a computational program (19). This correspondence between neural activation patterns and the predicted computational distributional patterns illustrates the validity of the distributional model in explaining the biological mechanism of concept acquisition. These findings suggest a neural implementation of distribution, showing how brain responses to lexical meaning reflect qualitatively distinct types of semantic relations (both concrete and abstract contained within Hebbian cell assemblies) correspond to unique neural topographies distributed across cortical regions (20).

Although the evidence provides strong support for the distributional approach to understanding and acquiring the meaning of concepts, the model still faces limitations and gaps. While the computational model's (Latent Semantic Analysis model) performance on the TOEFL test captures semantic structure and relationships, such standardized tests assess pattern recognition rather than of genuine conceptual understanding or generative language uses. Furthermore, although the Carota *et al*. (2021) study provides evidence for the neural implementation of distributional semantics, the model remains limited to capture the full semantic content of concepts.

Limitations of the Distributional Model

Despite distributional models like Latent Semantic Analysis achieving outstanding performance on specific linguistic tasks, the model is constrained in its ability to fully explain human semantic concept understanding. Fundamentally, this model still remains amodal, relying solely on linguistic corpus data as input and lacking mechanisms to explain how the words it processes and stores are linked to real-world referents or lived concepts (3). These limitations emerge on empirical, theoretical, and philosophical levels.

First, the Carota *et al*. (2021) neuroimaging study shows that, despite computational success and neuroscientific plausibility, distributional models still face fundamental limitations in explaining human semantic understanding. The study demonstrated that the distributional model significantly predicted neural activation patterns in the Left Inferior Frontal Gyrus and Angular Gyrus revealed by fMRI imaging, providing neuroscientific validation for co-occurrence based semantic representation. However, the same fMRI results also revealed the involvement of cortical regions and sensory-motor neurons alongside language regions during semantic processing (19). This directly indicates that sensory-motor grounding is necessary for language comprehension and concept acquisition beyond statistical patterns alone, requiring physical and embodied sensory experiences to capture comprehensive and real-world inferential meanings of words. Therefore, the statistical distributional model cannot comprehensively explain human concept acquisition.

Furthermore, on a philosophical level, the model can simulate semantic similarity but cannot explain why words matter to humans, highlighting the symbol grounding problem of the distributional model. This issue is famously demonstrated by Searle's Chinese Room thought experiment (21). Searle proposed a thought experiment where a person who knows no Chinese is placed in a room to receive Chinese input symbols. The person manipulates the symbols based solely on their appearance and syntactic structure, following explicit rules also encoded as physical tokens. Finally, the person produces an output that appears meaningful to a Chinese speaker despite the manipulator's lack of understanding of the language itself. This process simulates a computer's working mechanism, highlighting how this operation (rule-governed manipulation relying on analysis of a token's shape) does not allow computers to understand Chinese or words' true meaning. This experiment draws a distinction between semantic interpretability and intrinsic meaning. The symbols in the experiment are systematically interpretable as having meaning; however, the semantic interpretation based on pattern and shape recognition is not intrinsic to the symbols themselves.

Therefore, although the distributional model offers valuable insights into the importance of lexical context for comprehension of specific concepts, it leaves the symbol grounding problem unsolved. This essential issue highlights the limitations in this model's ability to fully address human cognition and the genuine semantic understanding in relation to the physical world around us. Therefore, an alternative perspective is needed to address how sensory experiences are involved in encoding a word's real-world meaning. This idea is explored in the embodied cognition approach, which argues that meanings are grounded in lived sensorimotor experiences in the physical and social world.

EMBODIED COGNITION APPROACH

Beyond the distributional approach to concept acquisition, another valuable alternative perspective in cognitive science is the embodied cognition approach. Embodied cognition rejects the notion of disembodied symbols that represent the meaning of words through statistical and inferential relationships, and argues that symbols are inherently embodied. Embodied cognition researchers suggest that meaning is deeply grounded in our sensory, motor, and social experiences in the world (22): we obtain concepts (including abstract ones) not from abstract rules or amodal "imagineless thoughts", but from lived experiences. This perspective offers a novel, empirically grounded framework for explaining abstract concept acquisition, how we successfully learn and represent such concepts, and resolving the symbol grounding problem. This section examines the two major subtheories within the embodied approach: Perceptual Symbol System (PSS) and Conceptual Metaphor Theory (CMT).

Perceptual Symbol System (PSS)

The PSS proposed by Barsalou is one of the most direct subtheories that addresses embodied cognition's core principles (4, 5). The theory argues that all concepts–including abstract ones–arise in sensorimotor systems. "Perceptual states" are a reenactment of experiences via reactivation of perceptual symbols–neural representations situated in the same sensorimotor areas of the brain that produced them– stored in modality-specific brain regions (4). During initial encoding, neural activations arising from perception of a concept are recorded and stored in long-term memory (4). When the concept is retrieved later, the perceptual representations reactivate the identical sensorimotor circuitry or neural networks originally involved in encoding (7).

This mechanism also applies to abstract concepts: retrievals reactivateS associated emotions and images, particularly for those with low abstractness and high imagery details. By simulating the symbolic perceptual components relating to the targeted concept, a more imagistic and concrete understanding can be obtained. For instance, the concept of *freedom* is grounded and situated in lived experience, where the brain "replays" the stored senses. A more specific example is kinesthetic movements without obstructions implying the concept of *freedom* – i.e. freedom of mobility – might stimulate the visual cortex (simulating visual images) and motor cortex (simulating running freely).

However, how would various separate sensory experiences (such as the visual and motor cortex corresponding to visual and action experiences) integrate to form a complete picture or understanding of a concept across sensory modalities? This problem of integrating and connecting fragmented sensory experiences to make sense of a concept is what Damasio called the "binding problem" in modal symbol systems. The "binding problem" refers to the issue of integrating sensorimotor fragments collected across space and time to form a holistic image of a concept (23). The neural inputs acquired from sensorimotor engagement occur in fragmented forms and in geographically separated cortices located in modal sensory cortices (visual, somatosensory, limbic, etc.). The brain's perception of external reality and its record is a multiple-site neurophysiological affair with differences in time and space. This requires integration of multiple aspects both within and across modalities, structuring fragments of features into entities, and binding entities into meaningful events.

This is where Damasio proposed a tailored solution: the convergence zones (CZs). The CZ exists as multi-layered neural ensembles that generate synaptic patterns in association cortices. They bind neural activity patterns that correspond to topographically organized fragment descriptions of physical structures, which become meaningfully connected because they co-occurred simultaneously or in sequence in the real world (24). The rule for such binding is that if there are similarities in spatial placement (things located relative to each other), temporal coincidence (happened at the exact same time), or temporal sequence (occurred in order relative to each other), or any combination of the above, they will be grouped together. CZs are located throughout the cerebrum cortex, at multiple neural levels, in association cortices of different orders, limbic cortices, subcortical limbic nuclei, and non-limbic subcortical nuclei such as the basal ganglia (24). Recalling the "freedom" example aforementioned, a holistic image for this concept consists of movement, space, and autonomy, which are clusters of sensorimotor fragments that are bound together in convergence zones to make sense and become vivid.

Crucially, convergence zones do not passively process the information they receive, they are actively being shaped by the interactions we have with our surroundings. The CZ receives feedforward loops from cortical regions and reciprocally sends feedback loops to the original sensory/motor cortices that contributed to generating the concept in the first place (13). While the convergence zone is fundamentally controlled by genetics, its bidirectional connectivity allows environmental interactions to modify the strength of neural connections and determine which patterns are bound between sensory regions (13, 24). This showcases how through repeated experiences, new neural patterns can be learned and encoded representations can be upgraded, demonstrating how concept acquisition is actively shaped by lived sensorimotor experiences, i.e. embodied.

These theoretical claims about sensorimotor grounding of concept acquisition have been empirically validated through neuroimaging research. For instance, neuroimaging study conducted by Hauk *et al*. (2004), using fMRI technique suggests that modality-specific brain regions activate when comprehending lexical concepts. Hauk *et al*.'s (2004) observation of motor regions' activation 200-300ms after stimulus presentation supports how sensorimotor regions are involved in semantic representation activities, showing how activated motor and premotor regions elicited by the action verbs correspond to a similar activity pattern observed as if physically carrying out the referred movement (25). This supports the relationship between embodiment and perceptual symbols. The fMRI scan showed that passively reading action words referring to face, arm, or leg actions (including lick, pick, or kick) can activate neurons in the primary motor cortex. These activations occur in areas directly adjacent to or overlapping with the brain areas activated by actual movements of the tongue, fingers, and feet (25). These results support that the perception of action verbs has specific correspondent underlying somatotopic activations of motor and premotor cortex, validating embodied approaches for concrete concepts.

Further evidence validating the embodied approach is the congruence between visual depictions and linguistic semantics that enhances concept comprehension efficiency. When congruence is established between the picture depicted and the implied orientation of the object in a sentence/text (26, 27), it is easier and quicker for the brain to respond and make sense of the lexical representation (sentence) and grasp its meaning. For example, participants are likely to respond quickly to pictures depicting a cat sitting on a mat when reading sentences that describe a cat sitting down, but respond slower when reading a sentence that describes a running cat. This effect allows researchers to conclude how perceptual manipulation (such as changing a visual depiction) could be capable of interfering with the conceptual processing involved in language comprehension (26–28). The delay in response time due to modality switches underscores the perceptual and sensorimotor basis of semantic comprehension, showing how the meaning of words can be better acquired through dynamic interaction between conceptual processing and perceptual manipulation.

These findings validate embodied approaches for concrete concepts, demonstrating how sensorimotor experiences ground meanings through a perceptual symbol system. However, the studies have focused primarily on concrete concepts, leaving a gap in explaining how highly abstract concepts are grounded, like *justice*, *freedom*, or *hope* that lack direct obvious physical or sensory referents with high abstractness and low imagery levels. In the Hauk *et al*. (2004) study, the action verbs examined are all concrete actions with direct sensorimotor correlates and low abstractness. Similarly, in the word-image congruency study, the lexical concepts tested are all concrete objects that can be depicted and presented easily, suggesting their high imagery level. This raises the question: How can abstract concepts be embodied? Linguistic evidence reveals that metaphors reduce abstractness and aid in grasping new complex concepts. This framework is formalized as Conceptual Metaphor Theory (CMT) developed by Lakoff and

Johnson, 1980. Conceptual Metaphor Theory addresses this challenge by proposing that abstract concepts are grounded through metaphorical mappings from already embodied concrete source domains to abstract target domains.

Conceptual Metaphor Theory (CMT)

When highly abstract concepts or sentences are decomposed into simpler metaphors, the creation of more vivid imagery reduces abstractness and increases imagery level, facilitating the comprehension of lexical meaning. Conceptual Metaphor Theory describes how one conceptual domain (target domain, which is typically abstract) is understood through another domain (source domain that is typically concrete). By establishing metaphorical expressions known as conceptual metaphors, more effective concept comprehension is fostered with the involvement of sensorimotor engagement that systematically corresponds to the two domains (3).

For example, the phrase ‘exploding with anger’ metaphorically describes the aggressiveness and degree of anger, which potentially implies impulsive actions. “Exploding” first suggests that the outbreak of anger is extreme following long compression, causing the sudden ‘explosion’. The term ‘exploding’ acts as the source domain providing rich sensory information, eliciting sensations of heat, fear, or fire, creating a vivid imagery that might activate the somatosensory, visual, and tactile cortical regions, facilitating a deeper understanding of ‘anger’, the target abstract domain.

This is supported by an empirical study comparing somatotopic activation patterns in the motor cortex when depicting literal and idiomatic expressions of the same concept in participants (such as ‘Pablo kicked the ball’ vs. ‘Pablo kicked the habit’ (26, 29). The fMRI results support the claim that both expressions assist the understanding of semantics via sensorimotor simulations of concrete components in the metaphor representation (26). The presence of concrete action verbs elicit activation in the somatosensory cortex in the brain, creating an imagistic understanding of the implication of stopping a habit in the phrase “kicking the habit”. This is evidence that using action verbs that are grounded in the sensorimotor system can enhance understanding of abstract concepts from an embodied perspective via neural simulation, consolidating the linguistic embodied approach.

Another behavioral study has further supported Conceptual Metaphors Theory’s claim that people are predisposed to use tangible sensorimotor categories and bodily experiences to construct complex abstract concepts – specifically, *morality*. The study has found that participants who recalled unethical behaviors had higher mental accessibility to cleansing vocabulary than those who recalled ethical behaviors, as shown by their performance on a word completion task (30). This finding was corroborated by a behavioral measure of likelihood to take an antiseptic cleaning wipe after recalling either unethical or ethical deed. Results of experiment 2 revealed that participants showed a higher desirability for cleansing products by preferring to take the antiseptic wipe over a neutral product (such as a pencil) if they have recalled an unethical deed (30). The results of both experiments reveal a direct association between physical cleansing and moral purification, indicating that abstract concepts of morality are grounded in concrete bodily experiences, supporting the cognitive validity of embodied conceptual metaphors.

Together, PSS and CMT address a complete mechanism for the comprehension of abstract concepts. PSS grounds real-world meanings for concrete concepts directly in sensorimotor experiences, constructing the foundation for CMT to extend this grounding to abstract concept representation via metaphorical depiction, mapping the source domains (concrete concepts) to comprehend target domains (abstract concepts). Abstract concepts are thus engaged in sensorimotor experience indirectly, mediated via systematic mapping to connect with embodied concrete concepts.

However, despite the embodied approach’s theoretical completeness, the model still faces empirical challenges that constrain its explanatory power, which the critique section below examines the limitations of the embodied approach.

Limitations of the Embodied Cognition Approach

The embodied approach faces methodological limitations that question the strength of its empirical support, specifically the issue of epiphenomenal activation. In general, neuroimaging evidence faces a critical interpretive limitation: the nature of these neurological activations is correlational or even epiphenomenal (secondary by-product) rather than causally related to the process of interest (31). For embodied cognition specifically, many fMRI studies demonstrate sensorimotor activation during semantic processing; however, this correlation does not establish causal necessity. Motor activation during lexical comprehension might reflect a consequence of understanding instead of being the mechanism, where activation of motor regions during language tasks does not prove that sensory and motor information are constitutive of semantic comprehension (32).

These issues imply potentially unreliable interpretation and empirical support for the embodied approach, thus leaving room for uncertainty in this approach's validity, where future research should aim to design more accurate methods, such as the Transcranial Magnetic Stimulation, to test a the direct causal links between the lexical stimuli and brain activity.

Beyond methodological limitations, the embodied approach also faces theoretical challenges with regard to its explanation of abstract concept acquisition via metaphors. Aziz-Zadeh *et al*. (2006) conducted an fMRI study that revealed that conventional metaphorical phrases did not show significant somatotopic activation in either brain hemisphere (33). Meanwhile, it is important to note that the metaphors used in the study were over-practiced, which researchers predict that once a metaphor becomes well-established in language conventions, it will no longer elicit activation of sensorimotor cortices in response to the reading of the corresponding metaphors (34). This finding challenges the embodied account of metaphor comprehension, suggesting that already established metaphors may not rely on sensorimotor enactment.

These limitations of the embodied approach indicate that while sensorimotor grounding is significant in semantic representation and initial acquisition, the extent of its importance and necessity of sensorimotor involvement remains unclear. The empirical evidence has raised the necessity of considering extensional variables, such as familiarity and conventionality levels that may affect the process of abstract concept acquisition and understanding via metaphors. Overall, with the limitations of purely distributional approaches and purely embodied approaches, these suggest that neither framework alone fully captures human semantic processing comprehensively. Therefore, an alternative approach is needed.

DISCUSSION – HYDRID DEVELOPMENTAL APPROACH

Several researchers have argued that neither the embodied approach nor the distributional model alone can fully explain the mechanism for abstract concept comprehension (35, 36). Therefore, an integration is needed to combine both theories' strengths, spotting the connections and links between them, and establishing a new hybrid framework. A hybrid developmental approach, rather than viewing them as competitors, predicts a sequential and collaborative relationship between the embodied approach and the distributional approach as a dynamic interaction with their relative dominance mediated by the factor of "familiarity". Specifically, embodied simulations govern the initial comprehension (grounding abstract terms in lived experience via metaphors to make sense of the word's meaning in a real-world setting), while distributional patterns enable contextual flexibility and updates (adjusting meaning based on co-occurring words and contexts) (37).

Linguistic tools are indispensable for abstract concept comprehension, as abstract concepts lack direct sensory/physical referents; they must be input or conveyed through either verbal or visual symbols. From the embodied approach's perspective, empirical evidence suggests that processing action-related words activates corresponding sensorimotor regions (27, 38), suggesting initial comprehension relies on sensorimotor simulation via metaphorical grounding (by reactivating involved cortical regions that generated the concept in the first encounter). This embodied simulation suggests how abstract terms are first decomposed into tangible, sensorimotor fragments, expressed in the form of concrete and cognitively approachable metaphors with low abstractness. Therefore, it is reasonable to predict that the first step of acquiring a brand new concept is initially grounded via embodied simulation and structured by conceptual metaphors.

However, repeated exposure reshapes processing. As familiarity grows, neural activation in sensorimotor regions weakens, symbolizing a shift from simulation-dependent sensorimotor engagement to memory-based retrieval that might be 'amodal' (4, 39). As Aziz-Zadeh & Damasio found that highly familiar metaphors no longer elicit the same motor cortical regions compared to newly presented metaphors, the empirical evidence from their experiment suggests how meaning transfers from dynamic sensorimotor traces (initial grounding) to abstract linguistic pattern recognition (distributional, amodal) (34). Thus, the reliance on repetitively reactivating the simulative neural networks is unnecessary, but shifts to distributional linguistic contextual associations.

Further empirical and theoretical research supports this claim with neuroimaging evidence that shows differences in neural activation for novel and conventional metaphor processing. Recent studies proposed a framework in which the degree of salience dictates how the brain regions process metaphors with regard to factors such as conventionality. This is known as the Graded Salience Hypothesis. Novel metaphors are not directly accessible from the mental lexicon, therefore its intended meaning is not salient, requiring initial processing of the literal meanings of the constituents. In contrast, conventional metaphors are encoded into mental lexicons with high semantic saliency and easy accessibility, without the need to process each constituent's literal meaning (39). This is evidenced by observable behavioral data from an empirical study that reveals individuals show much faster reaction time to conventional metaphor and literal meanings in comparison to novel metaphors, suggesting cognitive effort in semantic processing to make meaningful connections (40).

Conventionality in the context of semantic comprehension refers to a social and cultural construct, determining which metaphors or lexicon expression is encoded within a linguistic community (39). Conventionality is different but directly correlated to a factor called *familiarity*, where the transition of the relative dominance between the two models/systems is likely to be mediated by it. The factor of *familiarity* means that more exposures strengthen distributional associations for co-occurrences, reducing reliance on sensorimotor reactivation. Familiarity can be defined as an individual's linguistic construct influenced by their specialized field (e.g., technical medical terminologies for doctors), societal or media exposure, systematic training, or cultural influence. The level of familiarity is conceptualized as the cumulative frequency of exposure for a speaker within their environment and language usage (41). In addition, the threshold needed for the transformation between systems might be replaced by a continuum. As the level of familiarity increases, the system gradually switches from the initial sensorimotor representation of a word to a distributional, linguistic context-dependent representation of a concept.

To directly test this possibility, researchers can test people's behavioral and neurological responses to different levels of metaphor familiarity under highly controlled laboratory settings for training paradigms with adult participants. Training novices of an unfamiliar skill can potentially validate the proposed approach to investigate the change in processing and mental representation of abstract concepts to establish causal relationships. Researchers could systematically manipulate the familiarity by introducing novel and uncommon vocabularies in highly specialized fields such as obscure medical terminologies, implementing neuroimaging techniques to provide biologically supported correlation.

CONCLUSION

This review has evaluated two major theoretical approaches – the distributional model and embodied cognition – for explaining human concept acquisition, with particular focus on abstract concepts. Although the distributional model successfully predicts semantic similarities based on statistical patterns, it faces empirical challenges and theoretical limitations, such as the symbol grounding problem, in explaining human semantic comprehension. Meanwhile, despite strong empirical and neuroscientific research supporting the embodied approach's validity, methodological limitations prevent comprehensive explanation of abstract concept acquisition. The review has also discussed a possible hybrid approach in which semantic representation changes dynamically, depending on the key factor of *familiarity* that mediates the relative dominance of embodied versus distributional processing. Future research should address current methodological and theoretical limitations through controlled experiments that systematically manipulate familiarity while avoiding confounds present in development studies. For example, researchers could train adult novices on abstract concepts with varied familiarity operationalized as varied exposure frequencies, while tracking neural activation patterns to establish correlational relationships between experience and semantic representation. This would allow valid testing of whether familiarity mediates the transition from embodied to distributional processing, and would address theoretical gaps in human cognition.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest related to this work.

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