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Embodied Cognition And Language Comprehension

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Abstract

Embodied cognition states that behaviour is a product of real-time interaction between the nervous system of a body with particular capabilities and a complex environment which allows us to produce that particular behaviour (McNerney, n.d.). Linguistic studies, under cognitive science, first experienced the changes that came along with the introduction of embodied cognition. This pushed research ahead by years, answered many unanswered questions and further helped in development of AI. (Lakoff, 2012). The current study presents six points of views through which embodied cognition is studied.

This study further provides strong support to the claim that body posture affects attention processes; Emphasising the influences of posture and fixation distance on attention. Along with postural factors and reachability of stimulus, overall mobility capacity of an individual also influences visual attention behaviour. As such we see evidences in the study that our body status and capabilities do have a significant impact on our cognitive functions.

Environmental factors, with an emphasis on parent-child relations has also been thoroughly discussed. Concluding on the note that researcher's need to further explore and do in-depth studies to develop a better understanding about how our body (physically and mentally) along with our environment affects our cognition.

Introduction

Cognition refers to the mental processes that are performed by the mind such as perception, attention, memory, decision making, emotion, language comprehension and formation, critical thinking, and reasoning. These cognitive processes are performed by the mind through the creation of representations that enable us to understand and act upon our goals.

Traditionally, cognitive science has established that the mind performs cognitive functions independently, separate from the body. In this paradigm of cognitive science, which is referred to as the "first generation" of cognitive science (Garbarini&Adenzato, 2004), the mind is viewed as an information processing device. This tradition of cognitive science believes that an individual acquires information from the outside world through its senses, and this information is then translated to a common amodal code regardless of the sensory modality it was collected through. The coded information is processed by the mind and the processed information thus becomes amodal representations that are the building blocks of an individual's semantic memory (Shwarz& Lee, 2018).

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The mind was therefore viewed as a computer, wherein input information is encoded into a common format and is then stored and retrieved.

However, another rapidly growingparadigm of cognitive science argues that cognition does not occur independently of the body and is instead deeply rooted in and tied to the sensory experience of the body and the situation of the human body in their environment. This is known as embodied cognition. According to this theory of cognition, information and concepts are grounded in sensorimotor processes, and the information received through the senses is not encoded into one common amodal code, but the sensory modality of the information is retained. This paradigm of cognitive science which has been referred to as the "second generation" of cognitive science (Garbarini&Adenzato, 2004)states that cognition entails a multimodal encoding and storage of information.

The paradigm of embodied cognition has generated a lot of interest in the areas of understanding meaning generation and language comprehension, as fundamentally, this approach establishes that these processes are rooted in perceptual experiences of the body, and are not simply restricted to the mind/brain. This paper will aim to provide a comprehensive review of the literature on the embodiment of language comprehension. However, before exploring the embodied approach to language comprehension, it is crucial to establish certain fundamental principles of embodied cognition. Hence, prior to the review on embodiment in language comprehension, the paper will first briefly explain the history of embodied cognition, following which the paper will explore the role and functioning of the perceptual system in cognitive processes. The paper will then review research on embodied cognition's argument on the representation of mental concepts.

History of embodied cognition

The study of cognition as perceptual is not a modern phenomenon and has been in existence for more than 2,000 years, since the time of Aristotle and Epicurus in 4th century, when representations underlying cognition were viewed as imagistic. An imagistic view of cognitive representations continued during the time of Kant and Reid in the 18th century, and even in the 20th century. However, the perceptual view of cognition began dissipating, when the early twentieth century saw a banishment of mentalism, and a rising focus on behaviourism (Barsalou, 1999).

The mid twentieth century saw the beginning of the cognitive revolution, however the cognitive constructs that emerged at this time did not include perceptual cognition and imagistic representation. Barsalou (2008) gives two reasons for this. Firstly, the scholars of the cognitive revolution wanted to avoid the criticism that mentalism and imagery prior to the advent of behaviourism faced. Secondly, these new emerging cognitive constructs were heavily influenced by major developments in computer science, and therefore adopted an amodal approach to study cognition.

However, with increasing growing evidence to support embodiment of conceptsand perceptual representation, embodied cognition has become a widely accepted approach to study cognition. Pioneers in the field such as Barsalou and Lakoff have presented ground-breaking evidence to confirm the embodiment of cognition.

Perception and Embodied Cognition

Affordances

The concept of embodied cognition finds its roots in Gibson's theory of affordance. Gibson defined affordances as "properties of environmental structures that provide opportunities for action to complementary organisms" (Golonka, 2014). According to this theory, a living being's ability to perceive and act in their environment depends upon their ability to detect information about the

structures in their environment. Gibson argues that the way an individual perceives a structure in the external world, is in service of how the individual can act upon this structure. For example, an individual's perception of an apple will be based on the individual's perception of the different ways in which they can interact with or act upon the apple (i.e. reach out for it, bite it, smell it, etc.).

Therefore, Gibson's theory of Affordance implies that objects in the environment invite the individual to act upon them, and individuals can only sense and perceive objects in terms of what it means for our behaviour. Perception is hence not a process which contains a discrete set of input and outputs but is a system wherein the input and output are connected in a continuous loop. Perception allows the individual to act upon the environment and action on the environment helps the individual perceive the environment further. It is this perception – action loop or what Gibson has termed as the "perceptual system" that is central to cognition in the paradigm of embodied cognition. The brain is not the source of cognition but is instead in a reciprocal relationship with the perceptual system, that leads to the process of cognition.

Cognition is therefore a process that is dependent on the partnership between the individual's body and the physical world the individual is in.

Mirror Neurons

A significant research finding that has strengthened the claims of embodied cognition, and the link between perception and action, comes from studies in neuroscience that have discovered the existence and functioning of mirror neurons. Studies by Gallese and Goldman (1998) demonstrated that a certain set of neurons in monkeys' premotor cortex fired both when the monkey picked up food from a tray and when the monkey saw the experimenter pick up food from the tray. Oosterhof, et al., (2013) has provided evidence for the existence of mirror neurons in humans as well. The functioning of mirror neurons demonstrates that the link between action and perception is important in the cognitive task of observation.

Massive Redeployment Hypothesis

Goldman (2012) hypothesizes that the functioning of mirror neurons is an extension of a phenomenon known as the Massive Redeployment Hypothesis, wherein the brain reuses or redeploys cognitive processes that originally had different uses or functions. This phenomenon is also known as 'neural reuse', as it involves neural circuits that were originally developed for one particular function, to be exploited, and recycled, and put to different uses and made to perform other functions, without necessarily losing their original functions.

Goldman further suggests the occurrence of redeployment or neural reuse to explain the link found between perceptual and motor responses. In an experiment conducted by Hauk, et al., (2004), subjects' brain activity was measured using an fMRI under two conditions:

i) while moving their right/left foot, right/left index finger or tongue

ii) while reading action words such as 'kick', 'pick' and 'lick' (which is a foot, finger and tongue action respectively).

The results showed that while the dorsal areas of the primary motor cortex were activated by performing the actual movements, the same areas were also activated while reading the words. The results once again demonstrated that simply thinking of an action can activate perceptual motor areas in the brain.This proves that the understanding of the action verbs relies on motor activation.

According to Goldman, many codes in the human brain represent states of the body, from an internal perspective. Proprioception provides the brain with awareness of one's body position and movement and kinaesthesis provides the individual with the ability to feel movements in the limbs and muscles. These interoceptive sensations (stimuli within an organism) that provide the brain information about the body's internal states are represented in what Goldman labels as B-format, i.e. a body-related code. Goldman argues that those mental representations which are represented in the B-format are cognitions that can be termed as embodied cognitions. This is consistent with Barsalou's classification of all sensorimotor events as embodied (1999).

The redeployment theory can be applied to understanding Hauk's experiment, wherein the neural circuits originally generated for performing a motor act were reused or redeployed when the individual had to think of the motor verbs. This goes on to show that action concepts are stored in a motoric code, or a bodily code as Goldman has defined them, and the understanding of the verbs might involve partial simulations of the related actions.

Embodiment of mental concepts

Based off Gibson's theory of affordances, mental concepts will therefore vary from person to person by virtue of the different bodies each individual possesses, and the differing capabilities and constraints of each body. For example, the mental concept of a "chair", will differ for a child and an adult due to the varying interactions a child and an adult can respectively have with a chair. So, the mental concept of a "chair", which is conveyed by the written or listened word, will evoke the action of 'sitting' in the case of an adult, but may evoke the action of 'leaning on it' or 'standing upright on it' for a child (Scorolli&Borghi, 2008).

According to the paradigm that did not view cognition as embodied, cognitive and perceptual states are separate systems that work with a different set of principles. In the view of disembodied cognition, a subset of a perceptual state is not extracted and stored for later retrieval but is instead transduced to a completely different amodal representational format. Therefore, the symbols of representation in this view of cognition are amodal and non-perceptual, as they do not bare any correspondence to the perceptual state they were extracted from. These symbols are also arbitrary, as they do not have any form of correspondence to the perceptual state experienced. For example, the word 'apple' is the symbol that represents the concept of an apple, when one has to think of an apple. This symbol doesn't bare any correspondence to the visual, tactile or olfactory perceptual states that an individual's perception of an apple gives rise to.

Perceptual Symbols System

In opposition to this view of the representation of concepts and the nature of mental symbols, is that proposed by proponents of embodied cognition, such as Barsalou.Barsalou's work on perceptual symbol systems is integral in understanding embodied cognition. He states that cognition is inherently perceptual. According to Barsalou, a perceptual state that arises in an individual has two components, which are the unconscious neural representation of physical input and the optional conscious experience. Through selective attention, a subset of the perceptual state is extracted and stored permanently in long term memory. When retrieved, this perceptual memory can function symbolically. This perceptual memory can function as a referent and a symbol. The collections of these perceptual symbols are what underlies cognition. According to the perceptual symbol system, the symbols that underlie cognition are perceptual, and are hence modal. They are representative of the perceptual system that produced the perceptual state they were extracted from.

Lowrese (2011) articulates the difference between the embodied and disembodied views of cognition with the following example of a rose. According to disembodied cognition account, the mental concept of a rose is a product of associated concepts such as flower, red, thorny, and love. In the view of embodied cognition, the mental concept of a rose comes from the perceptual experience of the rose being activated, which leads to the associations with the rose's colours, smell and sight.

Lowrese's paper explores the symbol interdependency hypothesis which can be seen as a hypothesis that is taking off from Barsalou's perceptual symbols theory. Lowrese uses the term "symbolic cognition" to refer to disembodied/amodal cognition which is dependent on linguistic units and their associations with other linguistic units. According to the symbol interdependency hypothesis proposes that the symbolic and embodied accounts of cognition are not mutually exclusive but are mutually reinforcing.

Language comprehension and perceptual simulation

From the previous section, it is clear that the embodied approach to cognition proposes that mental concepts are represented perceptually. This proposition applies to the embodied view of language comprehension as well. Modal representations are integral in language comprehension, as proposed by Barsalou's review of literature on the same (2008). His review highlighted several studies that demonstrated the presence of spatial representations in the process of comprehension, as well a simulation of text meaning. His findings showed that readers of texts often construct simulations to represent the text's perceptual and motor content. Thus, Barsalou establishes that grounding and embodiment is vital to the process of comprehension.

Research has demonstrated that the mirror neuron system is activated while reading. This implies that different words will have differing effects on perception. For example, in Brunye, Ditman, et al.'s study (2009), when subjects were made to read a text in which the pronouns "I" and "you" were used, subjects adopted the perspective of the actor (enactor of the action). When third person pronouns were used, subjects adopted the perspective of an external viewer. The experiment demonstrated that the readers of a text will experience embodiment while comprehending the text. The degree of embodiment can be mediated through the use of pronouns, which will determine whether the simulation of the objects and events are from an external perspective or from the actor's perspective. Such a study provides crucial evidence that the comprehension of text involves the simulation of mental symbols for objects and events that are mentioned in the text, and these mental representations will be perceptual in nature.

Scorolli and Borghi (2008) argue as well that mental simulation is essential when comprehension takes place. A number of experiments have been conducted to demonstrate the effect of language, i.e. the use of particular words in the simulation of intrinsic properties of objects like its shape and size, and extrinsic properties such as the orientation of the object.

Zwan, Stanfield and Yaxley's study (2002) showed that during sentence comprehension, perceptual activation is activated automatically, even if a task doesn't demand for it. Subjects were presented with sentences describing an object in different locations, following which they were presented with a picture of the object and were asked to indicate whether the object in the picture matched the object in the sentence. For example, the sentences "he saw a lemon in a bowl"/ "he saw a lemon in a glass" were presented, following which they were shown a picture of a lemon. Responses were faster when the shape object corresponded with the sentence, i.e. in the example of the lemon, a picture of a slice of lemon was shown following the sentence of the lemon in the glass. The experiment thus demonstrated that sentence context is considered automatically in the perceptual simulation of representations.

Similarly, Glover and Dixon's experiment (2002) showed the effect of the word's "large" and "small" on a subject's initial manner of reaching and grasping for objects, even though the objects themselves were not large or small. This shows the influence of language in the activation of perception of size.

An experiment (Connell, 2007) to analyse whether sentence comprehension can activate perceptual information about colour involved participants being presented with a sentence about an object, followed by a picture of the object, and participants had to state whether the object shown in the picture was that mentioned in the sentence. The results found that the object in the picture was of an obviously mismatched colour, participants took lesser time to respond than if the colour was a possible matched. For example, the sentence "John looked at the steak on his plate", was followed by a picture of a steak. If the steak in the picture was brown or red in colour, response was slower than if the colour of the steak was an unmatched colour such as blue. The researchers suggested that with an unmatched colour, there was minimal interference to the perceptual information generated of the shape of the object. However, if the colour of the object matched, the perceptual information of colour would also be activated and hence would cause interference to the perception of shape. The experiment proved that colour is a less stable property than shape, as the former is a secondary, unimodal perceptual property while the latter is a primary, multimodal perceptual property.

Experiments have also demonstrated that perceptual information regarding perspective is simulated by language. Subjects of such an experiment (Borghi, Glenberg and Kaschak, 2004) were presented a sentence that described an object from an inside or outside perspective. For example, "you are eating in a restaurant"/" you" are waiting outside a restaurant". They were then presented with a noun such as "table" or "sign" and had ascertain whether the noun was part of the location they were in. the responses were faster if the noun presented matched the sentence perspective, i.e. responses were faster if the sentence given was "I am eating inside the restaurant" and the noun given was "table", since tables are found inside restaurant. However, if the noun "sign" was given, responses were relatively slower due to the mismatch in location. This experiment demonstrated that language comprehension leads to a These results showed that sentence and language comprehension will regulate the perceptual information of perspective, and the accessibility of other concepts.

Therefore, as demonstrated by the review of literature above, the paradigm of embodied cognition argues that during language comprehension, language works towards cueing the individual comprehending to simulate or construct the a perception of the described situation, and the comprehension that takes place can be a vicarious experience. This is essentially what constitutes the Immersive Experience Framework (IEF) (Zwaan, 2004).

Additionally, the Indexical Hypothesis (IH) states that the firs step in comprehension is indexing the words or phrases to analogic or perceptual symbols, followed by recognizing the affordances of the object and then coherently meshing the affordances and the symbols to construct an "envision able set of actions" (Glenberg& Robertson, 1997).

Weiskopf (2010) however provides a compelling argument that posits that language comprehension is not dependent on perceptual simulation. He argues that participants can perfectly understand the meaning of bizarre sentences such as "Adam pulled out of his bag a ham sandwich and used that to chisel an inch of ice off his windshield". Although this sentence has very low sensibility, and the sandwich's affordance is highly unlikely, the sentence can still be understood. According to Weskopf, a basic understanding of the meaning of a sentence can be grasped without perceptual simulation. He therefore puts forth the notion that while enactive simulation can be used in language comprehension but is not a necessity.

Weiskopf also raises other arguments against the notion of language comprehension being contingent on embodiment and perceptual simulation. He states that if the function of language is to "facilitate social coordination" and "establish shared beliefs about the environment", there are several beliefs of the environment where perceptual stimulation is not possible. For example, religious beliefs and beliefs regarding social hierarchies. Goldinger, Papesh, et al., (2016) have also argued against language comprehension being embodied on similar grounds. In their paper they present a number of sentences that they state simply cannot be simulated perceptually, for example, the sentence "Familiar actors are easily recognized across movies", has no way of being subtly or obviously perceptually simulated. Furthermore, they argue that even if a sentence has only a part of it that can be perceptually simulated then the argument of embodiment in language comprehension is weak. They elucidate this claim with the following sentence: "Jane handed David the stapler". While handling of the stapler can activate a motor simulation, the rest of the sentence cannot.

Weiskopf (2010) further argues that the embodiment of language comprehension depends on a very rich notion of what is expected from language comprehension. He differentiates this rich notion of language comprehension from the simple notion that language comprehension is the grasping of the truth of the content. He therefore states that considering the latter as the aim of language comprehension, language faculties are not embodied or dependent on embodiment, but embodiment can be used for deeper or richer language comprehension.

A parallel can be drawn between Weiskopf's argument and the findings of Lowrese and Jeuniaux's studies (2008; 2010), which demonstrated that in the process of comprehension, symbolic cognition controls the early stages of comprehension allowing the reader to form quick representations, and embodied cognition controls comprehension in subsequent stages allowing the reader to create a complete situation model.

Conclusion

In conclusion, the embodied approach to language comprehension is still a strong ground for oppositional arguments regarding the necessity of embodiment and perceptual simulation. A middle ground that can be arrived at is that language comprehension isn't dependent on embodiment but can benefit from perceptual embodiment. However, to further address the area, research must first begin at exploring the dichotomy between the two approaches towards the representation of mental concepts itself. Only with a firm addressal of the two vastly different approaches to representation of concepts, i.e. the linguistic, amodal approach and the perceptual, multimodal approach, can research further delve into language comprehension. Research must draw upon Lowrese's argument (2011) that the representational system is not either amodal or multimodal, but the two systems are mutually reinforcing. This argument by Lowrese can be reconciled with Lowrese and Jeuniaux's studies (2008; 2010), that talk about two levels of language comprehension – one that allows the reader to form quick representations, which is the amodal system, and one that allows the reader to form situational and contextual understanding, which is the multimodal perceptual system. Furthermore, future research in the field of embodied language comprehension must consider the vast findings of Lakoff and Johnson (1980), wherein they argue that metaphors pervade thought and action. For example, cultural sayings such as 'he is over the moon' or 'he is at the peak of his health' comes from the cultural lived experience of physically being erect and upwards when one is happy and healthy. A saying such as 'he is down in the dumps' emerges from the physical experience of lying down when one is sad, or depressed. Therefore, while this paper predominantly reviewed how language comprehension influences perception and action, Lakoff and Johnson's seminal book demonstrates that perceptual physical experiences influence language, i.e. the metaphors and phrases that a language creates and commonly

uses. This should therefore be considered in future research that explores the embodiment of language comprehension.

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