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Special issue article

Construing counterfactual worlds: The role of abstraction

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Abstract

The present article conceptualizes mental time travel as a special case of transcending psychological distance, which rests on the uniquely human ability to consider counterfactual and hypothetical worlds. We discuss the possible challenges that counterfactuality and futurity present before our cognitive system, which include severing the real from imagined worlds and dealing with uncertainty. We suggest, similar to extant approaches to theory of mind, that the use of abstract–symbolic mental representations helps overcome these difficulties. We present empirical evidence to support the claim that counterfactual and hypothetical objects are encoded in a more abstract manner than ascertained objects. Finally, we discuss the possible advantages of linguistic/disembodied representation over the embodied–experiential form. Copyright © 2012 John Wiley & Sons, Ltd.

> One of the major problems encountered in time travel is not that of becoming your own father or mother.... The major problem is simply one of grammar, and the main work to consult in this matter is Dr. Dan Streetmentioner's *Time Traveler's Handbook of 1001 Tense Formations*. It will tell you, for instance, how to describe something that was about to happen to you in the past before you avoided it by time-jumping forward two days in order to avoid it... Most readers get as far as the Future Semiconditionally Modified Subinverted Plagal Past Subjunctive Intentional before giving up; and in fact in later additions of the book all pages beyond this point have been left blank to save on printing costs.
>
> Douglas Adams (1980), "The Restaurant at the End of the Universe"

Although our immediate experience is limited to the present tense, we all share with Douglas Adams (at least to some degree) the ability to imagine and narrate future times and fictional worlds. But as the aforementioned excerpt insinuates, this ability to depart from the here and now is by no means trivial, as it might introduce some serious challenges before our cognitive system. Yet, although actual time travel remains a matter for science fiction books, mental time travel is a very real property of human cognition. In fact, the ability to explicitly predict and plan the future might have been a key factor in the survival of *Homo sapiens* throughout evolution (Suddendorf, 2006) and, thus, to a great extent, might be a defining property of humanity.

The present article conceptualizes mental time travel as a special case of traversing psychological distance and examines some of the possible mechanisms by which this remarkable feat is achieved. We discuss the suggestion that the uniquely human capacity for abstract–linguistic and disembodied representations is essential for the conception of falsehood and counterfactuality and thus might be pivotal in enabling mental time travel as well as the related ability of perspective taking. We then present some empirical evidence that will try to connect abstraction and counterfactuality. Finally, we discuss how the present theorizing relates to theories of embodied cognition and attempt to explicate the advantages of disembodied representation over the embodied–experiential form.

MENTAL TIME TRAVEL AS A SPECIAL CASE OF TRANSCENDING REALITY

Our ability to transcend the here and now can manifest itself in the temporal domain, but it is clearly not restricted to it. Humans also have the ability to imagine spatially distant places, take the perspective of other people, and consider uncertain and hypothetical situations. According to construal level theory (CLT; Liberman & Trope, 2008; Trope & Liberman, 2010), all these abilities are manifestations of a core function allowing us to traverse psychological distances or, in other words, to contemplate alternatives to our immediate reality.

Supporting the view that mental time travel, counterfactual reasoning, and perspective taking are variations of one common process, it has been found that the ability to perform these operations develop at roughly the same age (Levine, 2004; Fivush & Nelson, 2004; Wellman, Cross & Watson, 2001). And it is hypothesized that they share an evolutionary trajectory (e.g., Flinn, Geary, & Ward, 2005). Neuroimaging research had also lent strong support to the claim that these activities share a common core: A distributed network of brain areas usually referred to as the "default-mode network"

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(Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001) has been shown to be active in tasks that require prospection (e.g., Addis, Wong, & Schacter, 2007), imagining hypothetical scenarios (Hassabis, Kumaran, & Maguire, 2007), or performing theory of mind (ToM) tasks (e.g., Mitchell, Banaji, & Macrae, 2005)—leading some theorists to argue that its function is to allow "self-projection" (Buckner, Andrews-Hanna, & Schacter, 2008).

Furthermore, research within the framework of CLT has shown that different dimensions of psychological distance are interrelated (Bar-Anan, Liberman, Trope & Algom, 2007) and that as objects and events grow distant on each of the distance dimension (i.e., temporal distance, social distance, spatial distance, or degree of likelihood); they are perceived as more distant on each of the other distance dimensions as well (e.g., Stephan, Liberman, & Trope, 2010; Wakslak & Trope, 2009). Finally, much behavioral evidence within CLT and elsewhere (e.g., D'Argembeau & Van der Linden, 2004; Semin & Fiedler, 1989) has shown that distancing an object on each of these dimensions has similar effects on how people represent these objects and react toward them. Thus, all these lines of investigation converge to lend support to the hypothesis that the seemingly separate abilities of mental time travel, counterfactual reasoning, perspective taking and imagination are subserved by a common underlying mechanism. Endorsing this generalization might suggest that a deeper understanding of these abilities might emerge from an attempt to integrate insights derived from these diverse avenues of investigation.

PROBLEMS WITH REPRESENTING THINGS THAT ARE NOT

If indeed the uniquely human ability for hypothetical and counterfactual reasoning, prospection, and perspective taking are all subserved by a unitary mechanism, what is that mechanism? To address that question, let us first explicate a major problem that mental traversing of reality poses to the cognitive system. When mentally representing worlds that are not real (because they are future worlds, counterfactual alternatives, or pertain to other spatial or social perspectives), one needs to hold in mind that these representations are distinct from reality. For example, when I mentally prepare for a future encounter with a wild boar, or when I hear a friend's story about such an encounter, I should not confuse these thoughts with the presence of a real boar, as the appropriate and adaptive reactions are quite different depending on whether it is a real boar, a boar that a friend met in the past, or a boar that I might encounter in the future.

Research on embodied cognition (see Barsalou, 2008, for a comprehensive review) tells us that these different reactions share some similarities such that hearing about a boar activates the perceptual and motor networks that typically become activated when we encounter a real boar. For example, research has shown that when seeing a picture of a tool, people mentally simulate the motor action that this tool affords (Tucker & Ellis, 1998; Chao & Martin, 2000).

It might seem too easy to confuse representations with reality—the semantic network becomes activated, and related actions become simulated. Yet, healthy adults do not typically confuse real experiences with imagined ones (counterfactual, future, and another person's). How do we do that? What prevents us from confusing a mental simulation of a boar with a real boar?

NEED FOR META-COGNITIVE OPERATORS

One view is that what prevents confusion of reality with simulations is a meta-representational marker, a qualifier of the representation that marks it as "non-reality." Such a marker requires that a person is aware of the representation as an object that is distinct from reality. It is illustrative in this respect to look at how kids acquire the ability to make such representations. In the hallmark paradigm of this branch of research, the Sally–Anne false-belief task (Wimmer & Perner, 1983), a child observes an interaction between two actors. The first actor (Sally) hides an object in location *x* and then leaves the room. Meanwhile, the second actor (Anne) removes the objects and hides it location *y*. After seeing these events unfold, the child is asked where Sally is going to search for her object. The finding from this paradigm is that almost all children fail at this task before the age of 4 years, despite having an accurate memory and understanding of the portrayed sequence of events. This intriguing pattern of results suggests that children are deficient in their ability for "meta-representation" (Pylyshyn, 1978); they seem to lack a full comprehension of the concept of a mind as a non-physical vessel containing representations of the world. It is presumed that only after a child succeeds in severing the mental from physical worlds, he or she can understand the idea that a representation can be uncorrelated with reality or in the terminology of logical constants, can be false. Interestingly, More than 30 years of investigation into false-belief reasoning suggests that humans are the only species who exhibit this capacity (see Call & Tomasello, 2008, for a review).

A similar emphasis on the importance of meta-representation and falsehood comes from the research into children's ability for imagination and pretense. Children as young as 2 years old (Leslie, 1987) enjoy creating rich imaginative worlds in which they take on different identities and treat everyday objects and situations as something very different from what they actually are. As Leslie (1987) highlighted, when one engages in pretend play (rather than being simply mistaken or delusional), he or she must be able to "mark" the pretend representation as counterfactual. This representation can carry some sort of metaphorical relation, or family resemblance to the objects of reality (e.g., a hair dryer is more likely to serve as a ray gun than a hair roller), but it does not fully correlate with it. If a child was unable to do so, it would lead to what Leslie refers to as "representational abuse", in which the real and pretend states would be indistinguishable. Nichols and Stich (2000) similarly argued that children develop the ability to quarantine the real from the unreal using a mechanism they refer to as a "possible-worlds-box". This presumed segregation mechanism allows a child to remain an efficient and accurate interpreter of the immediate reality, while simultaneously simulating hypothetical and alternative worlds. Thus, as was the case with the false-belief tasks, the manipulation of imagined worlds seems to require the same severing of the mental from physical worlds and the understanding that a representation of reality does not have to fully correlate with it.

We would like to suggest that some insight into the nature of representations and their possible inconsistency with reality is crucial not only for ToM and pretense but also for mental time travel. Although this idea has been discussed in past literature (Suddendorf & Corballis, 1997), the work on mental time travel tends to focus on episodic memory as a reservoir of content from which future worlds are constructed (e.g., Bar, 2009; Schacter, Addis, & Buckner, 2008). Although this reservoir is unquestionably critical in the construction of imagined worlds, it may be not the only evolutionary stepping stone that has allowed humans to mentally travel to the future. It might be the case that our ability for mental time travel through the creation of many future "possible worlds" also hinged upon the severing of the mental from physical worlds and the ability to manipulate worlds that only loosely correlate with reality. To mentally travel to the future, one must be able to represent the future events as possibilities that remain distinct from reality. He or she must be able to create an adequate intentional relationship with the representation; otherwise, goal-directed behavior would collapse, as one would simply indulge oneself in fantasies of finding food, being rich or loved. Similarly, simply thinking of threatening counterfactual scenarios (say, nuclear war, hunger, betrayal, and etc.), to try and avoid them, would lead one to devastating anxiety and maladaptive behaviors. Positive and negative counterfactual thoughts are extremely prevalent in everyday life (see, e.g., Morrison & Roese, 2011), and yet they do not (usually) debilitate or lead to maladaptive reactions but rather serve an adaptive function (Epstude & Roese, 2008).

ABSTRACTION ENABLES META-COGNITIVE OPERATIONS

It is interesting to consider what is it exactly that limits young children (and non-human animals) in their ability to form meta-cognitive representations and to sever the real from imagined worlds. Many have suggested (e.g., Penn, Holyoak, & Povinelli, 2008; Inhelder & Piaget, 1964) that their representational capacities are limited to a concrete, sensorimotor depiction of the world. This type of mental code is not suited for depicting unobservable objects such as "a mind" or "representation" and hence might undermine their conception. Furthermore, as Leslie (1987) pointed out, "evolution has given a high premium on veridicality;" therefore, organisms were selected to be fast and unequivocal in their perception process, solving ambiguity and producing the output of a seemingly singular and true reality. It is somewhat difficult to imagine how our experiential modalities can be used to explicitly represent something as being untrue, tentative, or temporally distant. Thus, the high correlation between concrete perceptual representations and physical reality might carry with it substantial limitations; one of which might be the difficulty to represent meta-cognitive operators. In other words, a representation of meta-cognitive operators is inherently disembodied.

Many theoretical accounts have suggested that ToM reasoning (de Villiers & de Villiers, 2002; Carpendale & Lewis, 2004) and the concept of falsehood (Fodor, 1975; Jackendoff, 1996) require an abstract, symbolic/linguistic representational system. Indeed, within the framework of ToM research, evidence has been provided to substantiate such a link between linguistic ability and performance on false-belief tasks: Developmental studies have shown that the emergence of false-belief reasoning is highly correlated with developments in linguistic ability (Milligan, Astington, & Dack, 2007). Studies with hearing-impaired children (who are otherwise cognitively intact) have shown that they suffer a delay in their ToM capacity (Peterson & Siegal, 1999; Woolfe, Want, & Siegal, 2002); and finally, on a non-verbal version of the Sally–Anne paradigm, adults who perform a simultaneous verbal shadowing task (compared with a those performing a similarly demanding non-verbal task) display a highly impaired pattern of results (Newton & de Villiers, 2007). Therefore, our language faculty, which has long been considered as a hallmark of abstract cognition, might be crucial in our ability to sever the mental from physical worlds and transcend the here and now.

It is interesting to note that in terms of CLT, falsehood may be conceptualized as distance on the hypotheticality dimension, as an extreme case of low likelihood. In this view, falsehood, as any psychological distance, should be associated with more abstract mental representations. Like ToM, CLT suggests that abstraction plays a crucial role in representing things that are not certain and things that are false.

ABSTRACTION HELPS IN SEVERING THE REAL FROM IMAGINED WORLDS

Abstraction may be needed not only to represent the meta-cognitive concept of falsehood but also to construct representations that are not easily confused with reality. A vast amount of research conducted within the framework of reality-monitoring theory (Johnson and Raye, 1981) suggests that more concrete, vivid representations are more readily confused with reality (and thus are more likely to create false memories) than more abstract, general representations. For example, the more people imagine an event in vivid and concrete details, including its time, place, sensory details (sound and touch), and motor actions, the more they are likely to confuse this imaginary event with an event that really happened (e.g., Goff & Roediger, 1998).

Adopting this framework might hint to us that a strength of abstract representations is their relative low correlation with their referent. For example, the concept ANIMAL might refer to many instances of real-world experience with animals. Thus, when one activates this concept in mind, this activation will diffuse across innumerable specific experiences with cats, dogs, birds, and so on, supplying each of them with a small amount of activation. Activating the concept DANNY'S DOG WHEN HE WAS A LITTLE PUPPY will excite a more limited set of representations, supposedly allowing a more vivid mental image that would be more readily confused with actually seeing the dog.

In a similar vein, functional magnetic resonance imaging evidence (van Dam, Rueschemeyer, & Bekkering, 2010) suggests that the specificity of described motor sentences (i.e., "Clean the table"—which is an activity that can be performed in any number of ways, vs. "Wipe the table") modulates the degree to which imagery-related motor-cortex activity is recorded. Thus, the generality and lack of specificity inherent to abstraction might serve to attenuate activation of specific experiential instances, and doing so creates a much needed buffer between reality and its representation.

ABSTRACTION ALLOWS SIMULATING THE UNKNOWN

By not being tied to one (vivid and highly activated) exemplar, but rather activating a large set of exemplars, abstraction not only avoids confusion with reality but also allows encompassing many hypothetical worlds. Consider the following example: you are sitting peacefully in the jungle, when you suddenly hear a rattle in the woods. You immediately assume that it is a wild boar and simulate its appropriate size, appearance, and the motor responses relevant to the forthcoming interaction. Such an experiential simulation of the specific features of the boar will undoubtedly improve your ability to catch the prey. However, if you were mistaken, and the rattle was due to a snake, simulating an approaching boar could be quite disastrous. A better response, especially if the rattle indicates only a probable but not a certain encounter with a wild boar, would have been perhaps just to increase general vigilance and not to gamble upon a specific course of action until further information is attained. Hence, specificity of an evoked representation could be both beneficial and detrimental, and a major determining factor could be the amount of information at hand.

A similar logic is true for representations that are evoked intrinsically, as in the case of goal pursuit. There are many physical experiences that can be recapitulated to accomplish a specific goal such as setting up a meeting with a friend (e.g., writing an email, using the phone, etc.). The less we know about the context in which an intended action could occur (e.g., "will I have access to the computer?"), the better it is to represent the goal in prospective memory in a more abstract and invariant manner (i.e., through the statement "contacting Danny," instead of the sensory-motor experiential simulation "typing in Danny's name in the web browser"). Thus, another crucial feature of abstract representation is its relative invariability, which allows us to efficiently navigate behavior toward an uncertain, distal world—be it temporal, spatial, or social distance.

Our study examines the relation between (degrees of) falsehood and abstraction. We predicted that objects that are negated (e.g., the pipe in the sentence "this is not a pipe") would be represented more abstractly than objects that are probable (e.g., the pipe in the sentence "this might be a pipe"), which, in turn, will be represented more abstractly than asserted objects (the pipe in "this is a pipe"). This prediction follows from two related theoretical lines: First, it follows from the aforementioned discussion on the relation between negation and abstraction within the tradition of research on ToM. Second, it follows from CLT, which, as noted earlier, conceptualizes negation as distancing on the hypotheticality dimension.

EXPERIMENT: THE EFFECT OF UNCERTAINTY AND FALSITY ON SPECIFICITY OF PERCEPTUAL REPRESENTATION

We sought to test empirically whether people omit perceptual detail when they encode false or hypothetical events and whether they instead construe them in a more gist-based manner. To investigate this hypothesis, we adapted a memory task developed by Koutstaal (2003). In this paradigm, after participants memorize a set of pictures, they are tested with pictures that are either identical, similar (i.e., another token of the same type, e.g., a cat that is different from the one presented at encoding), or different lures. Identifying a *similar* stimulus as *new* is considered within this paradigm as a measure of general forgetting. More importantly, identifying a *similar* lure as *identical* is taken to reflect an abstract and semantic (rather than concrete and perceptual) representation, because if the subjects were to remember the word or category CAT, he or she should be impervious to the specific perceptual detail of the referent image.

In the present study, participants were presented with a sequence of propositions consisting of both verbal and pictorial pieces of information. Within the verbal part, we manipulated the likelihood of the described event. Specifically, the verbal stimulus conveyed one of three degrees of certainty, by presenting an *assertion* (a high likelihood, "Danny traveled to Germany and saw [a cat]"), a *conditional* (a medium likelihood, e.g., "If Danny will travel to Germany he will see [a cat]"), or a *negation* (low likelihood, "Danny traveled to Germany and did not see [a cat]"). The cat, in all the previous examples, was presented pictorially (Figure 1). To make sure that participants pay attention to the verbal part, we told them that they will be tested on their memory for whether the agent in each sentence *had seen* the object, *might have seen* the object, or *did not see* the object. We hypothesized that the percentage of responses in which participants mistake *similar* stimuli to be *identical* will increase as the likelihood of the event decreases and yet that the general forgetting (thinking that a *similar* stimulus is *new*) will not be affected by the event's likelihood.

Method

Participants

Thirty students from Tel Aviv University (27 women, age 20–28 years, mean age = 24 years) participated in the study for course credit. All the participants were native Hebrew speakers.

Materials

We used 30 pictures from a database used in Koutstaal et al. (2001). For the encoding phase, three short sentences were written for each picture, describing a situation pertaining to a protagonist named Danny (e.g., "If Danny will travel to Germany he will see a [cat]," "Danny traveled to Germany and did not see a [cat]," and "Danny traveled to Germany and saw

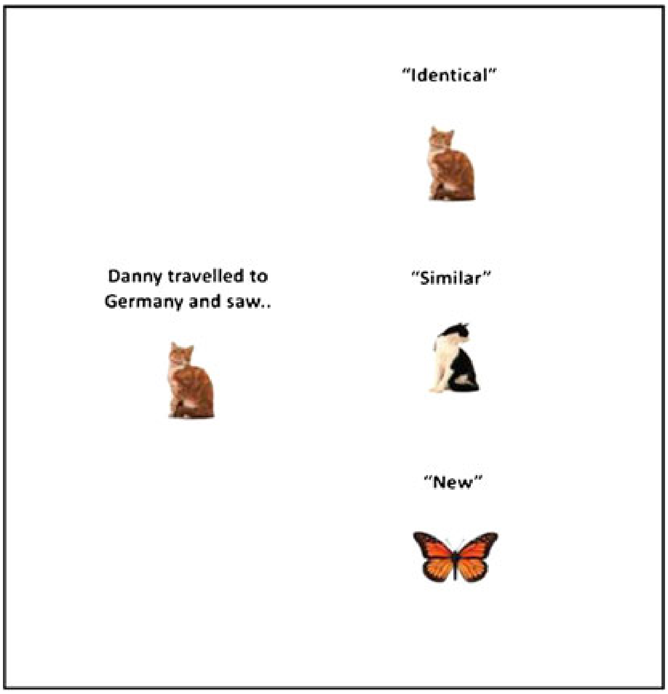

Figure 1. At encoding (leftmost picture), participants were presented with stimuli that included both verbal and pictorial pieces of information. At retrieval (rightmost pictures), some of the stimuli were identical to those previously displayed (upper box), some were similar but not identical to those previous displayed (middle box), and some stimuli were new (bottom box)

a [cat]"). The association between the depicted event (e.g., trip to Germany) and picture (e.g., cat) was held constant, resulting in a total of 90 sentences (30 pictures/events × 3 certainty levels). The stimuli sets for the encoding phase were created by randomly selecting 10 asserted, 10 negated, and 10 conditional items such that each participant saw each picture/event only once. Importantly, the items were counterbalanced across participants so that each picture–event pair appeared the same number of times in each of the three certainty levels. The retrieval stimuli set was created on the basis of the 30 pictures used in encoding but replacing five randomly selected pictures from each of the three certainty levels with pictures that were similar but not identical to the ones previously displayed. The similar pictures were always different tokens of the same type (e.g., a different cat and a red instead of green apple). Finally, 15 additional pictures from the Koutstaal et al. (2001) database were added to the retrieval stimuli set, serving as foils. These were the new stimuli.

Procedure

After signing consent forms, participants read instructions on a computer screen. They were shown examples of encoding items and were told that their task is to remember all the information for a subsequent test. Each item appeared in the center of the computer screen for 10 seconds, against a white background (see leftmost panel in Figure 1). After the encoding phase, participants played a game of Tetris for 10 minutes as a filler task and then performed the retrieval task. At retrieval, participants saw on the computer screen a total of 45 pictures displayed in a random order, one at a time, against a white background (rightmost panel in Figure 1). Fifteen pictures were identical to the ones presented at encoding, 15 pictures were similar but not identical to those presented at encoding, and 15 were new. Participants indicated in a self-paced manner whether each picture was identical, similar, or new with regard to the pictures they previously saw.

Results

Consistent with our hypothesis, a planned linear trend contrast revealed a significant effect of likelihood, $F(1, 29) = 3.55$, $p = 0.03$, Cohen's $d = 0.49$, so that rates of classifying a similar object as identical (computed as number out of 15) decreased linearly from negated objects (5.1%) through conditioned objects (3.3%) to asserted objects (2.4%; see Figure 2). No differences were found in the rate of classifying similar stimuli as identical, $F(2, 58) = 0.62$, *ns* (negated = 2.8%, conditioned = 4.0%, and asserted = 3.1%) supporting the claim that the observed trend represents a shift toward a less specific, more abstract encoding rather than mere forgetting. Furthermore, there was no difference in rates of classifying identical stimuli as new $F(2, 58) = 0.39$, *ns*, (negated = 0.6%, conditioned = 1.1%, and asserted = 0.4%) or of classifying identical stimuli as similar $F(2, 58) = 0.77$, *ns* (negated = 2.4%, conditioned = 2.2%, asserted = 3.1%).

DISCUSSION

In our study, participants encoded factual sentences (e.g., Danny traveled to Germany and saw a cat) more concretely than hypothetical sentences (e.g., If Danny will travel to Germany he will see a cat), which, in turn, were encoded more concretely than negated sentences (e.g., Danny traveled to Germany and did not see a cat). In the conceptual framework of CLT, the distinction between assertions, conditionals, and negations represents decreasing likelihood or increasing distance on the dimension of hypotheticality. We interpret this result as an initial evidence for the effect of distancing on the dimension of hypotheticality on specificity of visual encoding, showing that less likely events, which are further removed from veridicality, are represented more abstractly.

These results also lend support to the notion that a concrete perceptual code is less suitable for the retention of negated or

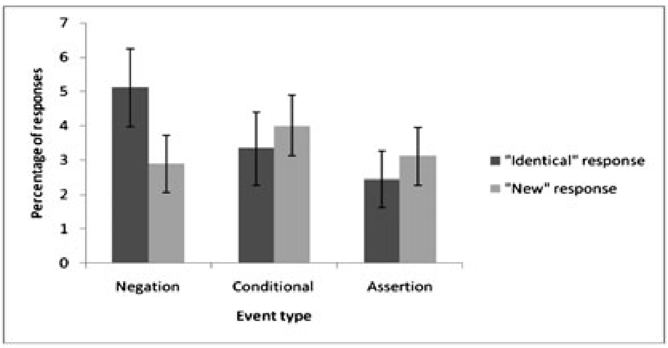

Figure 2. Percentage of "identical" and "new" responses for similar stimuli, as a function of event type. Both responses are incorrect, but only "identical" responses indicate abstract encoding

hypothetical world states. Viewed from that perspective, the present results are generally consistent with the view that abstraction might be involved in ToM tasks, as long as these tasks require representation of negated information of the form "it is not true that object *x* is in location *y*."

This result is also consistent with that of previous neuroimaging studies (Tettamanti et al., 2008; Tomasino, Weiss, & Fink, 2010) that have investigated the relationship between falsehood and concrete–experiential representation. Many studies (e.g., Hauk, Johnsrude & Pulvermuller, 2004; Tettamanti et al., 2005) have shown that when participants read sentences that describe a concrete motor action, neural activity is not limited to language-processing areas but rather extends to effector-specific areas within the motor cortex. This pattern of activation is taken as evidence to support the idea that our conceptual system is based upon experiential and concrete representation. And yet, importantly, when action sentences are negated (e.g., when participants read a sentence such as "do not push the button"), activation within motor areas was found to be significantly lower (Tettamanti et al., 2008; Tomasino et al., 2010).

In light of the theoretical claims presented in previous sections, the reviewed empirical evidence, and the new evidence reported here, we argue that there is good reason to believe that the mental representation of falsehood and hypotheticality departs from a concrete–experiential (in our case visual) representation and instead seems to recruit a more abstract mode of representation. Because the comprehension of falsehood and hypotheticality might be integral for our ability to transcend the here and now, we believe that the existence of a non-experiential mental code played a crucial role in the emergence of these abilities.

Our study indicated that negation promotes abstract encoding, but it did not directly test whether a linguistic/verbal mental code replaced specific visual representations with increasing abstraction, as would be suggested by dual-coding theories (e.g., Paivio, 1971). This possibility can be addressed in future studies that would use verbal shadowing procedures (e.g., Newton & de Villiers, 2007) or examine the activity within brain areas involved in language processing.

IS ALL COGNITION EMBODIED?

We are now in a position to address a more general theoretical question, that of embodied versus abstract cognition. The position we take, which stresses the importance of abstract–symbolic representations, corresponds to a traditional view of cognition, one that posits that humans have an a-modal and abstracted conceptual system (e.g., Pylyshyn, 1973). This view has recently been challenged by the theories of embodied cognition (e.g., Barsalou, 1999; Gibbs, 2006). According to one such prominent theory, the perceptual symbol systems theory (Barsalou, 1999), the human representational system is completely grounded in the sensori-motor and affective experience. In a nutshell, the theory suggests that the retrieval of a concept involves a re-enactment of the experiences associated with it during encoding. A number of mechanisms postulated within this model allow this perceptual code to create functional units of meaning. Much behavioral and neurocognitive evidence has been offered in recent years in support of the embodied theory (see Barsalou, 2008, for a review of empirical evidence). For example, as noted earlier, it was shown that processing of words related to the arm, leg, or mouth activates the appropriate cortical areas that are active during online movement (Hauk et al., 2004). This finding and many others have brought into question the classic view that the linguistic/semantic and sensori-motor realms comprise two segregated systems.

We adhere to a mid-way solution between the traditional and embodied accounts. Namely, it is possible that a spectrum of representation types exists, ranging from the highly depictive and experiential to an abstract/linguistic format. Such dual-system accounts of mental representation have been very influential throughout the history of psychological theory and research; their classical example is Paivio's (1971) dual-coding theory, which posits that we can use a pictorial or verbal mental code.

Moreover, it is possible that both forms of representation may be activated at the same time to a different degree. What determines the extent to which abstract and concrete representations are activated in a given situation? CLT posits that psychological distance is one such a factor. This hypothesis has been widely investigated within CLT, and it was shown that representations of psychologically proximal situations (e.g., events that take place in the near future, involve familiar places and people, etc.) tend to be construed in a more detailed, specific, and concrete manner and that when one contemplates psychologically distant objects and events, he or she represents them more schematically and abstractly (see Liberman & Trope, 2008; Trope & Liberman, 2010 for reviews). For example, in a series of experiments that relate to the verbal/pictorial dichotomy, Amit, Algom, and Trope (2009) have shown that people are more efficient at processing pictures that refer to proximal objects (e.g., a picture of a culturally familiar landmark such as the Israeli Parliament building shown to a group of Israeli students) and words that represent distal objects (e.g., the sentence "Tower of Pisa") than vice versa (e.g., responding to the linguistic stimuli "Israeli Parliament" and a pictorial representation of the Tower of Pisa).

CONCLUDING REMARKS

We suggested, applying CLT, that mental time travel is a special case of transcending psychological distance and thus is akin to perspective taking and counterfactual thought and requires the same abilities as pretense and ToM tasks. An ability that seems critical to these tasks is representation of falsehood and counterfactuality. We presented an empirical and theoretical support for the suggestion that representation of counterfactuality is facilitated by an abstract/linguistic rather than concrete/experiential mental representation.

Much work is still needed to better characterize the behavioral consequences of mental time travel, because as this special issue paper demonstrates, future-oriented cognition exerts its effects in many aspects of our daily lives. The present article attempted to shed some light on the mechanisms that enable us to transcend the here and now. We hope that a better account of these mechanisms will advance our understanding of the role that abstract thought and imagination play in our lives.

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