Trends in Cognitive Sciences

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Feature Review

How Linguistic Metaphor Scaffolds Reasoning

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Language helps people communicate and think. Precise and accurate language would seem best suited to achieve these goals. But a close look at the way people actually talk reveals an abundance of apparent imprecision in the form of metaphor: ideas are 'light bulbs', crime is a 'virus', and cancer is an 'enemy' in a 'war'. In this article, we review recent evidence that metaphoric language can facilitate communication and shape thinking even though it is literally false. We first discuss recent experiments showing that linguistic metaphor can guide thought and behavior. Then we explore the conditions under which metaphors are most influential. Throughout, we highlight theoretical and practical implications, as well as key challenges and opportunities for future research.

Trends

Metaphors pervade discussions of abstract concepts and complex issues: ideas are 'light bulbs', crime is a 'virus', and cancer is an 'enemy' in a 'war'.

At a process level, metaphors, like analogies, involve structure mapping, in which relational structure from the source domain is leveraged for thinking about the target domain.

Metaphors influence how people think about the topics they describe by shaping how people attend to, remember, and process information.

The effects of metaphor on reasoning are not simply the result of lexical priming.

Metaphors can covertly influence how people think. That is, people are not always aware that they have been influenced by a metaphor.

Metaphor Shapes Thought

Linguistic metaphors describe a topic of discussion in terms of a semantically unrelated domain [1–8]. Recent work in cognitive science has demonstrated that metaphors can shape the way people think (Table 1). For instance, in one study, Alan Turing was seen as more of a genius with more exceptional inventions when his ideas were described as light bulbs rather than as seeds [9]. In another study, people were more likely to support reform, rather than enforcement-oriented, approaches to crime reduction when crime was described as a virus than as a beast [8,10–11]. Experiments have also shown that personifying changes in stock prices ('climbing' and 'slipping'), rather than objectifying them ('increasing' and 'decreasing' in value), makes people more likely to think recent price trajectories will continue into the future [12,13]. And framing cancer as an 'enemy' in a 'war' has been found to reduce people's intentions to engage in self-limiting preventative behaviors (e.g., eating less red meat, smoking less; [14]) and to think that it would be harder for cancer patients to come to terms with their situation [15].

Metaphors have also been shown to affect behavior [16–20]. For instance, metaphor-based interventions – describing the brain as a 'muscle' that 'grows' with practice – can encourage students to adopt an incremental, rather than fixed, theory of intelligence [21]. In turn, an incremental theory of intelligence leads students to be more committed to their learning goals and persistent in the face of adversity.

How Metaphor Shapes Thought

Metaphors provide a framework for thinking about abstract concepts like ideas and intelligence, as well as complex social and health issues like crime, the economy, and cancer, by drawing on structured knowledge from a semantically unrelated domain (see Box 1). In this way, metaphors are like analogies – the terms metaphorical reasoning and analogical reasoning are often used interchangeably to describe how people use knowledge of one domain to talk and think about another [22]. As a result, there is considerable overlap in theoretical accounts of

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Table 1. Overview of Results from a Sample of Recent Metaphor Framing Experiments

Target domain	Source domain	Outcome	Refs
Cancer	Enemy vs neutral	'Enemy' reduces intention to engage in self-limiting preventative behaviors	[14]
Cancer	Journey vs battle	More acceptance of difficult outcomes on 'journey'	[15]
Loving relationship	Journey vs perfect union	Conflict hurts on 'perfect union' more than on 'journey'	[89]
Relationship	War vs two-way street	More guarded communication on 'war'	[37]
Trade	War vs two-way street	More support for trade tariffs on 'war'	[37]
Stock market	Personified as agent vs described as object	Prediction that market will continue on current trajectory when 'agent'	[12,13]
Business failure	Vehicle accident vs storm	More responsibility attributed to CEO on 'accident'; more responsibility to economic conditions on 'storm'	[40]
Crime	Virus vs beast	More support for social reform (rather than enforcement) on 'virus'	[8,10–11]
Climate change	War vs race	More urgency, risk perception, and willingness to change behavior on 'war' metaphor	[90]
Ideas	Light bulbs vs seeds	Ideas seem more exceptional as 'light bulbs'	[9]

metaphorical and analogical reasoning (although there are also a number of notable differences in how metaphors and analogies are used in naturalistic settings and in how cognitive scientists study metaphorical and analogical reasoning; see Box 2).

There are three components of a metaphor: a source domain, a target (or topic) domain, and a mapping between them. In the metaphor 'crime is a virus', virus is the source domain, and crime is the target domain. Mental representations of virus and crime problems are more than a jumble of associations; they have structure [23–26]. For instance, people know how to address a literal virus problem: by diagnosing the root cause and treating it. People also have knowledge of how to address a literal crime problem: maybe through enforcement tactics like increasing the police force; maybe through social reform like job-training programs.

Typically, the source domain in a metaphor (e.g., 'virus') is more familiar, concrete, or clearly delineated than target the domain (e.g., 'crime'). For instance, there is a stronger consensus on how to address a virus problem than a crime problem [8]. Metaphorically framing crime as a virus creates a mapping between these domains: highlighting relational structure that is similar, in this case, between crime and virus problems; and hiding dissimilarities [24].

A simplified schematic of the relational structure of crime and virus problems is depicted in Figure 1 – and contrasted with another metaphor for crime, as a beast – to illustrate the process of structure mapping in metaphorical reasoning. The figure shows, first, that all three domains are structured by knowledge of what causes the problems and methods for addressing the problems. Second, the figure shows that crime is a more complex issue than a virus or beast problem: there are multiple causes of crime, associated with different ways of addressing the problem; schemas for virus and beast problems are more straightforward. Third, the figure shows that there is structural similarity between the representation of crime and each of the other domains. However, the way in which crime is structurally similar to a virus is different from

Box 1. Metaphor in Natural Language and Metaphor Processing

In Natural Language

Metaphor is prevalent in natural language, making up as much as 20% of discourse [91]. Metaphors can be instantiated by nouns (crime is a 'virus'), verbs (crime 'plagues' the city), adjectives ('infectious' crime), and other parts of speech. Isolated instances of metaphor are common in discourse ('My lawyer is a shark'), but linguistic analyses have also highlighted the prevalence of systems of metaphors. That is, certain metaphoric mappings appear repeatedly in a variety of ways (crime is a 'virus': 'plaguing' communities; it's an 'epidemic'; we need to 'treat' it). These systems of metaphors have been called generative, because they can be extended in novel ways (let's try to 'inoculate' the city against crime). They have also been called conceptual metaphors because their prevalence may suggest a role for metaphor in long-term conceptual representation [5].

Metaphor Processing

Early theories of language processing distinguished between literal and figurative language because figurative language was thought to be more difficult to process than literal language [92]. Psychological experiments on metaphor comprehension, however, have found that, in context, metaphorical language is understood quickly, easily, and automatically (like literal language) (see [3] for review). These findings raise questions about the utility of distinguishing between literal and figurative language for theories of language processing [93,94].

There is behavioral and neuroscientific evidence that metaphors instantiate cross-domain mappings (in addition to linguistic evidence; [5]). For example, response time studies have revealed that reading conventional metaphors facilitates processing of novel extended metaphors [95]. Neuroimaging studies have shown that vivid sensorimotor metaphors engage neural networks that represent the corresponding sensation or action. For example, hearing 'she grasped the idea' activates motor cortex [96]; hearing 'he is sweet' activates gustatory areas [65].

the way crime is structurally similar to a beast. As a result, metaphorically framing crime as a virus highlights one way of addressing crime – through social reform; metaphorically framing crime as a beast highlights a different way of addressing crime – through enforcement.

Computational accounts of structure mapping have been explored in both symbolic [27] and distributional models [28,29] of analogical and metaphorical reasoning, as well as hybrid models [30].[a] In the case of more explicitly structured symbolic models, structure mapping is implemented as a mechanism that finds correspondences between separate propositional representations: as a process of identifying syntactically similar relations (e.g., caused by) in semantic representations of the source (virus) and target (crime) domains. Once the model identifies a coherent mapping between the source and target domains, it projects inferences from the more clearly delineated source domain to the target domain (e.g., diagnose and treat crime). In the case of less structured models, mapping is an emergent byproduct of the network's learned, overlapping, distributed representations: as a type of generalization. On this view, the semantic representation of a crime problem overlaps in some ways with the semantic representation of a virus problem and in other ways with the semantic representation of a beast problem. As a result, talking about crime as a virus calls to mind ways in which a crime problem is similar to a virus problem – thereby shaping the inferences people make about how to address crime.

A critical feature of all of these models is their characterization of metaphor as a dynamic process: prior knowledge about a source domain plays an active role in helping people construct a representation of the target domain in working memory, thereby shaping how

[a]An important question for formal models of semantic knowledge relates to the format of conceptual representation. In one type of model, conceptual representations are implemented as structured symbols like propositions in language. In another, conceptual representations are implemented as a set of numbers in a vector or matrix (like a neural system). Hybrid approaches use a combination of symbolic and distributed representations.

Box 2. The Relationship between Metaphor and Analogy

Metaphor is often considered a conventionalized analogy: analogy involves an explicit comparison ('like' or 'as'), whereas metaphor involves an implicit comparison (or categorization process; [22,31]). In natural language, analogies are more likely to be accompanied by an explanation, as in 'Crime is like a virus because it spreads by direct personal influence' [97]. Studies of analogical reasoning tend to focus on the comparison (structure mapping) process more explicitly by, for example, exposing people to two structurally similar problems and testing whether people spontaneously use what they have learned from one problem to solve the other (e.g., [82]). Studies of metaphorical reasoning tend to assume that people come to the task with prior knowledge of the source domain (e.g., a schema for how to solve a virus or beast problem).

people reason and make inferences about the target domain. As a result of how this process unfolds, there are a variety of factors that can make metaphors more or less influential in reasoning. Studies that have manipulated these factors help to illustrate how metaphors work. In the following sections we elaborate on our discussion of structure mapping and factors that can affect the potency of a metaphor by discussing the role of prior knowledge, language processing, memory, and attention in metaphorical reasoning.

The Role of Prior Knowledge in Metaphorical Reasoning

Metaphors and analogies are more likely to encourage congruent inferences when the structure of the source and target domains can be aligned more precisely – that is, when the metaphor or analogy is apt [24,31]. Some of the factors that affect the aptness of a metaphorical mapping relate to individual differences in people's knowledge of the target and source domains; other factors relate to the salience of the entailments, the implied meaning, of the metaphor.

First, people's prior knowledge of and attitudes toward the target domain play an important role in being able to establish and make inferences from a metaphor. On the one hand, people need to have some prior knowledge of the target domain for a mapping to take hold [32,33]. One study showed that describing semiobscure political leaders like former USA National Security Advisor Zbigniew Brzezinski with negative metaphors (e.g., as the developer of trade policies that were 'transatlantic spitwads aimed at the heart of the Soviet repression') versus positive metaphors (e.g., as the developer of trade policies that were 'transatlantic javelins') influenced judgments of the leaders, but only for readers who recognized the politicians [34].

On the other hand, people's knowledge of and attitude toward the target domain must be malleable for a metaphor to be influential; strong prior beliefs about the target domain can interfere with a metaphorical mapping [8,11,35–38]. For instance, people with deep-seated attitudes about how to solve a crime problem are less susceptible to the influence of a metaphor frame for crime [8,11,39].

It is unclear, however, how much prior knowledge about a target domain is necessary for a metaphor to influence thinking about that domain, and whether metaphors are processed differently depending on how much knowledge people have about the target domain. Of note, people can be made to feel less confident in their knowledge of a target domain, which can bolster the influence of a metaphor [40]. In one study, participants attributed blame to a CEO whose company filed for bankruptcy, which was either described metaphorically as a car crash – with the CEO as the metaphorical driver of the company – or non-metaphorically. The metaphorical description led participants to attribute more blame to the CEO for the bankruptcy, especially for participants who were made to feel uncertain about their knowledge of corporate bankruptcies.

Second, people's knowledge of the source domain also plays an important role in being able to establish a metaphorical mapping [41,42]. Investigations of common metaphor 'vehicles', the words that instantiate metaphorical source domains, reveal that they often refer to embodied

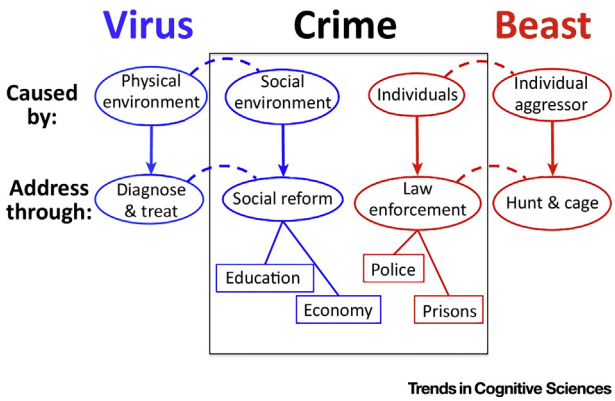

Figure 1. Depiction of Schemas for Virus, Crime, and Beast Domains. How framing crime as a virus draws out one way of thinking about crime, while framing crime as a beast draws out another way of thinking about crime.

experiences like space, motion, and containment and common cultural experiences like a journey, war, virus, or beast [5,43]. These domains may be particularly useful because they evoke clearly delineated schematic knowledge that is shared among speakers of a linguistic community (i.e., they establish common ground; [44]).

In contrast, metaphors have less of an impact when people lack relevant knowledge or interest in the source domain. For example, one series of studies tested the persuasive capacity of sports metaphors [45]. In an initial experiment, students who liked sports showed more support for a senior thesis requirement at their university when the requirement was described with a sports metaphor ('If college students want to play ball with the best . . . ') compared to when it was described with literal language ('If college students want to work with the best . . . '). Students who did not like sports, on the other hand, showed similar levels of support for the thesis requirement in the two conditions. In a follow-up experiment, the researchers asked another group of students to list what they were thinking as they heard one of the two persuasive messages. They found that the sports metaphor condition elicited more thoughts that were relevant to the thesis requirement debate among students who liked sports (compared to the literal condition and to students who did not like sports). This suggests that elaboration, systematic thinking about the target domain, may facilitate metaphorical reasoning in some cases – and that knowledge of and an interest in the source domain can encourage such elaboration (cf. [46,47]). Further investigation of the role of elaboration in metaphorical reasoning represents an important area of future research.

Third, metaphorical mappings are dynamic, drawing on salient structure evoked by the source domain, but constrained by people's knowledge of the target domain [48]. As a result, common metaphor vehicles like 'virus,' 'warrior,' and 'light bulb' do not have a single fixed metaphorical meaning [49]. For instance, describing an idea as a light bulb versus a seed leads to different perceptions of male versus female inventors: males are seen as smarter on the light bulb metaphor, while females are seen as smarter on the *seed* metaphor [9]. In other words, the entailments of a metaphor are not simply determined by and imported from the source domain; a variety of factors affect the meaning of a metaphor.

Finally, metaphorical mappings can be extended in ways that make them more (or less) influential [14,40,50–52]. For instance, when social reforms are framed as a way to 'treat' a crime 'virus' and enforcement tactics are framed as a way to 'fight' a crime 'beast', people are especially likely to endorse the metaphor-consistent response to crime [52]. Similarly, when

self-limiting preventative behaviors (eating less red meat, drinking less alcohol) are described as a way to 'fight' the 'enemy' of cancer, people report stronger intentions to limit themselves [14].

The Role of Language Processing in Metaphorical Reasoning

One way that metaphor shapes thought is by guiding people's interpretation of language (cf. [53]). For example, linguistic analyses reveal at least two ways in which the progression of time can be mapped onto space [54]. In one, time moves, as in 'The due date has passed' (time-moving). In the other, people move through time, as in 'We have passed the due date' (ego-moving). The two mappings suggest different ways of answering a question that includes a spatiotemporal metaphor – namely, 'Next Wednesday's meeting has been moved forward two days. What day is the meeting, now that it has been rescheduled?' If time moves towards an observer, then the meeting jumps forward from Wednesday to Monday. If people move through time, then the meeting shifts forward from Wednesday to Friday.

Consistent with this analysis, after reading time-moving spatiotemporal metaphors, people are more likely to think Wednesday's meeting has been moved to Monday; after reading ego-moving spatiotemporal metaphors, people are more likely to think Wednesday's meeting has been moved to Friday [55,56]. That is, the meaning of the question about Wednesday's meeting depends on how people are thinking about time in terms of space. In this way, metaphorical mappings can play an active role in language comprehension.

As a result of the role that metaphors play in constructing meaning, metaphors are more influential when they are presented early in a stream of processing, followed by text (or an image) that leaves room for interpretation [13,52,57–58] (see also [59]). For instance, in the studies that explored virus and beast metaphors for crime, the description of crime included several ambiguous words and phrases that could be interpreted as being more consistent with a virus schema or a beast schema [8]. Terms like 'vulnerabilities' and 'defense systems' and 'strength' could refer to social structures – like the economy – or they could refer to aspects of law enforcement – like the police. Participants were more likely to suggest a metaphor-congruent response to crime when the metaphor was presented at the beginning of the text, but this was not the case when metaphor was presented at the end.

Similarly, experiments have shown that metaphor framing effects are attenuated when a metaphor is followed by information that is inconsistent with the mapping (i.e., not only unambiguous but actively contradictory; [37]), or when people have less opportunity to construe the metaphorically framed information in a way that is consistent with the entailments of the metaphor [12].

The Role of Memory and Attention in Metaphorical Reasoning

If, as we have argued, metaphors play an active role in shaping people's mental representations of the topics they are used to describe, then metaphors should also have discernable effects on memory and attention. Metaphorically framing a description of an issue like crime or the economy should affect how people attend to the information in the description, how they organize that information in working memory, and, in turn, how they recall the description later on (cf. [23]). For instance, reading about a crime *virus* may encourage people to focus on and remember causal forces that give rise to crime, whereas reading about a crime *beast* may lead people to focus on and remember the urgent negative consequences of a serious crime problem [60].

These possibilities have been the subject of limited experimental investigation and represent an important avenue of future research. One way to test for a direct influence of metaphor on

attention is to track eye movements in a task where people process metaphorical language while viewing related visual scenes. One such study has shown that people fixate longer and more often on paths in visual scenes while processing metaphorical (fictive motion) sentences like 'The road goes through the desert' compared to literal counterparts like 'The road is in the desert' [61]. That is, metaphors influence how people deploy attentional resources to integrate visual and linguistic information [62].

Studies have also investigated the role of metaphor in attention indirectly: by testing whether processing certain types of metaphors (or analogies) have downstream effects on a subsequent, seemingly unrelated, task [60,63–64]. For example, metaphors are often used to talk about emotional states and are noteworthy for their ability to evoke emotion (e.g., the metaphorical description, 'she looked at him sweetly,' elicits more neural activation than a literal counterpart like 'she looked him kindly') [4–5,65]. As a result, certain types of metaphors may sensitize people to affective social cues [66–68]. One study investigated this possibility by testing people's ability to infer emotional expressions from pictures of faces [63]. The results indicated that reading metaphorical, compared to literal, language led to more accurate judgments of the facial expressions, suggesting that metaphors can affect how people attend to information in their social environment.

Further, studies of metaphor and analogy in memory reveal effects of metaphorical mappings on the retrieval of episodic descriptions [20,57,69–73]. For example, metaphors and analogies have been shown to create false memories [74–77]. Instantiating knowledge about alcohol prohibition has been shown to affect memory for a description of marijuana prohibition – leading to memory intrusions about marijuana prohibition that were consistent with alcohol prohibition [74]; instantiating knowledge about the persecution of left-handed people has been shown to affect memory for a description of the persecution of gay people – leading to memory intrusions about the persecution of gay people that were consistent with the persecution of left-handed people [76]. That is, processing a metaphor or analogy can cause people to make inferences about the target domain that influence working and long-term memory of the target domain.

Interim Summary

So far, we have shown that linguistic metaphors can affect the way people think and behave: by drawing on structured knowledge from a source domain to organize a representation of the target domain (see Table 2, Key Table, for a summary). The structure-mapping process can be modeled as an explicit mapping between propositional representations of conceptual structure [27,30] or as a type of generalization in subsymbolic (learned, overlapping, distributed) conceptual representations [28,29]. We have also discussed how the influence of metaphor on reasoning results from and contributes to language processing, attention, and memory, thus highlighting some of the conditions that can make metaphors more or less likely to influence thought (cf. [78]).

Challenges to a Mechanistic Account of Metaphorical Reasoning

Are the Effects of Metaphor the Result of Lexical Priming?

At the center of a number of the studies discussed thus far is the following: To what extent can the results be explained by lexical priming? That is, although we have argued that metaphors instantiate a mapping between a source and target domain, an alternative possibility is that these effects of metaphor result from a comparatively simple mechanism: spreading activation from lexical association [79].

On the one hand, it seems likely that lexical priming contributes to processing extended metaphors and establishing metaphoric mappings [52,80]. When people read that crime is

Key Table

Table 2. Overview of How Metaphors Shape Thought, Interspersed with Factors That Moderate the Influence of Metaphor On Reasoning

Factor	More influential	Less influential
1. Metaphors are more likely to influence reasoning when a precise (apt) mapping can be established between the source and target domains. That is, when salient relational structure from a more clearly delineated source domain can organize people's representation of the target domain.		
Target domain	Domains that are inherently abstract or complex seem most susceptible to the influence of a metaphor. Making people feel less confident in their knowledge of the target domain can bolster the effect of a metaphor.	People need to have some, but not too much, knowledge of the domain; they need to know enough for a mapping to take hold but not so much that their beliefs about the target domain are inflexible.
Source domain	Vehicles that evoke salient and clearly delineated structure – that refer to shared embodied or cultural experiences are more likely to be able to establish common ground and resonate.	Domains that lack salient structure, or that interest only a subset of people will have limited influence (e.g., sports metaphors).
Inferences	Describing inferences in a way that makes them more compatible with the metaphor can bolster the influence of a metaphor frame.	Describing inferences in a way that makes them less compatible with the metaphor can weaken the influence of a metaphor frame.
2. Metaphors provide a knowledge frame for assimilating subsequent information. When the subsequent information can be construed in a way that reinforces the metaphoric mapping, the metaphor will be more influential.		
Timing	Metaphors have more of an influence when they are presented early in a stream of processing, thereby influencing how people interpret subsequent information.	Metaphors have less of an influence when they are presented late in a stream of processing, when they do not have an opportunity to shape interpretations of related information.
Ambiguity	Increasing opportunities to construe information that builds on the metaphor strengthens the influence of a metaphor.	Reducing opportunities to construe information as consistent with the metaphor weakens the influence of a metaphor.
3. Metaphors affect how people attend to their environment and remember descriptions.		
4. Metaphorical reasoning is not simply the result of lexical priming.		
5. Metaphorical reasoning is not simply the result of people thinking explicitly and strategically about the target domain in terms of the source domain. That is, people can be influenced by metaphors without being aware of the metaphor.		

a virus, activation from the word 'virus' may spread to lexical associates like 'treat' and 'cause' – words that are often used to talk about reform-oriented approaches to crime-reduction. In this way, lexical association may be one of the many constraints that help to establish a metaphoric mapping.

On the other hand, several studies suggest that lexical association is not solely responsible for metaphorical reasoning. Language processing studies have shown that people are sensitive to nuances of metaphorical mappings – between, for example, 'time' and 'space' [55,56]. People are faster to read a series of spatiotemporal metaphors in which the mapping of time onto space is consistent (ego-moving vs time-moving) – even when the same spatial language (e.g., ahead, before, behind) is used for both consistent and inconsistent metaphors, thus controlling for lexical priming [81].

The lexical priming account has also been tested directly in studies of metaphorical reasoning [8,49]. For instance, participants were more likely to think social reform would be an effective

response to a crime 'virus' than a crime 'beast'. But this effect was only found when crime was described metaphorically – as a virus or beast – and not when people were asked to list a synonym for (i.e., lexically primed with) the word 'virus' or 'beast' before making their suggestion [8]. That is, lexical priming may contribute to the effect of linguistic metaphor on reasoning but it does not fully account for this influence.

Are People Consciously Using Metaphors to Think?

A second question relates to whether people explicitly use metaphors to think. For example, when reading that crime is a virus, are people consciously thinking about the ways in which crime is similar to a virus? Is this why people suggest different ways of addressing a crime 'virus' versus a crime 'beast'?

On the one hand, awareness plays an important role in analogical problem solving. For example, in one series of studies, only a small percentage of participants were able to solve a target problem (Dunker's radiation problem) without being given a hint to think about a relevant analog (a military problem with a structurally similar disperse-and-converge solution), whereas almost everyone was able to solve the target problem after being given the hint [82]. At least in some cases, people may need to explicitly recognize structural similarity in order to use metaphors or analogies to solve problems.

On the other hand, several studies have tested whether patterns of inference in metaphor framing tasks are the result of participants actively using the metaphors to think [11,37]. For example, in one series of studies, participants were asked to justify their response to a metaphorically framed dilemma: across six experiments, a relatively small proportion, between 7 and 17 percent of participants, referenced the metaphor [37]. In another series of studies, after reading a metaphorically framed description of crime and suggesting a response, participants were cued to recall the metaphor frame: roughly half the participants remembered the metaphor they had read, and the patterns of inference were metaphor-congruent for both groups [11]. These studies suggest that metaphors can covertly influence the way people think.

How Influential Are Metaphors?

Finally, how influential are metaphors? One meta-analysis estimated that metaphorical language is about 6 percent more persuasive than comparable literal language [83]. The studies reviewed here are consistent with this estimate – with a fairly wide range depending on when and how the metaphor was used.

One important consideration in attempting to quantify the influence of metaphor on reasoning is the laboratory environment, which may artificially constrain (or inflate) such estimates. Consider two descriptions of crime as a virus (Table 3): one from a metaphor framing study [8,11] and one from a magazine article [84]. Experiments are often designed to answer specific questions

Table 3. Crime Is a 'Virus'. A Comparison of Language Used in Psychological Experiments and in the Real World

Lab	Real world
Crime is a virus ravaging the city of Addison. Five years ago Addison was in good shape, with no obvious vulnerabilities. Unfortunately, in the past five years the city's defense systems have weakened, and the city has succumbed to crime.	Violence directly mimics infections like tuberculosis and AIDS and so the treatment ought to mimic the regimen applied to these diseases: go after the most infected, and stop the infection at its source.

about how metaphors influence language processing, memory, or inference; as a result, they are carefully constructed to, for example, minimally instantiate the metaphor. In the real world, metaphors are often extended and supported in ways that might make them more (or less) influential. Future work may seek to establish a more ecologically valid way of estimating the effect of metaphor by using more realistic stimuli.

Conclusions and Future Directions

Questions about the role of metaphor in reasoning are at the heart of cognitive science. The topic is inherently interdisciplinary – drawing on insights from linguistics, philosophy, psychology, computer science, and neuroscience; and shedding light on basic questions about how people integrate novel information with prior knowledge, in general, as well as specific questions about the relationship between language and thought (see Outstanding Questions).

In addition to the important theoretical implications of the work, these findings have significant practical implications as metaphors are often used to develop scientific theories [85], to frame complex policy issues [86], to explain difficult concepts in the classroom [87], and to understand health conditions [88]. Thus, one of the most promising avenues of future research may be to find ways in which metaphors can support the common good.

Outstanding Questions

How do metaphors affect information processing, memory, attention, and inference?

When are metaphors most likely to influence people? What factors make metaphors more or less influential?

When do metaphors function as heuristic cues? When does elaborating on a metaphor make it more (or less) influential?

Is there really a difference between literal and figurative language?

Do metaphors highlight existing similarities between conceptual domains or do they create similarity between conceptual domains? To what extent is metaphor a tool for creating new knowledge?

When, why, and how do people produce metaphorical language?

To what extent do patterns of metaphor use in natural language reflect the way people think about abstract concepts and complex issues? Is semantic knowledge of abstract concepts grounded, metaphorically, in representations of more concrete, experiential, concepts? When and how do entailments of common metaphors 'transfer' from the source to the target domain to influence social evaluations? When are metaphors reliably available to scaffold thinking about a social domain? For instance, is interpersonal affection warm, morality clean, and importance heavy?

Acknowledgements

We thank F. Durgin, C. Fausey, S. Flusberg, T. Matlock, and A. Porterfield for helpful comments on this manuscript.

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