Chapter 8

Spatial Metaphors in Temporal Reasoning

Dedre Gentner

We often talk about time in terms of space: of looking *forward* to a brighter tomorrow, of troubles that lie *behind* us, or of music that played all *through* the night. The language of spatial motion also seems to be imported into time, as when we say that the holidays are *approaching*, or that a theory was proposed *ahead* of its time. Many researchers have noted an orderly and systematic correspondence between the domains of *time* and *space* in language (Bennett, 1975; Bierswisch, 1967; Clark, 1973; Fillmore, 1971; Lehrer, 1990; Traugott, 1978). The following examples illustrate the parallel use of static spatial and temporal expressions:

at the corner → *at* noon

from here *to* there → *from* two o'clock *to* four o'clock

through the tunnel → *through* the night

There appear to be some universal properties in importing language about space to describe time (Clark, 1973; Traugott, 1978). First, since time is usually conceived as one-dimensional, the spatial terms that are borrowed are uni-dimensional terms (e.g., *front/back, up/down*) rather than terms that suggest two or three dimensions (e.g., *narrow/wide, shallow/deep*). Second, to capture temporal sequencing, directionally ordered terms such as *front/back* and *before/after* are used, rather than symmetric terms such as *right/left*. Overall, spatial terms referring to *front/back* relations are the ones most widely borrowed into the *time* domain cross-linguistically (Traugott, 1978).

There are two distinct space-time metaphoric systems in English and many other languages (see Bierwisch, 1967; Clark, 1973; Traugott, 1978): the *ego-moving* metaphor, wherein the speaker is moving along the time-line towards the future, and the *time-moving* metaphor, wherein the

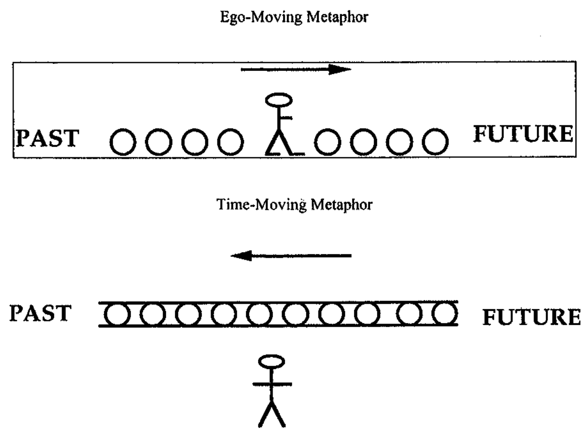

Figure 8.1
Time-moving and ego-moving metaphors.

speaker stands still and time—conceived of as a river or conveyor belt—flows by from future to past. The two systems appear based on two different spatial schemas (see Figure 8.1). Examples of the ego-moving metaphor are the following:

- I am going to do that.
- We are fast approaching the holidays.
- We must go forward with this plan.
- The Present is a Point just passed. (David Russell)

Examples of the time-moving metaphor are these:

- The years to come/the years gone by
- The holidays are coming fast.
- Night follows day.
- Time is a circus always packing up and moving away. (Ben Hecht)

The two systems lead to different assignments of *front/back* to the time-line (Clark, 1973; Fillmore, 1971; Lakoff & Johnson, 1980; Lakoff & Turner, 1989; Lehrer, 1990; Traugott, 1978). In the ego-moving system, the future is normally conceived of as in *front* and the past as *behind.* In the time-moving system, the reverse is true: time moves from the future to the past, so that past (earlier) events are in *front* and future (later) events are *behind.*

The apparent systematicity of the ego-moving and time-moving systems in language suggests that space provides a framework that is mapped into time to facilitate temporal reasoning. Such a view would be consistent with evidence that spatial representations are carried into abstract arenas such as interpretations of graphs (Gattis, in preparation; Gattis & Holyoak, 1996; Huttenlocher, 1968; Tversky, Kugelmass & Winter, 1991), and more generally with evidence that analogies from concrete domains are used in reasoning about abstract domains (Bassok & Holyoak, 1989; Gentner & Gentner, 1983; Holyoak & Thagard, 1995). Moreover, indirect evidence that space-time mappings serve conceptual functions can be found in the pervasive use of spatial representations of time across cultures in artifacts such as clocks, timelines, drawings, and musical notation (Friedman, 1990). Thus it is tempting to think of these metaphoric systems as a means of *spatial or visual reasoning*—"the use of ordered space to organize non-spatial information and generate new knowledge," as Gattis and Holyoak (1996) put it—about event sequences.

Despite the intuitive appeal of the idea of a conceptual mapping from space to time, there is good reason to be cautious here. The perils of relying on intuition in interpreting metaphorical language are delineated in Keysar and Bly's (1995) study of the illusory transparency of idioms. They gave people archaic English idioms (for which the meanings are no longer current) in different contexts. People who heard "The goose hangs high" in the context of a sad story considered that it expressed sadness (a dead goose); those who heard it in a happy story thought it expressed happiness (a plentiful larder). More tellingly, both groups were confident that they would have arrived at the same interpretations without the story; they felt that the interpretation could be derived simply from the idiom. Keysar and Bly found that the perceived transparency of an idiomatic expression (the perceived connection between the expression and its meaning) increases with repeated use of an expression, and is largely independent of whether such a connection is conceptually motivated.

Thus the mere presence of metaphorical language does not by itself tell us whether the space-time metaphor is a psychologically real conceptual mapping. For example, the temporal and spatial meanings could be represented as alternate meaning senses or even as separate homophonic lexical entries. The apparent systematicity would then be illusory, the result of post hoc regularization.

In order to establish the conceptual role of space-time mappings, we first lay out a set of possibilities, including skeptical alternatives. There are at least four broad possibilities. The strongest possibility is *system-mapping*: the abstract domain of time is organized and structured in terms of systems borrowed from the more and readily observable domain of space. That is, people actively use spatial mappings to think about time. In this case, the ego-moving and time-moving systems would constitute two distinct globally consistent systems that are metaphorically mapped from space to time and used on-line to process temporal expressions. The second possibility is *cognitive archaeology*: there are indeed two separate space-time conceptual systems, but although these systems were originally borrowed from space, they now exist as independent temporal systems. In this case the existence of two spatial-temporal systems may testify to the importance of spatial representation in the history of language. However, recourse to spatial knowledge is no longer needed during temporal reasoning.

The third possibility is *structural parallelism* in the domain representations. As Murphy (1996) suggests, it is possible that, due to inherent similarities in the referent domains of *space* and *time*, parallel relational systems evolved independently in the two domains. The common language then reflects structural alignment (Gentner & Markman, 1997; Medin, Goldstone & Gentner, 1993) between the two parallel domain representations. In this case space and time share conceptual systems, but neither is derived from the other. If either the second or third possibility holds, the ego-moving and time-moving systems could function as coherent systems within time. However, there would be no online processing asymmetry between time and space. The fourth and weakest possibility is *local lexical relations*. There are no large-scale systematic mappings; space-time metaphors consist simply of individual polysemies and/or homophonies. For example, a term like "before" would have spatial word senses, such as "spatially in front of," and also temporal word senses, such as "temporally prior to." A related possibility is that the spatial and temporal senses are stored as separate homophonic lexical entries. Either way the phenomenon would involve local lexical processes such as word-level priming and would not entail conceptual mapping.

The goal of the chapter is to evaluate these possibilities. More specifically, three experiments are discussed that use the metaphor consistency effect to discount the local lexical relations possibility. Then, other literature is reviewed that contrasts the remaining three alternatives.

1 Evidence for Conceptual Metaphors: The Metaphor Consistency Effect

How could one test for large-scale conceptual metaphoric systems? Gentner and Boronat (1992, in preparation; Gentner, 1992) devised a *mixed mapping* paradigm. This technique is based on the 'boggle' reaction that occurs when one reads mixed metaphors, such as these examples from the *New Yorker*:

- The ship of state is sailing towards a volcano.
- The U.S. and the Middle East are on parallel but nonconverging paths.

In both cases, the individual phrases are locally interpretable, yet the combination is arresting. This boggle response suggests the clash of two inconsistent metaphoric mappings.

This mixed mapping phenomenon formed the basic idea for the Gentner and Boronat technique. Our method was to set up a metaphoric mapping and then present a further statement either from the same metaphor system or a different one. If subjects are processing the metaphors as a systematic domain mapping, then the inconsistent metaphor should take longer to comprehend.

To establish a global mapping, we asked subjects to read vignettes containing a series of conceptual metaphors from a single coherent domain. The passages were presented one sentence at a time; subjects pressed a key to see the next sentence. The final test sentence was either consistent, in that the same metaphor was maintained throughout, e.g.,

Anna was boiling mad when you saw her.
Later she was doing a slow simmer.

or inconsistent, in that there was a shift of metaphor between the initial passage and the final sentence, e.g.,

Anna was a raging beast when you saw her.
Later she was doing a slow simmer.

The dependent measure was the time to read the last (metaphorical) sentence. To ensure comparability, this final test sentence was always the same; the initial setting passage was varied between conditions. In all cases the same meaning in the target domain was conveyed in the two passages.

Using this technique, Gentner and Boronat (1991, in preparation) found that subjects' reading time for the final sentence was longer following a shift between metaphoric systems. This cost in comprehension time for mixed mappings suggests that the metaphors were processed as part of global on-line mappings. Interestingly, we found this mixed mapping cost only for novel metaphors, not for highly conventional metaphors. This finding is consistent with other evidence that highly familiar metaphorical meanings are stored and processed at a lexical level (Cacciari & Tabossi, 1988; Swinney & Cutler, 1979). More broadly, it is consistent with the *career of metaphor* claim, that metaphors start as generative mappings and with increasing conventionalization come to have their metaphorical meanings stored as alternative senses of the base term (Bowdle & Gentner, 1995, 1999, in press; Gentner & Wolff, 1997, in press; Wolff & Gentner, 1992, 2000).

We interpret the mixed mapping cost as indicative of metaphors that are processed as large-scale conceptual systems. Other evidence for the existence of such global conceptual metaphors comes from studies by Allbritton, McKoon and Gerrig (1995) who found that large-scale conceptual metaphor schemas facilitated recognition judgments for schema-related sentences in text (see also Allbritton, 1995; Gattis & Holyoak, 1996; and Gibbs, 1990, 1994; but see Glucksberg, Brown & McGlone, 1993, for contradictory evidence).

We now return to *space* → *time* metaphors and to the question of their psychological status. Are *space* → *time* sequencing expressions processed as part of global conceptual systems? There is reason to doubt this possibility. As just discussed, Gentner and Boronat obtained evidence for domain mappings only when conceptual metaphors were relatively novel; tests using highly conventional metaphors (such as "get this topic across") did not reveal a significant cost for re-mapping. Glucksberg, Brown and McGlone (1993), whose metaphors were highly conventional, also found no evidence that global metaphoric systems are accessed during metaphor comprehension. Our findings suggest that their conclusion—that domain mappings are not involved in metaphoric processing—should be restricted to conventional metaphors; novel metaphors are processed as system mappings. But even so, *space* → *time* metaphors are highly conventional. Indeed, these metaphors are almost invisible: people are generally surprised to find that they use two different space-time mappings in everyday language. It therefore seems quite likely that, even if the two mapping metaphors were once active in the dim history of language, they now are stored simply as alternate word-senses of the spatial terms. If this is the case, we would not expect to see a mixed metaphor effect when space-time metaphors are used.

A second reason for caution is that the contrast between metaphors here is quite subtle, since both apply between the same two domains of *space* and *time*. In the materials used by Gentner and Boronat, two metaphors from different base domains (e.g., *heat* and *dangerous animal*) were applied to the same target (*anger*). In the present case, however, there are two conceptual systems from the same base domain, *space*, to the same target domain, *time*. For this reason, we will call these mappings *system mappings* rather than *domain mappings.* Evidence that these two space-time metaphors are psychologically distinct in online processing would be particularly interesting because it would suggest considerable representational specificity in metaphoric systems.

To test for the use of the two space-time metaphors in online processing, Gentner and Imai (1992) employed a reaction-time comprehension task similar to that used by Gentner and Boronat (1991; in preparation). A test sentence describing a temporal relation between one event (E1) and a second event (E2) was preceded by three setting sentences. In the Consistent mapping condition, the setting sentences and the test sentence used the same metaphoric system—either ego-moving or time-moving. In the Inconsistent mapping condition, the setting sentences used a different mapping system from that of the test sentence. According to the domain-mapping hypothesis, there should be a Mixed Mapping effect. Processing should be slower in the Inconsistent mapping condition than in the Consistent mapping condition. This is because in the Consistent condition, subjects can continue to build on the same systematic mapping as they progress from the setting sentences to the test sentence, but in the Inconsistent condition, to understand the test sentence subjects must discard their existing mapping and set up a new one.

To ensure that subjects really processed the stimulus sentences, we required them to place the events on a timeline. Figure 8.2 shows how the experimental materials were presented. Sentences were presented one at a

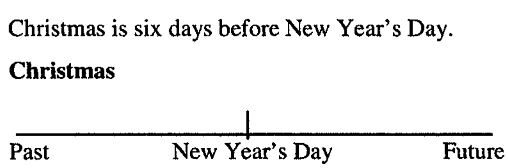

Figure 8.2
Stimulus presentation for Experiment 1.

time on the top of a CRT screen, with a timeline below. The reference event (which was always the second event mentioned (E2)) was located on the timeline. Subjects pressed one of two keys to indicate whether the first-mentioned event (E1) was located in the PAST or FUTURE of E2. Responses were scored for response time and accuracy.

There were 30 setting sentences—half using the time-moving metaphor and half using the ego-moving metaphor. These were presented in sets of three, followed by a test sentence, which was either in the time-moving or the ego-moving metaphor. Thus there were 10 test sentences, five from each metaphor. Subjects saw five blocks of three setting sentences, each set followed a test sentence. For all sentences their job was to press the past or future key to locate E1 relative to E2. Using the four possible combinations of setting and test sentence, we obtained a 2 (Metaphor Type) × 2 (Consistency) design with four between-subject conditions. A sample set of materials appears in Table 8.1.

The results showed an overall accuracy rate of 93.0%, with errors evenly distributed across the four conditions. In accord with the global mapping hypothesis, subjects in the Consistent conditions responded significantly faster ($M = 4228$ ms) than those in the Inconsistent conditions ($M = 4799$ ms). There was a marginal effect of Metaphor type: responses for the time-moving metaphor ($M = 4934$ ms) tended to take longer than

Table 8.1
Sample stimuli for experiment 1

Consistent
Setting sentences, time-moving
I will take the Math exam before the English exam.
My birthday is ahead of John's birthday.
I will take two months vacation after graduation.
Test sentence, time-moving
Dinner will be served preceding the session.
Inconsistent
Setting sentences, ego-moving
I am looking forward to the concert.
In the weeks ahead of him, he wanted to finish this project.
We are coming into troubled times.
Test sentence, time-moving
Dinner will be served preceding the session.

responses for the ego-moving metaphor ($M = 4093$ ms) (I return to this effect later in the discussion). There was no interaction between Consistency and Metaphor Type.

The mixed mapping cost—the fact that subjects were disrupted in making inferences when the test sentences shifted the metaphoric system of the setting sentences—is consistent with the system mapping hypothesis. This pattern suggests that at a minimum, the two metaphoric systems are coherent systems within the temporal domain. The results are consistent with the strong possibility that people understand these metaphorical terms via a systematic mapping from the domain of *space* to the domain of *time* (as well as with some related accounts discussed later). However, because the combinations of setting and test sentences were randomized, it is also possibility that a much more prosaic phenomenon—local lexical interactions of synonymous and otherwise related words—contributed to the results.

We conducted a second study to guard against the possibility that local lexical associations led to the Consistency effect. In this experiment we took advantage of a small set of spatio-temporal terms that can be used in both the ego-moving and time-moving metaphors, but which convey the *opposite* temporal order in the two systems. This set includes *before, ahead* and *behind.* This sequence reversal is exemplified in the following two sentences.

(1) Christmas comes before New Year's Day.

(2) The holiday season is before us.

In sentence (1) (time-moving), the E1 event (Christmas) is located in the *past* of E2 (New Year's). In sentence (2) (ego-moving), E1 (the holiday season) is located to the *future* of the referent E2 (U.S. nation).

The test sentences utilized the three terms *ahead, before* and *behind*; all are common to both the space → time mapping systems. By doing so, we could explicitly control and test for possible local effects. We manipulated the setting sentences so that the test sentences were preceded equally often by setting sentences of the following three types: the *same* term (e.g., *before* in Setting → *before* in test); the *opposite* term (e.g., *after* → *before*); or a *neutral* term (e.g., *coming* → *before*). If the advantage for the Consistent conditions obtained in Experiment 1 was merely due to local lexical priming and response bias effects, no overall advantage should be found for the Consistent mapping conditions in Experiment 2. More generally, if the effects are chiefly at the lexical level, we might expect an

Table 8.2
Sample stimulus set for experiment 2: six *ahead*-time-moving blocks

	Consistent	Inconsistent
Same	*S3:* Christmas is six days *ahead of* New Years. *Test:* Transistors came *ahead of* microprocessors.	*S3:* The final exam lies *ahead of* us. *Test:* The parade is *ahead of* the festival.
Opposite	*S3:* Adulthood falls *behind* puberty. *Test:* The physics exam is *ahead of* the English exam.	*S3:* We are happy that the war is *behind* us. *Test:* The news cast is *ahead of* the late night movie.
Neutral	*S3:* The most productive years are still *to come*. *Test:* I will arrive in Tokyo three days *ahead of* you.	*S3:* We met each other ten years *back*. *Test:* John's graduation is *ahead of* my graduation.

"S3" is the setting sentence that directly preceded the test sentence. The italics are for explication and did not appear in the actual experiment.

advantage for same-word priming and possibly a disadvantage for opposite word priming, and little or no effect for the neutral term. Consistency should either have no effect or an effect only in the same-word case.

Experiment 2 used methods similar to the first study: subjects again responded 'past' or 'future' to indicate the position of Event 1 relative to Event 2. Each subject saw twelve blocks of three setting sentences plus a test sentence—a total of 48 sentences. Of the twelve test sentences, six expressed the ego-moving metaphor; and six, the time-moving metaphor. Within each metaphor type, half the blocks were in the Consistent condition (i.e., the setting and test sentences were in the same metaphor system) and half were in the Inconsistent condition. The setting sentences appearing prior to a test sentence could either contain the same (e.g., *before/before*), opposite (e.g., *after/before*), or neutral (e.g., *preceding/before*) terms. Thus, each of the 12 blocks contained all combinations of two Metaphor types, two Metaphor Consistency conditions and three Lexical relations (See Gentner, Imai & Boroditsky, in preparation, for further details.) A sample stimulus set can be found in Table 8.2.

The results are summarized in Table 8.3. As predicted by the global mapping hypothesis, people were faster to process Consistent ($M = 4525.3$ ms.) than Inconsistent ($M = 4769.1$) metaphors.[1] As in the previous study, people were also significantly faster to process statements that used the

Table 8.3
Experiment 2: mean response times (msecs) for consistent and inconsistent metaphors for same, opposite, and neutral lexical relations

	Consistent	Inconsistent
Same	4369.6	4986.9
Opposite	4609.0	4670.5
Neutral	4597.2	4650.2
Total	4525.3	4769.1

ego-moving metaphor ($M = 3639.3$) than statements that used the time-moving metaphor ($M = 5655.2$).

Further, the Metaphor Consistency effect did not depend on lexical priming relations. Subjects were faster in the Consistent Condition than in the Inconsistent Condition in all three Lexical conditions (same, opposite, and neutral). This means that the Metaphorical Consistency effect was not an artifact of local lexical associations. We also found no evidence for a response-priming effect: item sets that required the same response in the test sentence (e.g., *future-future*) as in the setting sentence were no faster on average than those that required different responses. Thus the Mixed Mapping cost does not appear to result from local effects, but rather from a system-level facilitation. These results suggest that spatio-temporal metaphorical expressions are processed as part of large-scale conceptual systems, and not as lexical fragments. That is, the ego-moving and time-moving systems function as coherent conceptual frames.

So far these findings indicate that the ego-moving and time-moving spatial systems are used as global systems when people make temporal inferences. That is, they allow us to rule out the fourth and least interesting of the four possibilities laid out earlier, namely, that these metaphors are processed as purely local lexical relations. With this invitation to consider stronger possibilities, we turn to the larger question of whether *space* $\rightarrow$ *time* metaphoric systems have force in real life. Do people use these spatial metaphoric frameworks in natural temporal processing? To address this concern, we designed a third experiment that was a purely temporal task in a natural setting (Gentner, Imai & Boroditsky, in preparation, Experiment 3).

In Experiment 3, an experimenter went to O'Hare airport and asked people the kind of temporal questions that naturally come up in travel. The key manipulation was whether the questions maintained the same spatial metaphor throughout or shifted from one metaphor to the other. Experiment 3 was based on the same Mixed-mapping rationale as Experiments 1 and 2: If space-time event-sequencing statements are processed as coherent domain-mappings, then switching between the ego-moving and the time-moving metaphors should lead to increased processing time.

Passengers at Chicago's O'Hare airport (40 in all, balanced for gender across conditions) were approached individually by an experimenter with a digital watch (actually a stop watch) and engaged in a dialogue like the following:

E "Hello, I'm on my way to Boston." (Intro) "Is Boston *ahead* or behind us time-wise?" (EM setting question)
S "It's later there."
E "So should I turn my watch forward or back?" (Test question) (EM)
S "Forward."
E "Great. Thank you!"

In the Consistent condition (as shown), the setting question used the ego-moving metaphor like the test question. In the Inconsistent condition, the setting question ("Is it later or earlier in Boston than it is here?"[2]) used the time-moving metaphor and the test question used the ego-moving metaphor. We used the same (ego-moving) test question throughout. At the end of the test question, the experimenter surreptitiously started the stop watch. Timing terminated when the subject responded to the test question. As the questions dealt with adjusting a watch to match a time-zone change, the participants did not suspect that they were being timed.

Within the setting question, half the subjects heard the incorrect possibility first (e.g., "earlier or later"), and half heard the correct possibility first (e.g., "later or earlier"). Thus there were four possible setting questions (two ego-moving and two time-moving), and one test question (ego-moving). All responses were written down by the experimenter immediately following the exchange.

The results were as predicted: subjects in the Consistent condition ($M = 1445$ ms) responded significantly faster than subjects in the Inconsistent condition ($M = 2722$ ms), $t(38) = 2.449$, $p < .05$. Most people answered correctly; three erroneous responses were excluded from the analyses. Neither order of presentation nor gender had any significant effect on response times. These results demonstrate a sizable cost for shifting between metaphorical systems in ordinary commonsense reasoning about time. This is evidence for the psychological reality of the two metaphorical systems.

Interestingly, we found that many (60%) subjects in the Inconsistent condition (i.e., given the time-moving setting question) converted the question to an ego-moving framework. Responses to the setting question in the Inconsistent condition could be either Direct or Converted:

E "Is it earlier or later in Boston than it is here?"
S *Direct*: "It is later."
Converted: "Well, they are ahead of us, so it is later."

No subjects in the ego-moving (Consistent) condition converted to the time-moving metaphor: in contrast, as noted above, 60% of the time-moving subjects spontaneously converted to the ego-moving metaphor. This is concordant with the findings in Experiments 1 and 2 that the time-moving metaphor was more difficult (in terms of requiring longer response times) than the ego-moving metaphor.

Not surprisingly, subjects who converted to the ego-moving frame ($M = 1912$ ms) were much faster on the test question (in the Inconsistent condition) than those who did not convert ($M = 3938$ ms) $t(18) = 4$, $p < .01$. Subjects who converted had already adopted an ego-moving framework; when presented with the (ego-moving) test question they had no need to re-map and could respond quickly. In contrast, subjects who did not convert needed to abandon their old time-moving structure and set up a new ego-moving structure to answer the test question.

The results of the airport study also address a concern raised by McGlone and Harding (1998), namely, that the use of a timeline in Experiments 1 and 2 may have accentuated, or even created, a reliance on spatial representations in this task. It is clearly possible that subjects in the first two studies were influenced by the explicit timeline task to transfer temporal information into a spatial format. However, the persistence of the metaphor consistency effect at O'Hare is testament to the psychological reality of these spatio-temporal metaphoric systems.

Across all three studies, we found that processing took longer in the Inconsistent mapping condition than in the Consistent condition. This is evidence that large-scale conceptual systems underlie the processing of spatio-temporal metaphors on-line. This conclusion is further buttressed by a study by McGlone and Harding (1998). Participants answered blocks of questions phrased in either the ego-moving or the time-moving metaphor. The ego-moving blocks were composed of statements like "We passed the deadline yesterday." The time-moving blocks were composed of statements like "The deadline was passed yesterday." For each statement participants were asked to indicate the day of the week that the events in the statement had occurred or will occur. After each block, participants were presented with an ambiguous temporal statement, which could be interpreted using either metaphor (yielding different answers)—e.g., "Friday's game has been moved forward a day"—and were asked to perform the same task. McGlone and Harding found that participants in the ego-moving condition tended to respond according to the metaphoric system they had seen in the previous block: Following ego-moving metaphors, they responded that the game was on Saturday, and following time-moving metaphors they responded that the game was on Thursday.

Taken together, these results suggest that the ego-moving and time-moving systems function as coherent systems of relations. People reason in these temporal systems using relational structure parallel to that in the spatial base domain. The results obtained from the three experiments are evidence for two distinct psychological systems used in processing event-sequencing statements. The two metaphoric systems discussed in this paper are highly conventional and are rarely noticed in everyday language. Yet our experiments showed that when people make inferences about temporal relations in text, they process more fluently if the sequence of metaphors belongs to the same global metaphor system. Further, we observed the same effect in a purely temporal, oral task conducted in a natural setting. These findings make it very unlikely that spatio-temporal metaphors are processed simply by lexical look-up of local secondary meanings in the lexicon. Rather, they suggest the existence of two psychologically distinct, globally consistent schemas for sequencing events in time.

We can set aside the alternative of local lexical processing (alternative 4). But can we conclude that time is (partly or wholly) structured by spatial analogies? Not yet. There are still three possible mechanisms, as noted earlier. The first is the *system-mapping* account, which indeed postulates that time is (partly) structured by space, by means of analogical mappings from spatial frames to temporal frames. In such a system-mapping, the representational structures of the domains of space and time are aligned, and further relations connected to the base system are projected as candidate inferences from the base domain (*space*) to the target domain (*time*) (Gentner & Markman, 1997). Thus, parallels between space and time are partly discovered and partly imported.

On this account, an existing domain-mapping can facilitate future consistent mappings via a process of incremental mapping. In incremental mapping, an existing system of correspondences is extended by introducing new structure into the base and computing new correspondences and new candidate inferences consistent with the existing mapping. Such incremental mapping has been shown to be computationally feasible in such models as Keane and Brayshaw's (1988) Incremental Analogy Machine (IAM), and Forbus, Ferguson and Gentner's (1994) Incremental Structure-Mapping Engine (I-SME).

However, the second possibility, *cognitive archaeology*, is also consistent with our findings. On this account, space-time metaphors were originally analogical mappings, but have over time become entrenched in relational systems within the temporal domain. (Note that this possibility differs from possibility 4, the *local lexical processing* account, in postulating two connected systems of temporal relations parallel to (and borrowed from) the corresponding spatial systems.) Such a view would be consistent with the contention that abstract domains such as time are structured by metaphorical mappings from more concrete experiential domains such as space (Fauconnier, 1990; Gibbs, 1994; Lakoff & Johnson, 1980). We must also consider the third possibility, *structural parallelism* (Murphy, 1996). On the structural parallelism account, time and space can be structurally aligned by virtue of their parallel relational systems. The perception of aligned structure led historically to the use of the same terms, but there is no directional mapping from space to time. These last two accounts differ in their linguistic history assumptions but lead to the same current state. The *cognitive archaelogy* account holds that the metaphors were originally directional mappings from space to time, but how simply express relational systems that are now entrenched in both domains. The *structural parallelism* account holds that the metaphors were never directional, but rather expressed an inherent parallelism in the relational systems for space and time. On both accounts, there is no current reliance on spatial representation in temporal reasoning. Thus space may have had a special role in deriving temporal representations (as in the cognitive archaeology view) or not (as in the structural parallelism view), but there is no current directionality between space and time.

Although our findings and those of McGlone and Harding are compatible with these last two accounts, recent research by Boroditsky (in preparation) argues for the stronger account of *system mapping* (alternative 1). Boroditsky found evidence for an asymmetry: People appear to understand time in terms of space, but not space in terms of time. Participants were slowed in their processing of temporal statements when they were primed with an inconsistent spatial schema, relative to a consistent spatial schema. This consistency effect occurred for transfer from space to time, but not for transfer from time to space, indicating that there is a directional structure-mapping between these two domains. A further finding was that people were influenced by spatial perspective when reasoning about events in time. These results lend support to the metaphorical mapping claim. Together with the present results, they suggest that our representation of time is structured in part by online structural analogies with the more concrete experiential domain of space.

It should be noted that the metaphorical mapping account does not entail the extreme position that spatial mappings *create* temporal representations—that is, it does not imply that the structure of space is imposed on time as on a *tabula rasa*. Murphy (1996) persuasively argues against this extreme interpretation of metaphorical processing, maintaining instead that metaphors typically express a structural alignment between the two relational systems (e.g., Gentner & Markman, 1997; Medin, Goldstone & Gentner, 1993). However, in structure-mapping the most typical case is that an initial structural alignment leads to further mapping of inferences from the base domain to the less coherent domain. Thus the system-mapping account overlaps with the structural parallelism account; in both cases, the metaphorical insight begins with structural alignment. The evidence here suggests that spatial and temporal sequencing are perceived as partly parallel, but that space, as the richer and more elaborated relational system, is used as a further source of inferences about time.

2 Why Are Time-Moving Metaphors More Difficult Than Ego-Moving Metaphors?

In Experiments 1 and 2, ego-moving metaphors were processed faster than time-moving metaphors, overall. In Experiment 3 we observed spontaneous conversion from the time-moving to the ego-moving metaphor. Such conversions never occurred in the reverse direction, despite an equal number of opportunities. It seems that the O'Hare participants preferred to reason with the ego-moving metaphor. This observation, together with the finding in Experiments 1 and 2 that subjects took longer to respond to time-moving metaphors than to ego-moving metaphors suggests that the ego-moving metaphor is somehow easier or more natural for English speakers.

The most obvious advantage of the ego-moving framework is that it requires fewer distinct conceptual points. Statements in the ego-moving metaphor express the temporal relationship between an event and an observer (e.g., "We are approaching the holidays") and therefore can be represented as two points on a time-line:

[Past ... us/(observer) ... holidays ... Future]

Statements using the time-moving metaphor, in contrast, typically express the temporal relationship between two events from the point of view of an observer (e.g., "Spring will come after winter"). In this case, three time points must be represented, one each for event 1, event 2 and the observer:

[Past ... winter ... (observer) ... spring ... Future]

The fact that the time-moving metaphor is typically a three-term relation whereas the ego-moving metaphor is typically a two-term relation probably contributes to the greater processing difficulty of time-moving metaphors.

We can draw a second explanation for the apparent relative difficulty of time-moving metaphors from recent work on temporal reasoning by Schaeken, Johnson-Laird and d'Ydewalle (in press). Because, as discussed above, the relative temporal location of an observer is not specified in the time-moving metaphor, the observer can occur as a third point anywhere on the timeline. For example, the statement "John arrives ahead of Mary" can produce the following three timelines:

[Past ... Obs ... John ... Mary ... Future]
[Past ... John ... Obs ... Mary ... Future]
[Past ... John ... Mary ... Obs ... Future]

Schaeken et al. (in press) found that subjects take longer to reason about temporal sequences when more than one sequence can be constructed from the available information (as in the example above). Therefore, if subjects in our experiments were trying to place an observer on a time-moving timeline, they would incur a processing time cost that may give rise to the main effects for metaphor type found in Experiments 1 and 2. Such effects of multiple mental models might contribute to the greater difficulty of time-moving metaphors.[3]

3 Beyond Two Systems

We have suggested that spatial mappings influence the processing of temporal sequences. But we stop short of suggesting that "space structures time." The event sequencing studied here is only one facet of temporal representation and reasoning. Further, the ego-moving and time-moving metaphors are only two of a larger set of temporal metaphors, many of which are far less obviously spatial. Lakoff and his colleagues have reported several metaphors for *time* in English (Lakoff & Johnson, 1980; Lakoff & Turner, 1989); and Fraser (1987) and Alverson (1994) note that many different time metaphors have occurred across history and across languages. However, Alverson reports that the space-time ego-moving and time-moving metaphors are among those that occur repeatedly cross-linguistically.

I speculate that when sufficient cross-linguistic data are gathered, we will find that although the ego-moving and time-moving metaphors are not the only ways to structure time, they will be widespread in the world's languages. Our experiences of space and time are such that the two domains are perceived as partly parallel structures (as Murphy suggests). But this parallel structure is only the beginning. Our representations of space are so exceptionally coherent and well-structured that (I suggest) we go beyond the initial parallel structure to import further relations. We use spatial language to talk about order of precedence among events (which might be simple parallelism), but we go on to apply notions like an event receding into the past or looming over our future. This is typical of analogical mapping. An initial alignment between common relational structures invites the mapping of further inferences from the more systematic domain to the less systematic domain. Thus, candidate inferences are projected from the highly structured domain of *space* to the more ephemeral domain of *time* (Bowdle & Gentner, 1997; Clement & Gentner, 1991; Gentner, Falkenhainer & Skorstad, 1988; Gentner & Markman, 1997; Markman, 1997).

4 Global Consistency and Conventionality

A striking aspect of this research is that we found system-level consistency effects for space-time metaphors that are highly conventional. This runs contrary to the findings of Gentner and Boronat (1991, in preparation; See also Gentner, 1992, in press; Gentner & Wolff, 2000) who found consistency effects for novel but not conventional metaphors, and of Glucksberg, Brown and McGlone (1993), who failed to find any consistency effects for conventional metaphors. Indeed, we and others have suggested that conventional metaphors and idioms may be encoded and processed simply as alternate lexical entries, and not as part of large-scale mappings (Bowdle & Gentner, 1995, 1999, in preparation; Cacciari & Tabossi, 1988; Gentner, Bowdle, Wolff & Boronat, in press; Gentner & Wolff, 1997, 2000; Swinney & Cutler, 1979; Wolff & Gentner, 1992, 2000, in preparation).

Why should space-time metaphors continue to act as domain mappings, unlike other conventional metaphors? One possibility, as noted above, is that these space-time metaphors may in part be constitutive of temporal representational structure (Langacker, 1986; Talmy, 1985, 1987). By highlighting particular relations, the use of concrete spatial models may be illuminating for articulating the structure of time. A second consideration is that, unlike many conventional metaphors—e.g., "Anger is a raging beast" or "Music is food for the soul"—that convey some sensory attributive properties, these spatio-temporal sequencing metaphors are entirely relational. The spatial terms derive their meanings from their positions within their respective relational systems. Thus they may more naturally retain their system-level interpretations and resist congealing into local lexical associations.

A final point is the conceptual utility of the space-time metaphor. The two space-time systems exhibit three characteristics that facilitate reasoning, as laid out by Gattis (in preparation). They use ordered space to represent elements (here, events) and their relations (sequential ordering); they use spatial dimensions (here, a single linear dimension, which is placed in correspondence with time's single dimension); and they appear to form non-arbitrary analogs for abstract concepts. Temporal reasoning is non-trivial, as any traveler can attest. Perhaps these metaphors retain their systematicity because they do serious work for us.

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Notes

1. In a 3 (Group) × 2 (Consistency) × 2 (Metaphor type) × 3 (Context Word type) mixed-measures ANOVA effect of Consistency was marginally significant, $F(1, 69) = 3.74$, $p = 0.057$. Further, the effect of Consistency was significant when the *same* condition was removed and the analysis performed over only the opposite and neutral conditions.

2. Although this phrase preserves the sense of one event preceding another, it is admittedly at best a rather poor example of a time-moving metaphor.

3. Another possibility that should be investigated is whether the ego-moving metaphor simply occurs more frequently in discourse than the time-moving metaphor. But even if it does, it would not be clear whether such a frequency differential was cause or effect of the greater processing ease.

NOTE: These references are for the entire volume - not for Gentner's chapter only.

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