Is the future always ahead? Evidence for system-mappings in understanding space-time metaphors.

Dedre Gentner and **Mutsumi Imai**
Department of Psychology
Northwestern University
2029 Sheridan Road Evanston, IL, 60208
gentner@aristotle.ils.nwu.edu, imai@aristotle.ils.nwu.edu

Abstract

Languages often use spatial terms to talk about time. FRONT-BACK spatial terms are the terms most often imported from SPACE to TIME cross-linguistically. However, in English there are two different metaphorical mapping systems assigning FRONT - BACK to events in time. This research examines the psychological reality of the two mapping systems: specifically, we ask whether subjects construct global domain-mappings between SPACE and TIME when comprehending sentences such as "Graduation lies before her" and "His birthday comes before Christmas."

Two experiments were conducted to test the above question. In both experiments, subjects' comprehension time was slowed down when temporal relations were presented across the two different metaphorical systems inconsistently. This suggests that people had to pay a substantial remapping cost when the mapping system was switched from one to the other. The existence of domain mappings in on-line processing further suggests that the two SPACE/TIME metaphorical mapping systems are psychologically real.

Introduction[1]

We often talk about time in terms of space. It has been pointed out that the correspondence between the two domains is orderly and systematic (e.g. Bennett, 1975; Clark, 1973; Lehrer, 1990; Traugott, 1978).

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Table 1 shows some SPACE-TIME correspondence in English (taken from Lehrer, 1990). Language in the TIME domain is roughly divided into three aspects: tense, sequencing, and aspect (Traugott, 1978). Our concern here is with sequencing, the system whereby events are temporally ordered with respect to each other and to the speaker. There are some universal properties in importing language about SPACE to describe TIME (Clark, 1973; Traugott, 1978). First, since TIME is usually conceived as an uni-dimensional property, the spatial terms that are borrowed are uni-dimensional terms (e.g., *front/back, up/down*) rather than terms that capture two or three dimensions (e.g. *narrow/wide, shallow/deep*). Second, to capture the sequential order of events, the time-line has to be directional. Thus 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.

Two systems for sequencing events

In the English language, it has been pointed out that there are actually two SPACE-->TIME metaphoric systems. The first system can be termed the EGO-MOVING metaphor, where EGO or the observer's context progresses along the time-line towards the future. The second system is the TIME-MOVING metaphor. In this metaphor, a time-line is conceived of as a river or conveyor belt on which events are moving from the

Table 1. SPACE-TIME correspondence in Language.

SPACE	TIME
at the corner	*at* noon
from here *to* there	*from* two o'clock *to* four o'clock
through the tunnel	*through* the night
He stood *before* the house	it happened *before* evening
He was running *ahead of* me	He arrived *ahead of* me

FUTURE to the PAST (See Fig. 1). These two systems lead to different assignments of FRONT/BACK terms to a time-line (Clark, 1973; Fillmore, 1971; Lakoff & Johnson, 1980; Traugott, 1978). For example, in the EGO-MOVING system, FRONT is assigned to the *future (later)* event (e.g. " The war is *behind* us." or "His whole future is *before* him."). In the TIME-MOVING system, in contrast, FRONT is assigned to a *past (earlier)* event. (e.g. "I will see you *before* 4 o'clock" or " The reception *is after* the talk.")

Our question here is whether these two metaphoric systems -- the EGO-MOVING and the TIME-MOVING systems -- are psychologically real metaphors: that is, are they processed as metaphoric mappings in real time. This question is part of a larger psychological issue of metaphoric processing, namely, whether conceptual metaphors are psychologically processed as generative domain mappings (Gentner & Gentner, 1983; Gentner & Boronat, 1991; Gibbs & O'Brien, 1990; Lakoff & Johnson, 1980).

Conceptual metaphors and the domain-mapping hypothesis

Lakoff and his colleagues have pointed out the presence of large-scale systems of conventional conceptual metaphors: language from one domain that is habitually used in other domains (Lakoff & Johnson, 1980; Kövecses, 1986). These metaphors can often be characterized as originating in one or more abstract schemas in the base (or source) domain: e.g. ANGER IS HEAT/FIRE, ARGUMENT IS WAR. Here are some examples of conventional expressions reflecting the ANGER IS FIRE schema (from Kövecses, 1986):

Those are *inflammatory* remarks.
She was *doing a slow burn.*
He was *breathing fire.*
Your insincere apology just *added fuel to the fire.*

Such linguistic patterns suggest that many conceptual domains can be described and organized systematically in terms of more tangible and familiar domains. However, the question remains as to whether such metaphoric systems are psychologically processed as domain-mappings. That is, do people actually comprehend these domain metaphors by carrying out analogical mappings from a base domain to a target domain? Alternatively, the metaphoric meaning could be stored as an additional meaning sense of the base term. In this case, a word like "inflammatory" would have (at least) two word senses associated with it: 'causes fire' and 'causes/promotes anger'. There would be no global domain-mapping, only a series of local polysemies. In this case such conceptual systems are informative about the history of language, but not about current processing.

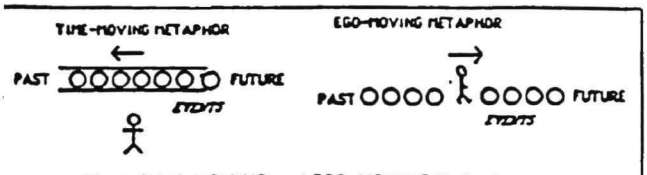

Fig 1. TIME-MOVING and EGO-MOVING Metaphors

Some evidence for the domain-mapping hypothesis has been found in research studying how people make inferences from science analogies (Gentner & Gentner, 1983) and in comprehending and imaging idiomatic phrases (Gibbs & O'Brien, 1990). However, these studies did not bear on on-line comprehension processes.

What would it mean for conceptual metaphors to be processed as domain mappings? In structure-mapping theory, the knowledge representations of the two domains are structurally aligned and further relations (*candidate inferences*) connected to the common system of relations are mapped from the base to the target (Gentner, 1983, 1989; Falkenhainer, Forbus & Gentner, 1989; see also Burstein, 1988). Gentner and Boronat (1991) applied this framework to extended discourse metaphors. They reasoned that when a series of metaphors is presented from a single cohesive schema, people should be able to integrate each local metaphor into a global mapping from one conceptual system to the other. In this case, processing should be fluent. In contrast, when metaphors from different domains are juxtaposed, the hearer must shift from one base-target mapping to another, and consequently processing should be disrupted.

Gentner and Boronat devised a paradigm in which a series of conceptual metaphors from a single coherent source domain is presented in a connected text. This should establish a global mapping which serves as a setting for the final test sentence. In the Consistent mapping condition, the same metaphor is maintained throughout; in the Inconsistent mapping condition, the metaphor shifts between the initial passage and the final sentence. Using this technique, Gentner & Boronat (1991) found that subject's reading time for the final sentence was slowed down following a shift from one metaphor to another. This *cost of remapping* whe the underlying metaphor shifted suggests that the metaphors were processed as domain mappings.

Are SPACE/TIME metaphors processed as domain mappings?

The central question here is whether the two metaphoric systems -- the EGO-MOVING and the TIME-MOVING systems -- are processed as domain mappings in real time. There is reason to doubt this. First, 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 remapping. The SPACE/TIME metaphors are highly conventional and frequently used in everyday language; indeed, the expressions reflecting the two metaphoric systems are almost invisible; people rarely notice that there are two different SPACE-TIME mapping systems in their everyday language. This might suggest that there will be no domain-mapping effect. It could be that the two mapping metaphors were alive in the history of language, but now are only stored as alternate word-senses of the spatial terms.

A second reason we might not expect to see a mapping effect is that the contrast between metaphors here is quite subtle. In the materials used by Gentner and Boronat, two metaphors from different base domains (e.g. HEAT, DANGEROUS ANIMAL) were applied to the same target (ANGER). In the present case, however, we have 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 for distinct global system-mappings here would be particularly interesting, since it would suggest considerable representational specificity in the on-line mapping process.

The two metaphoric systems both serve to sequence events in a time-line, yet produce different temporal orders. Therefore, the cost of shifting from one system to the other may be substantial. Indeed, there are cases in which shifting from one system to the other produces opposite temporal order for the same words: e.g., *before, ahead* and *behind.* Compare the following two sentences:

(1) Christmas is six days *ahead of* New Year's Day.
(2) The holiday season is just *ahead of* us.

Let us denote the event first mentioned in each sentence E_1 and the second event E_2 in Fig.2. The two time lines below show how E_1 and E_2 are placed in the time-line. The relative PAST and FUTURE of both E_1 and E_2 is reversed between (1') and (2'), even though the same term *ahead of* is used to describe both temporal relations.

To test the system mapping hypothesis, we employed a variation of the paradigm used by Gentner & Boronat (1991). Because the linguistic expressions reflecting the two mapping systems are highly conventional, we were concerned that merely having subjects read might not be fully able to capture the phenomena. Because of the high familiarity of the expressions, subjects might mistakenly think they "understood" what the sentence means without deeply processing the sequential relations between events described in the sentence. To be sure that subjects fully comprehended the sentences, we employed a paradigm that requires deeper processing than merely reading text.

Figure 3 shows how the experimental materials were presented. Sentences were presented one at a time on the top of the CRT screen, with a time line below. The event mentioned in the second place (E_2 in the notation given earlier) was located on the time-line. Subjects pressed one of two keys to indicate whether the first-mentioned event (E_1) was located PAST or FUTURE of E_2 in the time-line (see Figure 3). Subjects' accuracy and response time were recorded.

The general method was very similar to the Gentner & Boronat study. A test sentence describing a temporal relation between E_1 and E_2 was preceded by 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 utilized a different mapping system from that in the Test. According to the domain-mapping

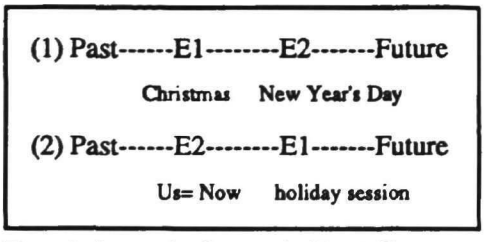

Figure 2: Sequencing 2 events in (1) and (2)

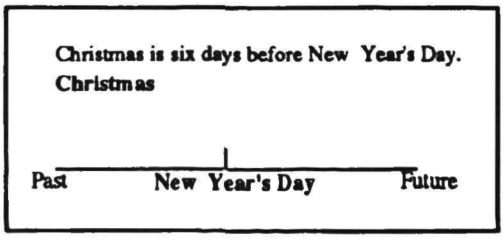

Figure 3. An example of material in Ex 1& 2

hypothesis, processing should be faster in the Consistent mapping condition than in the Inconsistent 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 another.

The alternative possibility would be that people process temporal relations at a local, purely lexical level and the systematic mapping will not take place. In this case, we should find no difference where a series of temporal relations are provided systematically in a single system or haphazardly from the two different systems. Two experiments have been conducted in order to examine this question.

Experiment 1

Method

Subjects: Subjects were 112 Northwestern University students who received course credit for their participation.

Materials: The materials consisted of two SETTING sets and two Test sets. One Setting set consisted of 15 sentences from the EGO-MOVING mapping system; the other consisted of 15 sentences from the TIME-MOVING mapping system. Likewise, one Test set consisted of five sentences from the EGO-MOVING system; the other consisted of 5 sentences from the TIME-MOVING system.

Design: The design was a 2 (Metaphor Type) X 2 (Consistency) between-subject design. There were four between-subject conditions, consisting of the four possible combinations of Setting set and Test set. Condition 1: TIME-MOVING SETTING --TIME-MOVING TEST; Condition 2: EGO-MOVING SETTING--TIME-MOVING TEST; Condition 3: EGO-MOVING SETTING -- EGO-MOVING TEST; and Condition 4: TIME-MOVING SETTING--EGO-MOVING TEST.

Procedure: Subjects saw a sentence and a diagram on the CRT screen as depicted in Fig. 2. They were instructed to respond by pressing one of two keys to indicate whether the first event (E_1) in the sentence takes place in the PAST or FUTURE relative to the second event (E_2). The second event (E_2) was located on a time line as shown in Fig. 2. Subjects saw five blocks of three Setting sentences. After each such block a Test sentence was presented. The organization of Setting sentences within blocks and the presentation order of the Test sentences were randomized. Subsequently, in the two Consistent Conditions (Conditions 1 & 3), the subjects saw all the 20 sentences from a single mapping system (either EGO or TIME-MOVING system). In the two Inconsistent conditions, the mapping system was switched in every fourth sentence.

Results and Discussion

As predicted, subjects in the consistent conditions responded faster [Mean=4228.0] than those in the inconsistent conditions [Mean=4798.7]. A 2 X 2 ANOVA confirmed a significant effect of Consistency, $F(1, 108)=5.074$, $p<.05$. Error responses were excluded from the analyses. The overall accuracy rate was 93.08% and was evenly distributed across the four conditions. There was no main effect of Metaphor type nor interaction between Consistency and Metaphor Type.

The fact that subjects were faster to make inferences when the test sentences continued the same metaphor as the setting sentences is consistent with the system mapping hypothesis. This pattern suggests that people understand these metaphors via a systematic mapping of metaphors, so that processing further metaphors belonging to the same system is facilitated relative to shifting to metaphors belonging to a different system.

However, because of our randomization procedures, we were concerned about local effects that could have inflated the effect for Consistency. The most important of these was repeated words. If a Test sentence was preceded by a Setting sentence using the same spatio-temporal term (e.g., *before-before*,), local lexical associations could clearly affect the results through same-word priming. In our design, the probability of such same-word repetition was low but non-zero. We were also concerned about the possibility of response bias in cases when the same response occurred in the last setting sentence and in the test sentence (e.g., PAST/PAST).

Experiment 2 was designed to control those local factors strictly. In Experiment 2, the Test sentences utilized only three terms: *ahead*, *before* and *behind*. All of these are common to both the Space/Time mapping systems. In order to separate the global mapping effects from possible local effects, we manipulated the Setting sentences just prior to the Test sentences. In both the Consistent mapping and Inconsistent mapping conditions, the Test sentences were preceded equally often by Setting sentences of the following three types: the Same term

(Context Word) (e.g. *before* in Setting and *before* in Test); the Opposite term (e.g. *after-before*); or a Neutral term (e.g., *preceding-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. Rather, the difference between the Consistent and Inconsistent mappings should be observed only when the preceding Setting sentence uses the same term as the Test.

Experiment 2

Method

Subjects: The subjects were 72 students at Northwestern University who received course credit for their participation.

Design and Materials: Each subject received one of three sets of materials. Each of the three sets consisted of 12 blocks of 3 Setting sentences and a Test sentence. Therefore, the subjects saw total of 48 sentences, 36 Setting and 12 Test . Of the 12 Test sentences, 6 contained the temporal relations reflecting the EGO-MOVING metaphor, and the other 6 reflected the TIME-MOVING metaphor. Of the six blocks in each metaphor type, 3 blocks were in the Consistent Condition (i.e., the Setting and Test sentences were in the same mapping system). The other 3 blocks were in the Inconsistent Condition. Further, the Setting sentences appearing prior to a Test sentence included one of the following Context Word Types: 1) the Same word; 2) the Opposite word; 3) the Neutral word. Thus, each of the 12 blocks reflected each combination of 2 Metaphors types, 2 Consistency in mapping and 3 Context word types. As mentioned earlier, we restricted ourselves to *ahead*, *before* and *behind* as test relational terms in the Test sentences. Thus, we have 3 Test Word types in the two mapping metaphors, yielding 6 types of item sets consisting of 6 Test sentences. We divided the six item sets into 3 Assignment Groups on the contingency that each Group received both types of mapping metaphors in the different Test Word. Thus, the design of the experiment was 3 (Assignment Group) X 2 (Metaphor) X 2 (Consistency) X 3 (Context Word).

Procedure: The method of stimulus presentation and response was the same as in Experiment 1. The 12 blocks reflecting the 12 within subject conditions was totally randomized. Each subject saw the same Test sentence only once but each Test sentence was assigned to the Consistent and Inconsistent conditions in each Context Word Type an equal number of times across subjects.

Results and Discussion

As predicted, responses were faster in the Consistent than in the Inconsistent conditions, as shown in Table 2. However, before considering the reaction-time results in detail, we should discuss the accuracy rate. Overall accuracy rate was high and evenly distributed across conditions except when the word in the Test was *behind* in the TIME-MOVING mapping metaphor. The overall accuracy rate without *behind-Time Moving* item set was 95.27 % and no significant difference was obtained between the Consistent and Inconsistent conditions. In contrast, in the *behind*-TIME-MOVING Metaphor item set, the difference in accuracy between the Consistent and Inconsistent conditions was almost significant (81.9% in Consistent vs. 68.1% in Inconsistent), t=2.00, p=0.0568. Also, there was a speed-accuracy trade-off for this item set. Therefore, we analyzed the reaction time both including and excluding the assignment group in which this item set was contained (Group 3).

A 3 (Group) X 2 (Consistency) X 2 (Metaphor type) X 3 (Context Word type) mixed-measures ANOVA was conducted. We will report only the effects involving Consistency and Context Word Type.[2]

In the analysis including Group 3, the effect for Consistency was only marginally significant, $F(1,69)=3.743$, $p=0.057$. However, there was a significant interaction between Consistency and Assignment Group and Consistency X Metaphor due to the speed-accuracy trade-off observed in the *behind-Time Moving* item set in Group 3. A similar analysis excluding Group 3 revealed a significant effect of Consistency, $F(1, 46)=12.714$, $p<0.01$. No significant Consistency X Group or Consistency X Metaphor effects were found. No significant main effect for Context Word or interaction effect for Consistency X Context Word was found in the analyses including or excluding Group 3. No significant overall Consistency X Context Word

[2] There were significant main effects for Group and Metaphor. However, the effects were due to the length or other properties of the items. There were a few other high-way interactions significant at $p<.05$. However, they seemed all to be due to particular item properties and small number of data points.

Table 2. Means for the Consistent and Inconsistent conditions at three levels of Context Word Type

	Consistent	Inconsistent
Same	4345.67	4998.04
Opposite	4549.57	4659.24
Neutral	4597.17	4650.23

interaction was found, $F(2,69)=0.034$, either. Means for the Consistent and Inconsistent Conditions at the three levels of Contextword are given below in Table 2. The pattern of means suggests that the subjects were slower in the Inconsistent Condition than the Consistent Condition at all levels of Context Word.

In addition, we conducted an ANOVA excluding the Same Context Word condition to examine if there is still a main effect for Consistency when the Context word was Neutral or Opposite. The Consistency effect was significant, $F=5.452$ (1,46), $p<.05$.

The results of Experiment 2 replicated the results obtained in Experiment 1. Further, the effect of Consistency was obtained when the possible local factors were strictly controlled by the manipulation of the Context Word. This strongly indicates that the global system mappings take place when people make an inference about temporal relations.

General Discussion and Conclusion

The results obtained from the two experiments are evidence for system mappings in SPACE-->TIME. The two metaphoric mapping systems discussed in this paper are very natural 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 mapping system. The results here suggest that when a current mapping system is shifted to another system during the global mapping, people have to redo the mapping between the two domains (i.e. SPACE and TIME) with a cost in on-line processing. This in turn suggests that the two SPACE-TIME metaphoric mapping systems are psychologically real and not a mere historic relic.

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