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Linear Word Order Modulates the Cost of Metonymy Comprehension: Dynamics of Conceptual Composition

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Abstract

We investigate the relation between conceptual and syntactic structure by focusing on the phenomenon of circumstantial metonymy e.g., "Table #6 wants another pizza". We hypothesize that the construal of a metonymic interpretation is facilitated when the metonymized argument e.g., "Table #6" is retrieved before the metonymy-trigger e.g., "wants", since this gives the processor more time to build the event structure that metonymy demands. This predicts greater cost of metonymy composition when the argument is in object position (after the trigger) relative to subject position (before the trigger). An acceptability task shows a main effect of metonymy for both syntactic positions. A self-paced reading task demonstrates a cost for metonymy only in object position. This indicates that the cost of metonymy composition is rooted in the requirement that the conceptual structure for the metonymic argument be fully retrieved, a process constrained by the order of lexical retrieval provided by syntactic structure.

Keywords: syntactic linear order; metonymy; sentence comprehension; event composition; semantic processing

Introduction

Psycholinguistic evidence of the past 20 years or so have challenged the assumption that syntactic structure exhaustively determines semantic composition favoring instead a parallel system of composition and interactive relation between the two subsystems (e.g. Pustejovsky, 1995; Jackendoff, 1997, 2007, 2019; Pinango, Zurif & Jackendoff, 1999, Birch, Albrecht & Myers, 2000; Kuperberg, 2007; Morgan, E., van der Meer, A., Vulchanova, M., Blasi, D & Baggio, 2020; Do & Kaiser, 2021). This raises the question, which we explore here, of the extent to which syntactic structure supports linguistic meaning composition. Specifically, we hypothesize that linear word order modulates conceptual composition such that earlier lexical retrieval leads to more complete activation, facilitating context-dependent compositional processes like metonymy.

Circumstantial Metonymy

To that end, we focus on so-called circumstantial metonymy as in sentence (1):

(1) At a restaurant, the waiter says to the bartender: "The burger at table 5 wants two more beers".

The problem that this sentence presents to the processor is the following. In its most salient interpretation, the noun phrase "the burger at table 5" is conceptually incongruous with its predicate "wants", which selects for arguments that can experience desire. In principle, this meaning is unacceptable. But the conceptual system affords a way of saving the structure by allowing the construal of an event representation that introduces an implicit plausible experiencer "the person who ordered/bought the burger" and semantically associates it with the explicit argument "burger". This process, known as metonymy, comes at a comprehension cost, which has been robustly measured through a variety of methods (e.g., Frisson & Pickering, 1999, 2007; Humphrey, Kemper & Radel, 2004; Lowder & Gordon, 2013; Schumacher, 2013; Bott, Rees, & Frisson, 2016; Piñango, Zhang, Foster-Hanson, Negishi, Lacadie & Constable, 2017; Yurchenko, et al. 2020; Bambini, Bott & Schumacher, 2021; among others.)

If the association is frequent and salient enough, it can be conventionalized and lexicalized (e.g., Nunberg, 1995; Frisson & Pickering, 2007, Piñango, et al., 2017) as in the case of conventionalized systematic metonymy:

(2) Lisa read Shakespeare this year

By contrast, circumstantial metonymy resists pressure to conventionalize, arguably due to its reliance on specific contexts to be built on them (see Piñango, et al., 2017 for discussion). That is the case of (3) below, whose metonymic interpretation relies on knowledge of a general

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correspondence between locations and individuals occupying them.

(3) A flight attendant says to another: "Seat 19 asked for more water".

Such locations can be spatial—e.g., seats, tables, room numbers, addresses— or temporal, e.g., appointment-time or class-time, as in (4).

(4) Ana's assistant clarifies to someone on the phone: "Ana is having lunch with her 10 o'clock today".

As we observe, context construal plays a key role in the interpretation of circumstantial metonymy. An essential component is the additional event representation that connects the linguistically explicit but implausible argument with the implicit yet conceptually plausible one. This said, related factors such as the speaker's intention, syntactic structure, and lexical frequency have been proposed to play a role in how this building of metonymic conceptual structure occurs in real-time (Schumacher, 2013; Lowder & Gordon, 2013). Here, we focus on syntactic structure.

The Role of Syntax in Sentence Comprehension

Psycholinguistic research has shown that the way lexical items are linearly arranged in a sentence not only affects meaning but can also affect the accessibility and cost of processing. Specifically, previous work has investigated the alignment of syntactic prominence and conceptual salience, finding that a more aligned correspondence results in more accurate and faster processing, e.g., the actor of the event being in the subject position of the sentence. These studies suggest that there are some processing and comprehension advantages associated with prominent syntactic positions such as the subject position (e.g., McKoon, Ratcliff, Ward & Sproat, 1993; Birch & Garnsey, 1995; Birch, Albrecht & Myers, 2000; Klin, Weingartner, Guzman & Levine, 2004; Foraker & McElree, 2007; Gattei, Sevilla, Tabullo, Wainselboim, Paris & Shalom, 2018; Do & Kaiser, 2021) .

Our Research Question

Here we ask if the reason that syntactic position interacts with processing speed and accuracy is that for many of the languages tested, high prominence positions occur earlier in the sentence. We ask if the advantages associated with syntactic positions could be an issue of word order. Earlier occurrence increases the chances that the processor will have the time to build a more complete conceptual structure associated with the lexical item, one that includes not only salient preferred readings but also less salient ones. This, in turn, facilitates composition with later lexical items. On this account, we would expect a modulation of compositional effects as a function of syntactic position i.e., linear order. This is the exploration that circumstantial metonymy affords. In what follows, we explain our hypothesis in greater detail, along with a formulation of a counter-hypothesis. Then, we report results from two tasks that seek to adjudicate between them.

Two Hypotheses

1. Non-Interactive Hypothesis of Metonymic Processing

If we would consider metonymy as a purely semantic compositional process, with no intervention of syntax whatsoever, its processing will not be affected by the sequential order of the lexical items involved. Because the cost of its processing would have its source in the metonymic process itself, the same amount of processing cost for both structures is expected. In other words, this hypothesis suggests that metonymy belongs strictly to the conceptual level, that its cost is simply related to problems in the interpretation of the lexical items in a specific LCS, and that the different mental representations (conceptual and syntactic) do not interact in its processing. Therefore, this hypothesis predicts that the cost of metonymy processing will be the same regardless of word order.

2. Word Order Modulation of Conceptual Composition during Sentence Comprehension

We hypothesize that the processing of circumstantial metonymy is affected by the order in which the lexical items that trigger the metonymic conceptual association appear in the sentence.

The rationale for this hypothesis is straightforward: Lexical retrieval that occurs earlier in the sentence increases the chances that the processor will have the time to build a more complete conceptual structure —one that also includes the implicit event— involving those lexical meanings. Such structure will be allowed to incorporate not only highly frequent and therefore preferred interpretations —the so-called "literal"—, but also construals that while dispreferred, the immediate context still affords —the metonymic one—. The modulation thus involves differences in timing of retrieval that word order differences entail.

This hypothesis predicts that if the explicit argument on which the metonymic event construal is built appears *before* the predicate that triggers the conceptual incongruence, the cost associated with the event representation building will be smaller than the cost of metonymy when the explicit argument appears *after* the predicate. The processor will have the metonymic interpretation available from an early stage if the argument is in the subject position, while if it has to construct it later in the sentence —in the object position—, after the more constraining predicate (the trigger) has appeared, it will take the processor more time to do so, similar to a garden path effect.

Methods

Participants

Fifty participants (25 identified as women and 25 identified as men; age range 21-70, mean age: 41) were recruited from

Prolific (https://www.prolific.com/). All participants were self-reported native English speakers from the United States and had no language impairments.

Design

Participants were presented with 120 experimental sentences, which consisted of sets of circumstantial metonymic sentences that varied the position of the metonymy in the sentence (Subject Position and Object Position) and their non-metonymic counterparts. All sentences were in English.

The final script contained in addition 100 filler sentences consisting of novel systematic metonymy sentences, adapted from Piñango, et al. (2017). 25 filler sentences were systematic metonymies, 25 were their non-metonymic counterparts, and the remaining 50 were 'Mixed fillers', sentences with contexts that privileged a non-metonymic interpretation followed by a metonymic sentence. These were included as a baseline of less acceptable items. Both hypotheses predict that these would show the lowest acceptability and lowest reading times. Sample stimuli are presented in Tables 1 and 2.

Each script was pseudorandomized so no two sentences from the same condition were presented consecutively. Participants were distributed over two lists to guarantee that no two participants read the sentences in the same order.

Procedure

Participants were instructed to perform two-tasks: self-paced reading and rating, both built on PCIbex (Zehr & Schwarz, 2023). They were instructed to read the sentences at their own pace, by pressing the spacebar, and then rate them according to a 5-level Likert scale (adapted from Sánchez-Alonso, Piñango & Deo, 2019):

1. I do not understand this sentence and I or any speaker of English would never say it this way
2. I or any speaker of English would not say this but I can understand the meaning
3. I am not sure. The sentence sounds good but a speaker of English would not say it this way
4. A speaker of English would say these sentences. I understand the meaning but I could or could not say it in this way
5. A speaker of English would definitely say these sentences. I understand the meaning and I myself would say it in this way

Half of the sentences were shown with the scale with the 1 to 5 order and half with 5 to 1 to avoid training effects.

Comprehension questions appeared after half of the sentences to test that participants were paying attention to the task.

Table 1: Sample Stimuli (Experimental).

Condition	**Example**
Metonymy Subject Position (25)	In a diner, one waitress tells another: the grilled cheese **wants** another glass of water.
NonMetSubjPos (25)	In a diner, one waitress tells another: The old man **wants** another glass of water.
Metonymy Object Position (25)	In a diner, one cook tells another: The waitress asked the **grilled cheese**[1] to get out.
NonMetObjPos (25)	In a diner, one cook tells another: The waitress dropped the **grilled cheese** on the floor. **in bold**: metonymy trigger

Table 2: Sample Filler Sentences.

Systematic Metonymy Filler (50)	That snob claims to hate poetry by M.G MacFarland and his contemporaries. But I heard that he re-reads MacFarland whenever he can.
Non-Metonymy Filler (25)	That man claims he hasn't ever met MacFarland or his colleagues. But I heard that he meets MacFarland whenever he can.
"Mixed" Filler (25)	(non-met. context sentence) I heard an interesting radio interview with Benjamin Blackburn yesterday. (metonymy sentence) I'd love to someday buy a Blackburn if I had the chance.

Analysis and Results

Part 1: Rating Task

Data from 47 participants and 112 experimental items were included in the final analysis. Two sets of stimuli had to be removed from the data due to technical issues in the design and three participants had to be removed due to extremely fast reading times and less than 80% response accuracy on the comprehension questions.

Responses from the rating task experiment were analyzed by fitting a Linear Mixed-Effect Model (LMEM), using R

[1] Metonymic elements that consisted of two words were presented in the same word window.

(R Core Team, 2014), lme4 (Bates, Maechler, Bolker, & Walker, 2014) and lmerTest (Kuznetsova, Brockhoff & Christensen 2017), to assess the effects of metonymy and syntactic position in the acceptability of the sentences, as well as their interaction. In addition, by-participant and by-item random intercepts and random slopes were included. The variables were treatment coded, and the reference levels were the non metonymic sentences for kind of sentence, and the subject position for the syntactic position.

Figure 1 displays mean acceptability ratings by condition. When the sentence was not metonymic, participants rated the sentence highly acceptable (closer to 5 on the Likert scale). That score decreased if the sentence included a metonymic association. This pattern is confirmed in the LMEM by a significant main effect of metonymy. When comparing syntactic positions, sentences with metonymy in the subject position were rated higher than those with metonymy in object position. This pattern is confirmed in the LMEM by a significant main effect of syntactic position.

Crucially, the metonymy by position interaction was also significant: sentences with metonymy in the subject position were rated higher than those with metonymy in object position (see Table 3).

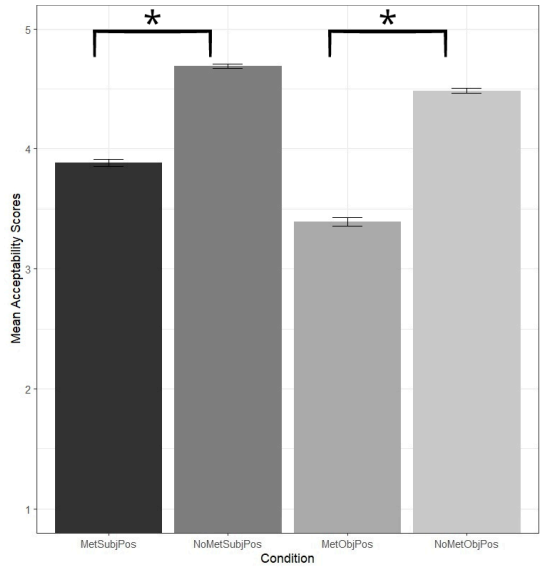


Figure 1: Mean Acceptability across Experimental Conditions.

Table 3: Summary of LMM for Rating Task.

predictor	estimate	st. error	t-value	p-value
Met.	-1.09	0.036	-29.64	< 2e-16 ***
SubjPos.	0.2	0.036	5.54	3.08e-08 ***
Met:SubjPos	0.28	0.052	5.53	3.22e-08 ***

With respect to the fillers, the 'Mixed' condition showed the lowest ratings (Figure 2), as expected, although they were still within the acceptable range +/- 3, suggesting that participants could have been construing a sensical conceptual representation connecting the explicit and the implicit arguments across context-sentence pairing, a sensical although compositionally costly possibility. The fact that metonymy fillers were rated slightly higher than their non-metonymic counterparts (although the difference does not reach significance) confirms that the processing of novel metonymies is less costly when provided with enough context, as well as the conventionalization and lexicalization of the patterns of the kind producer-by-product, place-for-event, etc.

Another complementary possible explanation for these results is that participants were able to construct a "good enough" (Ferreira, 2003; Ferreira & Patson, 2007) conceptual representation. This means that, because the sentences were not completely nonsensical, they were engaging in a "shallow" and incomplete comprehension process, driven by the need to complete the task (rate the sentences according to a fixed scale).

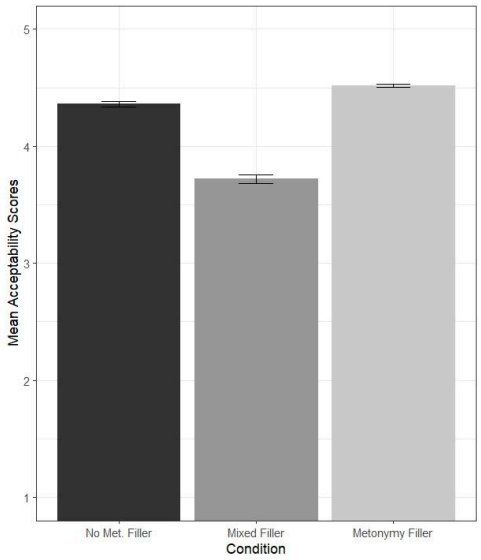


Figure 2: Fillers' Mean Acceptability.

Part 2: Self-Paced Reading task

We established a priori limits in reading times to filter those trials that were read too quickly or too slowly. Those were 120 milliseconds and 2000 milliseconds respectively. 6% of trials were removed based on these limits.

Following our research question, the goal was to assess if there was an effect of metonymy on reading times in each syntactic position. Using R (R Core Team, 2014), lme4 (Bates, Maechler, Bolker, & Walker, 2014) and lmerTest (Kuznetsova & Brockhoff & Christensen 2017) we fit Linear Mixed-Effect Models (LMEM) to whole-sentence reading times as well as individual word reading times. The fixed effects were sentence type (metonymy vs. non-metonymy) and syntactic position, as well as their interaction. The model also included by-participant and

by-item random intercepts and random slopes. Like in Task 1, the variables were treatment coded.

After assessing normality and homoscedasticity, we performed a logarithmic transformation of the word-level reading times and residualized them on two control predictors: character length and the order in which the item appeared for the participant (Winter, 2019). Due to inherent differences in the experimental stimuli with metonymy in subject vs. object condition, separate models were constructed for the two kinds of sentences.

Overall Reading Times

The results, displayed in Table 4, show no effect of metonymy on sentence-level reading times in the Subject Position conditions. For the Object Position conditions, we do observe an effect of metonymy on the overall reading time:

Table 4: Summary of LMM for Overall Reading Times.

predictor	estimate	st. error	t-value	p-value
Met:Object Position	3.149e-02	6.409e-03	4.91	9.09e-07 ***
Met:Subject Position	4.846e-03	5.879e-03	0.82	0.4

Word-by-word analysis

The word-by-word analyses are displayed in Figures 3 and 4 and Table 5. They show that when the metonymic argument is placed in the object position, reading times for that argument are systematically higher as compared to their non-metonymic counterparts. This difference is sustained across CWP+1 and CWP+2. In the Subject Position conditions, these differences are not significant. Moreover, we observe that in the subject position, the reading times of the metonymic condition increased after the critical word position (the verb, in this case), which resonates with the results found in Piñango, et. al. (2017). In our results, however, this trend did not reach significance.

Given that not all critical words were the same across Object conditions, to assess possible confounding effects of word frequency, we checked the frequency of the critical words that differed within each metonymy vs. non-metonymy contrast in the Corpus of Contemporary American English (COCA) the frequency of those critical words that differed. We found that the majority (53.3%) of the critical words of the metonymy condition were more frequent than their non metonymic counterparts, ruling out a potential effect of frequency that could slow down the reading times of the sentences with metonymy in object position.

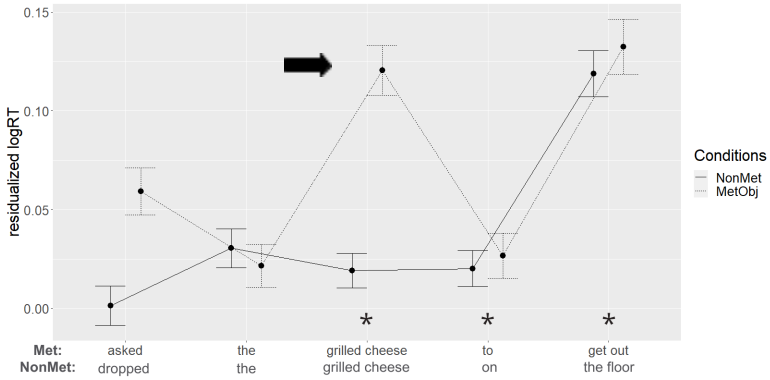


Figure 3: Metonymy in Object position and its non-metonymy counterpart

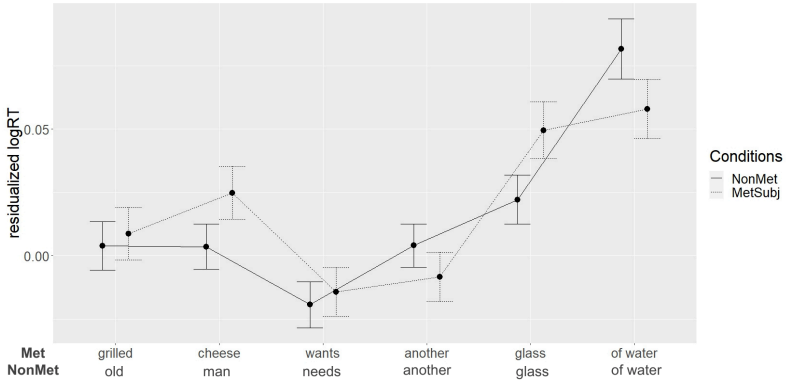


Figure 4. Metonymy in Subject position and its non-metonymy counterpart

Table 5: Summary of word-by-word analysis

conditions	word position	p-value
Obj. Condition: Metonymy vs. No Metonymy	Critical word position	0.000184***
	CWP +1	0.043316*
	CWP +2	0.017974*
Subj. Condition: Metonymy vs. No Metonymy	Critical word position	0.7018
	CWP +1	0.3870
	CWP +2	0.2581

Discussion

Results from Task 1 show a main effect of metonymy for both conditions. Metonymic sentences, while acceptable, were rated lower than their non-metonymic counterparts indicating the impact of contextualization that the metonymic sentences demand (Lai & Piñango, 2019). This suggests that participants are always sensitive to the metonymic association, regardless of where the metonymy is located in the sentence. The average acceptability is still

above the middle level, so even if some metonymies are more acceptable than others (in this case, those located in subject position are more acceptable than those located in object position), the metonymic LCS is still achieved regardless of syntactic position.

Results from Task 2 provide a closer look at the time-course of the construal of the metonymic event connecting the explicit argument with an implicit one. They suggest that the full cost of metonymy in the comprehension process is only visible when the explicit argument is not given enough time to unfold conceptually before the composition with the verb's meaning needs to take place. Such situation happens only in the Object Condition. In sum, we find significantly slower reading times when the metonymy is located in an object position, both at the sentence level and at the word level, starting at the critical word position. However, we don't find them at all when they are located in the subject position.

These results are in line with our Word Order Modulation Hypothesis, given that they point to an influence of the metonymy's syntactic position on its processing. The grammatical positions of lexical items are not only indicators of information structure (Bresnan, 2001), but also help "set the scene" for different meaning compositional processes.

Our results suggest that, although with a parallel structure, the processing system leverages the fast acting syntactic information to guide the timing of composition at the conceptual level, and that the processor's sensitivity to a timing difference has millisecond-level resolution. Placing the metonymic (explicit) argument in the subject position creates a salient possibility of a metonymic LCS (Bresnan, 2001). For the sentence "The grilled cheese wants another glass of water" the construal of an ordering event where "grilled cheese" is the "thing ordered" in the context of a restaurant is rather salient and because it happens early in the sentence, the potential metonymic event has a chance to be created. Its subsequent composition with the verb can occur more smoothly, with less visible cost.

By contrast, if the metonymic argument is located in the object position, the metonymic event must be created "on the fly" without support from the verb's meaning with which it must also compose. In the sentence "The waitress asked the grilled cheese to leave the room", the verb "asked" selects for an animate entity which grilled cheese does not satisfy. It is at that time that the alternative event representation is built, linking the explicit argument with the implicit one and thus reconciling the selectional conflict. As seen both in the reading times and in the rating scores, this processing problem is not insurmountable, but its resolution comes at a processing cost, observed in the form of slower processing.

This explanation relates to *proportional pre-activation* in language comprehension (e.g., Reichle, et al., 2003, Brothers & Kuperberg, 2021). Certain words or linguistic features get activated proportionally and continuously at every point of the sentence based on previous input, while also being 'fed' by how correct those predictions were. Based on previous input, the processor estimates the likelihood of occurrence of each word. Multiple words get activated at each point, but the previous context will preactivate some of them. The more predictable or likely to be activated a word is, the less time it takes to the processor to retrieve it..

We propose that this can be extended to lexico-conceptual structures (LCSs). Upon lexical retrieval, different LCSs in the sentence get pre-activated but the activation of a metonymic one takes longer if it occurs in the object position because nothing in the previous input has contributed to its likelihood of being activated. By contrast, being in the subject position facilitates the metonymic compositional process because nothing previously inhibits it and there is time for full construal of the congruent event to emerge before it needs to compose with the now less incongruent verb. This suggests that there is no discrete boundary between an original or "literal" meaning and a "figurative", derived, one, but rather that different related interpretations coexist as a result of the same dynamic on-line meaning construction mechanism.

Conclusions

Our results point at an effect of syntactic position in the processing of circumstantial metonymy. Metonymic sentences were rated higher in the scale when in subject position than object position, and overall it took longer to read those sentences where the metonymy was located in the object position. Moreover, our word-by-word analysis revealed that the effect of metonymy is only significant in object position, indicating that placing the metonymy in the subject position does not present additional cost at the word level either.

These differences in processing have been hypothesized to be an issue of word order. The results show that word order facilitates the availability of multiple interpretations, including a metonymic one, by making them available from the beginning (in the case of subject position, which appears first in the sentence) until one of them gets "picked". This is, the possibility of a metonymic interpretation appears earlier in time and gets selected faster because the previous input had already privileged its likelihood to be accurate. In object position, on the other hand, the interpretation of metonymy is more costly because, like in Brothers and Kuperberg (2021)'s approach, building a new, unexpected LCS takes more time. Nevertheless, as our results show, the metonymic interpretation is indeed retrieved, which suggests that even if it presents an additional cost with respect to non-metonymic sentences, a metonymic reading is still available. These results allow us to think of meaning as a dynamic space where concepts are not fixed and discrete but rather malleable and constantly interconnected with each other. Overall, these results point to a comprehension system that takes into consideration both grammatical positions and conceptual mechanisms in an interactive way.

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