Problem solving, narrative, and second language reasoning demands

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This article reviews the literature of problem solving, narrative and second language (L2) reasoning demands from the perspective of task-based language teaching (TBLT). A problem-solving task is characterized by the presence of a gap between the initial and goal states, where the gap is defined as the problem in that space. Type of reasoning may differ depending on the domain reasoning is required. Thus, reasoning could be causal, spatial, or intentional. Relating a narrative then could be seen as a reasoning activity, especially when the learner needs to identify reasons of the characters’ psychological motives involved in the story.

Problem solving

Problem space components

Duncker (1954), the founding father of problem solving, started his book with the oft-cited following words:

A problem arises when a living creature has a goal but does not know
how this goal is to be reached. Whenever one cannot go from the given situation to the desired situation simply by action, then there has to be recourse to thinking. (By action we here understand the performance of obvious operations.) Such thinking has the task of devising some action which may mediate between the existing and the desired situations. Thus, the ‘solution’ of a practical problem must fulfill two demands: in the first place, its realization must bring about the goal situation, and in the second place one must be able to arrive at it from the given situation simply through action. (Duncker, 1954, p. 1)

Here problems are defined as gaps or inconsistencies between the initial state and the goal/desired state (Greeno, 1978). Also mentioned is the nature of problems; that is, they depend on individual’s perceptions (e.g., Anzai, 1985; Greeno, 1978; Novick & Bassok, 2005; Sternberg, 1999). Thus, what constitutes a problem may differ depending on the individual. Furthermore, what is perceived to be a problem may not be a problem in the future once a solution is established.

**Problem types**

There have been some proposals regarding criteria of problem types. Useful problem types, which are still cited in the literature, were proposed by Greeno (1978). Greeno (1978) proposed a process-based problem typology: structure-inducing, constructing arrangement problems and transformation. Typical problems of structure induction are analogy problems (e.g., A : B : : C :) and series extrapolation (e.g., ABCBCD__). According to Greeno (1978), the main cognitive ability required to solve these problems is a form of understanding by identifying relations of elements and fitting them into patterns.
In typical arrangement problems, problem components are presented, and they need to be combined based on certain criteria. Typical problems include anagrams and jigsaw puzzles. According to Greeno (1978), arrangement problems involve trial and error processes and trial solutions that may or may not narrow down possibilities need to be evaluated (i.e., a series of constructive search for composition).

In transformation problems, the solver is typically given an initial and a goal state and is required to transform the initial state into the goal one. Typical instances of this problem type are the Tower of Hanoi and toy-block problems. According to Greeno (1978, also see Novick & Bassok, 2005), transformation problems mainly require the solver to analyze situations and understand available operators (e.g., disc moves in the Tower of Hanoi), based on which global and local plans need to be generated (i.e., means-ends analysis, which is one type of heuristic problem solving strategy\(^1\), see Sternberg, 1999).

**Degree of constraints**

Another useful notion in understanding problems, which was proposed by

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\(^1\) Heuristics are problem solving strategies that do not necessarily guarantee the successful solution. Algorithms are problem solving strategies that guarantee the successful solution. In real life, heuristics strategies are often preferred even when an algorithm is available. Sternberg’s (1999) example illustrates this point using an example of an algorithm called exhaustive search (Novick & Bassok, 2005). Thus, when you go to a mega book store to find a book, but you are not sure if the book is in the book store, the only algorithm is to check each book in the store until the target book is found; if not, you may visit another book store. This is clearly time-consuming and various heuristic strategies are used such as asking a clerk for help, looking through an index etc. These heuristics are useful but you may never be perfectly sure that whether the book is in fact not available when you cannot find the book using those heuristics.
Reitman (1965), is the continuum of ill-definedness and well-definedness. The distinction concerns the degree of variation or ambiguity provided by the problem space components. Reitman illustrates what well-defined structure means, with recourse to a typical example of well-defined problem, propositional calculus, in the following way: “in the propositional calculus example the absolute fixing of the initial and terminal components and the absolute restriction of the process components to a well-specified set of operators provides an adequate closed constraint basis for deciding when a proposed solution is acceptable” (Reitman, 1965, p. 151).

In contrast, ill-defined problems are characterized by higher degrees of ambiguity in responses, operations, and their consequences. Thus, due to their lesser constraints, ill-defined problems (like most problems in daily life) allow greater inter-individual variations such as writing essays, drawing, and cooking and so forth. It should be noted that the notion of ill-definedness and well-definedness, as Reitman clarifies, is not only applicable to inter-problem attributes but also to distribution of well-definedness (or ill-definedness) over within problem space components. The intentional reasoning tasks used in the present study can be characterized as ill-defined (i.e., open tasks) in that greater variations in story contents (i.e., greater degree of constructive use of imagination) can be expected.

To sum up this section, problem solving comprises the initial and desired/goal states, and the gap between the states including intermediate ones constitutes a problem. Problems can be described at general, content-free levels or types and they also differ in the degree of constraints. In the next section, I describe the nature and types of narratives and the nature of reasoning or mental simulation required in relating narratives.
Narrative

General description of narrative

Narrative is a type of discourse that is usually considered as a story consisting of several elements. They include a plot, protagonists or characters, temporal and causal structures, a setting in time and place, and an opening and ending. The story can be based on something that has happened before, that the story-teller has been told is going to happen, that is from a book, or that is based on the imagination. Thus, in general, "[n]arrative ... is the depiction of events driven by the intentional behavior of one or more autonomous agents in a manner that manifests an imagined world which parallels the world of real experience" (Mar, 2004, p. 1416, also see Talmy, 2000, for a much broader conceptualization of narrative as products of what he calls "narrative cognitive system").

Two modes of story-narrative

In order to characterize story-narratives from a slightly broader perspective, Loveland and Tunali (1993) present a narrative framework and compare and contrast story-narratives with other types of "narratives" that share similar structures and functions. According to their framework, story-narratives are ones that we usually refer to as narratives, which may deal with certain topics and consist of descriptions of causally connected events. Story-narratives can also be fictitious or based on anecdotes. Anecdotes are something that happened whereas fictions are something that can happen and the latter need to be created by the speaker intentionally. Both modes of story-narratives can of course be retold (i.e., narrative retelling) and they can be told spontaneously (e.g., because the story-teller wants to share something interesting with interlocutors) or elicited by others (e.g., in response to a
question regarding what happened). A major difference between the two modes of story-narratives is that in fictitious story-narratives, the story-teller must construct either the characters or the events with recourse to imagination.

**Script narratives, informative/didactic narratives, and recitation/performance**

Other narrative forms, within Loveland and Tunali's (1993) framework, include what they call script narratives, informative/didactic narratives, and recitation/performance. Script narratives, as the name suggests, concerns how things usually take place (e.g., generalized or routines activities we do in the morning, such as taking a shower, brushing teeth, having breakfast and so on). Script narratives are usually elicited but they do not give detailed information when compared with anecdote-based story-narratives due to their generalized nature. Informative/didactic narratives concern various information giving verbal acts such as giving instructions regarding how to turn off the oven (Skehan, 1998), which is usually told spontaneously by the speaker, and giving route directions (Robinson, 2001), which is usually elicited by another on the street. Didactic narratives include lectures, speeches, and preaches. According to Loveland and Tunali (1993), both informative and didactic narratives have goals but they are not necessarily causally structured like story-narratives. Finally, recitations/performance includes those verbal acts that are well-learned in the past. They include making the oath of allegiance, reading out a passage from the Bible, reciting an English passage in front of the foreign language teacher, and so on. Appropriateness of the use of these narratives is tightly linked to cultural and social situations (e.g., imagine that the L2 learner suddenly starts to recite an English passage during natural conversation with a native speaker, which is clearly inappropriate but appropriate in certain situations in the L2
Reasoning demands in TBLT

Types of reasoning

Reasoning can be categorized into different types. There is a class of reasoning called deductive reasoning. It guarantees a successful solution in a problem solving situation (i.e., algorithms) or can draw a correct conclusion given true premises in solving a problem at school. In this sense, deductive reasoning is free of content. Reasoning can also be inductive. Inductive reasoning does not necessarily lead to a correct conclusion. It is an inferential process to abstract some regularities based on instances. Analogical reasoning (Gentner, 1999; Holyoak, 2005; Holyoak, K., & Morrison, 2005b; Holyoak & Thagard, 1995) is usually considered as a type of inductive reasoning although it can also be considered as a type of deductive reasoning in certain situations (Suzuki, 1996). The distinction between deductive and inductive reasoning is handy, but both can be observed in a task (Holyoak, K., & Morrison, 2005a). Both modes of reasoning are also domain general, abstract and logical to a certain extent in that they themselves are applicable in many situations and have no substantial content. In Pinker’s (1997) words, they are not “ecological” in that human beings are not evolved into true scientists or mathematicians. This is mainly because, according to Pinker, in everyday situations, domain specific knowledge is of more crucial importance for survival, partly because obtaining scientific knowledge is simply too expensive (e.g., we do not conduct a truly scientific experiment for cooking classroom). Loveland and Tunali (1993) mention that recitations/performance narratives differ from story-narratives in that the speaker neither needs to construct an organized structure by selecting information nor understands the narrative contents.
in everyday situations) and partly because the brain is oriented mainly towards adaptation but not necessarily toward truth. In short, Pinker thinks that people’s everyday reasoning is driven by domain-specific knowledge and concepts and in this sense people are folk biologists, physicists, and psychologists.

**Reasoning tasks in early TBLT**

Within the context of early task-based research and teaching, reasoning tasks were viewed as types of pedagogic tasks (e.g., Ellis, 2003; Nuevo, 2006). Prabhu (1987) for instance contrasted “reasoning-gap” activities with information-gap and opinion-gap activities, claiming for the superiority of reasoning tasks for L2 learning in that they allow the learner to engage in meaning formulation activities thanks to their problem-solving nature, where pedagogical interventions can also be predictably conducted. He also emphasized that the learner can obtain a sense of control during task performance. According to Prabhu, reasoning tasks then go beyond simple and repetitious decoding and encoding of information and they are pedagogically more desirable.

**Reasoning tasks in more recent TBLT: Causal, spatial, and intentional reasoning**

Within the context of the modern TBLT, rather than emphasizing the utility of reasoning tasks as task type, Robinson (2005) points out the importance of manipulating reasoning “demands” from simple to complex within reasoning types. According to Robinson (2005, 2007a), reasoning demands can be approached by distinguishing three task complexity dimensions: causal, spatial, and intentional reasoning. Causal reasoning concerns establishing causal relations between causes and outcomes.
Robinson (2005) claims that L2 pedagogic tasks that make demands on causal reasoning require the L2 speaker to "justify beliefs, and support interpretations of why events follow each other by giving reasons" (Robinson, 2005, p. 5). Causal reasoning is then considered as important to TBLT partly because, compared with no causal reasoning tasks, it is likely to affect the extent which the L2 learner notices and uses linguistic items that are relevant to those tasks' conceptual demands (e.g., use of subordinate conjunctions such as because, since, as, and logical connectors such as therefore, hence, as a result) and partly because task complexity is hypothesized to draw attention to get a grips of relevant conceptual/semantic categories employed during L2 grammatical encoding. Consequently, those linguistic items that tend to correlate with the degree of conceptual demands of causal reasoning tasks are hypothesized to give the learner language a developmental boost.

Spatial reasoning is important in everyday situations, for instance, where navigating a route through space in driving and understanding the spatial structure of the city are required. Studies on spatial cognition show that spatial knowledge is hypothesized to be represented as a "cognitive map" (e.g., Carassa, Aprigliano, & Geminiani, 2000). The cognitive map includes people's canonical or preferred orientations (e.g., in the north hemisphere countries, north is usually up in reading a map). More importantly, also represented in the cognitive map are three types of knowledge (Carassa, et al., 2000; Wickens & Hollands, 2000), which differ in the degree of knowledge elaboration. The first two knowledge types are egocentric or ego-centered. They are landmark knowledge and route knowledge. The former is gained by direct experience in the environment and is relevant to individual and characterized as topological networks of landmarks, whereas the latter is proceduralized verbal knowledge regarding how to get from one place to
another (Wickens & Hollands, 2000). Those two knowledge sources are rich in local information (i.e., the current place and nearby) but are limited in usefulness mainly partly because they do not provide useful information when landmarks are separated by great distances (Carassa, et al., 2000).

The last type of spatial knowledge is not egocentric but world-centered, which is called survey knowledge (or survey maps) or the one from a bird’s-eye perspective. According to Wickens and Hollands (2000), survey knowledge is more abstract (and never experienced) and “truly spatial knowledge that will allow the traveler to draw an accurate map of the environment, containing fewer distortions than one drawn from route knowledge” (p. 165). Carassa, et al. (2000) also mention that the survey map allows people to come up with shortcuts in finding ways, which is characterized by planning and reasoning. The three types of cognitive maps are acquired and elaborated in the order they are presented here (i.e., from ego-centric to world-centered knowledge bases) and the development is largely dependent on active exploration of the space (i.e., prior knowledge of the space). In this way the person generates and develops spatial knowledge to form coherent and flexible information sources.

In spatial terms, learning an L2 means both uncovering how the L2 encode the spatial concepts (i.e., linguistic means) and understanding how L2 items are used (Carroll, Becker, Bhardwaj, Kelly, Porquier, & Veronique, 1993), which is where the notion of task complexity raises the stakes. Carroll, et al. (1993) report a developmental order of spatial expressions from cross-linguistic perspectives in the domain of static spatial descriptions. Slobin (1993), after reviewing their work, mentions that adult naturalistic L2 learners show similar developmental trends to the L1 acquisition of locative prepositions (i.e., from topological to the projective, axis-based locative expressions). In discussing possible reasons for the similar developmental
trends, Slobin (1993) mentions that complex concepts to be verbalized are not simply available to children but they are available to adults, which is a crucial difference, but those complex concepts may not be accessible to adults, which may be a reason for the likeness of the learning trends. Here the issue of conceptual accessibility comes into the picture and so spatial reasoning tasks then gain importance as far as Slobin's speculation is valid. The Cognition Hypothesis calms that increasing task complexity leads to the natural recapitulation of the developmental trends through greater conceptual activation, establishing the conceptual basis toward L2 restructuring and development (i.e., sensitivity to the L2 grammatical systems), and developmentally naturally directing the learner's focal attention to how the L2 items encode various spatial concepts (e.g., typological differences in lexicalization patterns of motion verbs) or grammaticization of categories of rethinking for speaking (e.g., from discourse-/pragmatic-dominant mode and basic learner variety to the L2 specifics), and the L2 linguistic means are used in communication (Perdue & Klein, 1993).

Finally, intentional reasoning is specific to human social/psychological domain and it is often described as everyday psychological reasoning. This type of reasoning is based on the mentalistic view on human behavior and is dependent on our capacity to imagine or represent subjective states of the mind of others and ourselves especially, their beliefs and desires. The notions implicated in the practice of appreciating and explaining people's intentional

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2 Below are the definitions of "beliefs" and "desires" given by Bartsch and Wellman (1995): beliefs are meant to refer to a general category of thoughts encompassing knowledge, opinions, guesses, convictions, and hunches, that is, all mental states that attempt to reflect something true about the world. More broadly, thoughts include not only serious beliefs but also fanciful ideas, states of imagination, and dreams—mental states that represent fictional worlds. Desires are also to be understood as a general category including wants, urges, and states of caring about something" (p. 5)
behaviors (including internal behaviors or thoughts) with reference to the agent’s mental states (e.g., desires and beliefs) has been variously termed (reflecting differences in theoretical beliefs in philosophy and developmental/social psychology) as “mindreading” (Baron-Cohen, 1995), “theory of mind” (e.g., Baron-Cohen, Tager-Flusberg, & Cohen, 1993), “landscape of consciousness” (Bruner, 1986), “perspective taking” (Aksu-Koc & Tekdemir, 2004), “entering into a community of minds” (Nelson, 2005), “concept of mind” (Halford, 2005), “individualistic pathway to social understanding” (Greenfield, 2005), “folk concept of intentionality” (Malle, 1999, 2004) “mentalizing” (Frith & Frith, 2003, cited by Fusté-Herrmann, Silliman, Bahr, Fasnacht, & Federico, 2006) and so forth, and is often contrasted with the behaviorists’ reasoning based on the stimulus-response view (e.g., Bartsch & Wellman, 1995; Pinker, 1997) and with unintentional causal explanations (Malle, 1999, 2004).

L2 pedagogic tasks with intentional reasoning demands require reference to agent’s mental states. Those mental states can be referred to with mental state terms (e.g., Bartsch & Wellman, 1995; Fusté-Herrmann, et al., 2006; Hall & Nagy, 1987) and it is predicted that gradually increasing intentional reasoning task complexity will direct the learner’s attention to concepts related to intentional reasoning and provide conceptual rationales for using them in verbal expressions, as L1 studies show that physiological, emotional, and desire terms emerge earlier than cognitive state terms (see Fusté-Herrmann, et al., 2006; Lee & Rescorla, 2002).

**Conclusion**

This article reviewed problem-solving, narrative, and reasoning demands in TBLT. A problem-solving task is characterized by the presence of a gap
between the initial and goal states, where the gap is defined as the problem in that space. Creating a gap is a useful principle in creating tasks, which often imposes reasoning demands on the learner. But type of reasoning may differ depending on the domain reasoning is required. Thus, reasoning could be causal, spatial, or intentional. In this sense, relating a narrative could be seen as a reasoning task, especially when the learner needs to identify reasons of the characters' psychological motives involved in the story.

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