S

SCHEMA

A schema is a high-level conceptual structure or framework that organizes prior experience and helps us to interpret new situations. The key function of a schema is to provide a summary of our past experiences by abstracting out their important and stable components. For example, we might have a schema for a classroom that includes the fact that it typically contains a chalkboard, bookshelves, and chairs. Schemas provide a framework for rapidly processing information in our environment. For example, each time we enter a classroom, we do not have to consider each element in the room individually (e.g., chair, table, chalkboard). Instead, our schemas "fill in" what we naturally expect to be present, helping to reduce cognitive load. Similarly, schemas also allow us to predict or infer unknown information in completely new situations. If we read about a third grade classroom in a book, we can use our established classroom schema to predict aspects of its appearance, including the presence of a coatroom and the types of posters that might decorate the walls.

Schemas play an important role in language and linguistic processing by helping to frame the **SEMANTIC** content of a situation. Even when linguistic input is sparse or vague, activation of the appropriate schema can aid in the comprehension and retention of linguistically communicated material (see next section for an example). In addition, schemas and **SCRIPTS** often help us to define and interpret the discourse associated with particular contexts. In the classroom example, certain aspect of the communication between a student and teacher are captured by the schema, including the facts that students should quietly raise their hand in order to get the teacher's attention and that the teacher will stand facing the class and may call upon the student.

In a functional sense, schemas share much in common with categories (see CATEGORIZATION) or **CONCEPTS**. However, a distinguishing feature of schemas is that they are *structured* mental representations made up of multiple components. Schemas typically contain various *slots*, which each take on any number of *values*, and a set of relational structures that organize the slots and represent their interconnections. The values of particular slots are usually determined by the current context, percepts, or situation. For example, the schema for a generic room might include a slot for walls, doors, and windows, which could be filled with specific values (i.e., wooden door, bay windows, etc.). Slots that are left unspecified in the current situation are given default values, which reflect expectations or inferences about unseen or unknown information. Schemas derive their predictive power through a process of "filling in" default values so that incomplete knowledge about the current situation can be supplemented by past experience. In addition, a slot may be filled by other schemas, allowing for the **COMPOSITIONAL** construction of more complex structures.

The History of Schemas

Contemporary work on schemas was initiated F. Bartlett (1932), who was interested in the role that prior knowledge played in the interpretation and memory for stories. His work largely challenged the perspective of behaviorism by emphasizing the role of internalized representations in the control of behavior and thought. In one set of studies, participants were told a Native American folktale that included a number of unfamiliar cultural elements. On subsequent occasions, participants were brought back to the lab and asked to retell the story. Over time, participants' account of the story drifted in systematic ways, including the omission of information that did not make sense to them and the reinterpretation of certain facts in order to match their own cultural backgrounds.

Schemas actively guide our interpretation of new events and are, thus, highly related to **STEREOTYPES** and scripts (Schank and Abelson 1977). Consider the following passage:

> It can be hard work going down, but luckily the facilities make it much easier going up. Keep them pointed upwards, and be careful when you exit so you don't stop things from moving. Be on the lookout for others who are having difficulty, and watch out for the edges!

J. Bransford and M. K. Johnson (1972) showed how ambiguous passages similar to this one are at first difficult to interpret; however, when cues about the appropriate schema to apply (snow skiing) are provided, the information makes more sense and is easier to remember.

Bartlett's pioneering ideas led the way for considerable research demonstrating the role of prior knowledge on memory and **ENCODING**. However, schemas remained a relatively vague and ill-specified construct until the work of artificial intelligence pioneer Marvin Minsky (1975). Minsky was interested in developing computer systems with intelligent real-world behaviors. Like a number of later theorists (e.g., Rumelhart 1980), Minsky believed that the basic unit of knowledge representation should be a predicated structure that he called a *frame*. Frames are symbolic knowledge structures that contain fixed structural relationships between a number of attributes. The modern conception of schemas as being composed of slots and fillers inherits directly from Minsky's frames.

In contrast to the highly structured, symbolic processes assumed by Minsky, other theorists have attempted to develop accounts of schema representation from the perspective of **CONNECTIONISM**. Connectionist networks represent knowledge as a set of simple processing units that are connected to one another with weights. Activation flows through the network and causes different units to become more or less active on the basis of the patterns of input and the way the units are connected (see SPREADING ACTIVATION). Weights can be positive or negative and can thus represent either excitatory or inhibitory relationships between units.

D. Rumelhart and colleagues (1986) showed how special types of connectionist networks (called *constraint satisfaction networks*) could provide many of the same processing features as symbolic frames, including the ability to represent structured attributes and default values. For example, units in the network might represent objects that one might encounter in a typical room such as a *globe*, *blackboard*, *bed*, or *desk*. Positive association weights between these units are used to represent the fact that these items often occur together. Thus, the units for *globes*, *blackboards*, and *desks* might be mutually interconnected with

9780521866897SX.indd 725 3/1/2010 3:24:41 PM

positive weights, while *blackboards* and *beds* might be linked by a strongly negative weight. If a partial description or view of a classroom activates the *blackboard* and *pencil sharpener* element, other classroom elements (such as *desk* or *globe*) will also become active through their positive links to the observed events, while classroom-irrelevant information (such as a *bed*) would be inhibited. Structured attributes could form by subsets of mutually inhibitory elements. For example, most classrooms have either a *blackboard* or a *whiteboard*. Mutually inhibitory weights between *blackboard* and *whiteboard* units can ensure that only one value would fill this slot for at a time. Critically, the parallel distributed processing (PDP) approach to schemas dispenses with the traditional structure of schema representations, with slots, fillers, and relations favoring **EMERGENT** and implicit structures, such as part–whole relations and hierarchies.

Schemas and Memory

The schemas we use when interpreting a new situation heavily influence what we encode about a situation and are able to remember. For example, W. F. Brewer and J. C. Treyens (1981) were interested in how schemas might influence the way that objects are encoded into memory. In their studies, participants were shown a picture of a typical office and were tested for their memory of objects in the room. Their results showed that the schema recruited by participants (i.e., a typical office) influenced what they remembered about the scene. For example, people were able to accurately recall office-appropriate items such as desks, chairs, and bookshelves. However, the schema also filtered out from memory surprising or irregular items, such as a human skull, that was placed in the room.

While these studies suggested that processing the world through the "lens" of a schema favors schema-consistent information over schema-inconsistent information, other work has found the opposite effect (cf. Bower, Black, and Turner 1979). The apparent contradiction between these two views of schema-mediated memory processing was resolved by K. Rojahn and T. Pettigrew (1992), who found that after accounting appropriately for false alarm rates, schema-inconsistent information is generally remembered better than schema-consistent information. Similarly, categorizing objects by providing their **BASIC LEVEL** category label can lead to worse memory because doing so recruits schema-based representations of the object category (Lupyan 2005). In fact, young children sometimes show better memory for items than do adults because adults process items in terms of well-established categories and schemas, whereas children use similarity-based processes tied more directly to the perceptual features of the input (Sloutsky and Fisher 2004). In this sense, applying a schema (or label) can remove from the encoding process the details necessary for identification.

Connecting Schemas, Bodies, and Worlds

The traditional view of schemas (inherited from Minsky) emphasizes, to a large extent, amodal, symbolic processes that operate over highly processed and abstracted units. Contemporary work has attempted to extend the schema concept to include processes grounded in bodies and external environment (see EMBODIMENT). Perhaps most notable is L. Barsalou's (1999) perceptual symbol system theory. Like schemas, perceptual symbol systems involve framelike structures that have slots, preserve fixed relationships between attributes, and may take on default values. However, the objects upon which these framelike structures operate are direct, multimodal, sensory-motor representations. Evidence in favor of this approach includes the fact that brain areas representing particular concepts appear to overlap with perceptual processing of that concept. For example, damage to the visual cortex impairs conceptual processing of categories that are primarily visual in nature. The fundamental contribution of the perceptual symbols approach is to rethink the relationship between conceptual and perceptual processing and to suggest how symbolic, schema-like mental structures might emerge from perceptual experience.

Similarly, in cognitive linguistics, **IMAGE SCHEMAS** have been proposed as a way to link bodily actions, perceptual experience, and semantic processing (Johnson 1987; Lakoff 1987). Image schemas are an embodied prelinguistic structure of experience that can provide the basis of **CONCEPTUAL METAPHORS**. For example, one might have a generalized containment schema that represents an object being inside another object (just like a small ball might physically fit inside a cup). This representation is assumed to be an abstracted, but perceptual, instantiation of the concept and includes a number of structured spatial relationships. Generative meanings can be produced on the basis of this schema through metaphorical mappings. For example, understanding a phrase such as "a deep depression takes a long time to get out of" is accomplished through metaphor by the general containment schema (so one might envision the depressed person rising out of the depression like an element out of its physical container; Johnson 1987). Like perceptual symbol systems, image schemas emphasize perceptual, multisensory, embodied content in schema-like representations.

The Future of Schemas

The importance of schematized background knowledge on cognitive processes such as memory, interpretation, and inference is now well appreciated in the literature. However, there remains considerable debate about the precise mechanisms that support this behavior. Several of the more exciting avenues for future work include reconceptualizing the notion of schema outside of the literal, symbolic frames of Minsky with slots and fillers. These developments include dynamical systems models (where a schema would be a robust attractor state), neural networks (with mutually interacting microfeatures), and perceptually grounded, modal symbol systems.

– Todd M. Gureckis and Robert L. Goldstone

WORKS CITED AND SUGGESTIONS FOR FURTHER READING

Barsalou, L. 1992. "Frames, concepts, and conceptual fields." In *Frames, Fields and Contrasts: New Essays in Semantic and Lexical Organization*, ed. A. Lehrer and E. Kitta, 21–74. Hillsdale, NJ: Lawrence Erlbaum. An excellent introduction to the issues involving the representation of schemas and frames.

———. 1999. "Perceptual symbol systems." *Behavioral and Brain Sciences* **22**: 577–660.

Bartlett, F. 1932. *Remembering*. Cambridge: Cambridge University Press.

Bower, G., J. Black, and T. Turner. 1979. "Scripts in memory for text." *Cognitive Psychology* **11**.2: 177–220.

9780521866897SX.indd 726 3/1/2010 3:24:41 PM

Bransford, J., and M. K. Johnson. 1972. "Contextual prerequisites for understanding: Some investigations of comprehension and recall." *Journal of Verbal Learning and Memory* **11**: 717–26.

Brewer, W. F., and J. C. Treyens. 1981. "Role of schemata in memory for places." *Cognitive Psychology* **13**: 207–30.

Johnson, M. 1987. *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason.* Chicago: University of Chicago Press.

Lakoff, G. 1987. *Women, Fire, and Dangerous Things.* Chicago: University of Chicago Press.

Lupyan, G. 2005. "When naming means forgetting: Verbal classification leads to worse memory." In *Proceedings of the 27th Annual Meeting of the Cognitive Science Society*, ed. B. Bara, L. Barsalou, and M. Bucciarelli. Hillsdale, NJ: Lawrence Erlbaum.

Mandler, J. 1984. *Stories, Scripts, and Scenes: Aspects of Schema Theory*. Hillsdale, NJ: Lawrence Erlbaum.

Minsky, M. 1975. "A framework for representing knowledge." In *The Psychology of Computer Vision*, ed. P. Winston, 211–77. New York: McGraw-Hill.

Rojahn, K., and T. Pettigrew. 1992. "Memory for schema-relevant information: A meta-analytic resolution." *British Journal of Social Psychology* **31**: 2.

Rumelhart, D. 1980. "Schemata: The building blocks of cognition." In *Theoretical Issues in Reading and Comprehension*, ed. R. Spiro, B. Bruce, and W. Brewer, 33–58. Hillsdale, NJ: Lawrence Erlbaum. An interesting and influential argument that schema may represent the basic units of everyday knowledge in cognitive systems.

Rumelhart, D., P. Smolensky, J. McClelland, and G. Hinton. 1986. "Schemata and sequential thought processes in PDP models." In *Parallel Distributed Processing: Explorations in the Microstructure of Cognition. Vol. 2.* Ed. J. McClelland and D. Rumelhart, 7–57. Cambridge, MA: MIT Press.

Sloutsky, V. M., and A. V. Fisher. 2004. "When development and learning decrease memory." *Psychological Science* **15**: 553–8.

Schank, R., and R. Abelson. 1977. *Scripts, Plans, Goals and Understanding*. Hillsdale, NJ: Lawrence Erlbaum.

SCRIPTS

Let me tell you a simple story.

> John went to a restaurant. He ordered lobster. He paid the check and left.

Now let me ask you some questions about your understanding of this story.

> What did John eat? Did he sit down? Who did he give money to? Why?

These questions are easy to answer. Unfortunately, your answers to them have no basis in actual fact. He may have put the lobster in his pocket. He might have been standing on one foot while eating (if he was eating.) Who really knows whom he paid?

We feel we know the answer to these questions because we are relying on knowledge we have about common situations encountered in our own lives. What kind of knowledge is this? Where does it reside? How is it that our understanding depends upon guessing?

People have scripts. A script can be best understood as a package of knowledge that people have about particular kinds of situations that they have encountered frequently. There are culturally common scripts – everyone you knows shares them – and there are idiosyncratic scripts – only you know about them. When I refer to something that takes place in a restaurant, I can leave out most of the details because I know that my listener can fill them in. I know what you know. But if I were telling a story about a situation with which only I was familiar, I would have to explain what was happening in great detail. Knowing that you have the baseball script, I can describe a game to you quite quickly. But if I were speaking to someone who had never seen a baseball game, either I would have to make reference to a script he or she already had (cricket perhaps) or else I would be in for a long explanation.

Scripts help us understand what others are telling us, and they also help us comprehend what we are seeing and experiencing. When we listen to people talk about scripts, we don't know that we cannot even comprehend what they are saying even though we likely know every word. What does "they decided to go for it on fourth and one on their own two despite being up a field goal and were stuffed at the line of scrimmage for a safety" mean to someone who speaks perfect English and knows nothing about American football?

The world, and especially language, in incomprehensible without the background knowledge that scripts provide. When a small child fails to understand what was said to him or her, the lack of appropriate scripts is more likely the root of the problem than lack of appropriate words. Even a toddler who does not speak knows the morning routine or the ride in the car script. Scripts drive our expectations, and when they are violated, we are confused.

When we want to order in a restaurant and start to talk to the waiter and he hands us a piece of paper and a pencil, we are surprised. We may not know what to do. But we may have had experience with private clubs that want orders written down. If not, we ask. When our expectations are violated, when a script fails and things don't happen the way we expected, we must adjust.

In daily life, adjustments to script violations are the basis of learning. Next time, we will know to expect the waiter to hand us a paper and pencil. Or we might generalize and decide that next time doesn't only mean in this restaurant but in any restaurant of this type. Making generalizations about type is a major aspect of learning. Every time a script is violated in some way, every time our expectations fail, we must rewrite the script so that we are not fooled next time.

Since scripts are really just packages of expectations about what people will do in given situations, we are constantly surprised because people don't always do what we expect. This means, in effect, that while scripts serve the obvious role of telling us what will happen next, they also have a less obvious role as organizers of memories of experiences we have had.

Remember that time in the airplane when the flight attendant threw the food packages at the passengers? You would remember such an experience and might tell people a story about it: "You know what happened on my flight?" Stories are descriptions of script violations of an interesting sort. But suppose that this happened twice or five times, or suppose it happened every time you flew a particular airline. Then, you would want to match one script violation with another to come to the realization that it wasn't a script violation at all, just a different script you hadn't known about. Learning depends upon being able to remember when and how a script failed, marking that failure with a memory or story about the failure event, and then being able to recognize a similar incident and make a new script.

Scripts fail all the time. This is why people have trouble understanding one another. Their scripts are not identical. What one person assumes about a situation – the script built because of the experiences he or she has had – may not match another's because that person has had different experiences. Children get upset when their scripts fail. They cry because what they assumed would happen didn't happen. Their world model is naive and faulty. But they recover day by day, growing scripts that are just like the ones that adults have. They do this by expecting, failing, explaining their failure (maybe they ask someone for help), and then making a new expectation that will probably fail, too, someday. This *cycle of understanding* is a means by which people can learn every day from every experience.

Now, of course some people stop learning. They expect all scripts to be followed the way they always were. They get angry when a fork is on the wrong side of a plate because that's the way it has always been and has to be. We all have such rigidity in following our scripts. There are some that we wouldn't consider violating because we want to live in an orderly world. We confuse people when we fail to follow culturally agreed-upon scripts. We depend upon people to follow the rules. And our understanding of the behavior of others depends upon everyone agreeing to behave in restaurants the way people behave in restaurants. It is so much easier to communicate that way.

Scripts dominate our thinking lives. They organize our memories, they drive our comprehension, and they cause learning to happen when they fail. They provide the background knowledge for understanding the world we live in. That understanding has little to do with words or vision. We don't know what we are seeing or what we are hearing if we are witnessing or hearing about something for which we are lacking a script. We may not know why we do what we do when we are in a script. When we are told on an airplane to turn off all electronic devices, we turn off the computer and the iPod, but not our watch or our pacemaker. We know the script. The words don't matter all that much.

– Roger C. Schank

WORKS CITED AND SUGGESTIONS FOR FURTHER READING

Schank, R. 1999. *Dynamic Memory Revisited.* Cambridge: Cambridge University Press

Schank, R., and R. P. Abelson. 1977. *Scripts, Plans, Goals, and Understanding.* Hillsdale, NJ: Lawrence Erlbaum.

SECOND LANGUAGE ACQUISITION

At its inception in the 1960s, the research emphasis in modern second language acquisition (SLA) was on non-native language development (but also simultaneous childhood bilingualism) by children or adults learning naturalistically and/or with the aid of formal instruction, as individuals or in groups, in foreign and second language environments. Work in SLA now encompasses all that, plus the same phenomena in lingua franca settings, second language attrition and loss, second dialect acquisition (SDA), and third (fourth, etc.) language acquisition.

There is no dominant SLA theory. Sophisticated work has been conducted within a **UNIVERSAL GRAMMAR** (UG) framework (White, 2003a), the general nativist model of William O'Grady (2003), **FUNCTIONALIST** approaches like Talmy Givón's (Sato, 1990), and **EMERGENTIST** positions (Ellis, 1998). Psychological models motivate work on cognitive mechanisms and processes, including attention and memory (Robinson 2003; Tomlin and Villa, 1994), automaticity (Segalowitz 2003), implicit and explicit learning (DeKeyser 2003), and intentional and incidental learning (Hulstijn 2003).

Altogether, some 40–60 theories (loosely defined) *of* or *in* SLA coexist uneasily, some complementary but many oppositional (Beretta, 1991), and theoretical proliferation is arguably one of the field's chief obstacles to progress. The theories differ in source, with some imported from linguistics and psychology, others developed, data first, within SLA itself. They differ in scope (child or adult, formal or informal), form (causal-process and set-of-laws), type (special nativist, general nativist, hybrid nativist, and empiricist), and content (primarily linguistic, cognitive, or social variables considered important). Examinations of the theory construction process have appeared in recent years, with proposals offered for minimum criteria for adequate theories (Crookes 1992; Gregg 2003; Jordan 2004) and for comparative theory evaluation (Long 2007, 3–40).

Most SLA research falls within the domain of cognitive science, and internally, within one of three areas: i) patterns and processes in interlanguage (IL, the psycholinguistic equivalent of an idiolect) development, ii) the linguistic environment, and iii) individual differences. While far from an exhaustive listing, judging from the number of studies over time reported in the leading refereed journals (*Studies in Second Language Acquisition*, *Language Learning*, *Second Language Research*, *Bilingualism: Language and Cognition*, etc.), the following is representative of work within each of the three areas, and indicates what, in the sense of Laudan (1977), SLA researchers consider the most salient "problems" to be solved. The database on some is sufficient to have merited qualitative and statistical meta-analyses of the findings (Norris and Ortega 2006).

Patterns and Processes in IL

DEVELOPMENTAL SEQUENCES. While each learner's idiosyncratic version of a second language (L2) – his or her IL – is different, at least in detail, all exhibit some common patterns and features, and those from particular learner groups (e.g., learners with the same first language, or L1), share still more. Thus, instructed and naturalistic learners from different L1 backgrounds commit many of the same errors and error types, albeit in different frequencies at different proficiency levels (Pica 1983). Again, regardless of acquisition context and L1 background, they traverse broadly similar developmental sequences. An example is the well-documented four-stage sequence for L2 English (ESL) negation: *no* V (*No have job), *don't* V (*He don't work on Friday), aux-neg (He can't play the guitar), and analyzed *don't* (He doesn't like me). Stages in a sequence (by definition) cannot be skipped (e.g., as a result of instruction), and L1 differences can modify, but not change, the sequence. For instance, the L1 position of the negator can influence the time a learner spends at a given stage, such that learners whose native language, for example, Spanish, has preverbal negation will tend