A Reconceptualization of Generalization and Generalization Problems

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In this essay, I argue that issues of language generalization are best viewed as part of the broader issue of how individuals apply existing knowledge to situations that range from familiar to novel. The ability to flexibly apply existing knowledge is influenced by at least four factors: (a) the type of knowledge in question; (b) the level at which this knowledge is represented; (c) the similarity of the transfer situation to the original learning situation; and (d) performance factors that relate primarily to the limitations of the human information processing system. Children with speech or language impairments tend to be less flexible than others in applying knowledge. However, this inflexibility is underpinned by (a) deficient reasoning abilities that lead to difficulty acquiring language knowledge and noticing the occasions in which existing knowledge should be applied; and (b) greater vulnerability to linguistic processing demands.

Every person who has some interest in the learning or teaching process has an acknowledged or unacknowledged view about generalization. As exemplified in this series of articles, the issue of generalization in language learning is controversial. These controversies can be attributed to the complexity of language and learning phenomena and the diverse theoretical attempts to explain how language is learned.

In this essay, I will argue that issues of language generalization are best viewed as part of the broader issue of how individuals apply existing knowledge to situations that range from familiar to novel. Stated another way: What do individuals do with the knowledge they have? This view of generalization leads to questions about the nature of the current knowledge base and the flexibility with which existing knowledge is applied.

The ability to flexibly apply existing knowledge is influenced by at least four factors: (a) the type of knowledge in question; (b) the level at which this knowledge is represented; (c) the similarity of the transfer situation to the original learning situation; and (d) performance factors, including the physical and communicative contexts in which the knowledge is applied, and the affective states and information processing demands associated with producing language forms. The influence of each of these factors will be discussed in the following sections.

Knowledge Types and Representations

In recent years, a growing number of cognitive psychologists have begun to
investigate transfer mechanisms in learning (e.g., Brown, Kane, & Echols, 1986; Gholson, Eymard, Morgan, & Kamhi, 1987; Gick & Holyoak, 1983). Brown et al. (1986) point out, for example, that “flexible use of knowledge is a prerequisite for learning and development; hence the study of transfer has an enduring place in the history of psychology” (p. 103). It is interesting to note that behaviorist psychologists study generalization behaviors, while cognitive psychologists study the acquisition of problem representations and transfer mechanisms.

Two apparently contradictory claims regarding the application of knowledge have been made in the literature: The first claim is that learning in young children is inflexible; it is thought to be restricted or tied to specific situations. The second claim is that children constantly attempt to update what they know and increase their knowledge by interpreting novel events via analogy to a familiar instance or in terms of their extant theories of the world (Brown et al., 1986). This contradiction is also seen in the juxtaposed claims that (a) young children’s knowledge is fragile and fleeting, and (b) the major impediment to the acquisition of new knowledge in young children is their persistent and inappropriate application of naive theories (Brown et al., 1986). It has been argued that young children have difficulty relinquishing inadequate or partially adequate theories for new, more accurate ones (e.g., Carey, 1985). Thus, young children’s knowledge is viewed as fleeting and fragile on the one hand, and strongly entrenched and resistant to change on the other (Brown et al., 1986).

Brown et al. (1986) attempt to bring coherence to these contradictory views by differentiating among types of knowledge to be transferred in terms of its structural organization and functional significance to the learner. They propose a continuum of knowledge that spans four points: (a) theory, (b) principle, (c) isolated rule, and (d) specific solution. If what is to be transferred consists of coherent theory or principled understanding, it is all but impossible to impede flexible application of prior knowledge because we view and organize the world according to our preexisting theories and principles. It is when the learner is required to apply a previously learned isolated rule or specific solution that transfer problems exist. Young children, it is argued, use their emergent, naive theories to make sense out of novel situations, but are reluctant to apply fragmentary, unassimilated, context-specific knowledge to analogous problem domains (Brown et al., 1986; Holyoak, Junn, & Billman, 1984).

These notions are supported by data from recent studies on children and adult problem-solving abilities (e.g., Brown et al., 1986; Gholson et al., 1987; Gick & Holyoak, 1983). In these studies, subjects are asked to solve a particular problem and then transfer the problem solution to analogous or related problems. The data indicate that both children and adults must be trained to criterion (correctly demonstrating the problem solution) on two analogous problems in order to perform well on the transfer task. In the Gholson et al. (1987) study, children trained on only one problem needed an average of 14 moves to solve a 7-move transfer problem. In contrast, children trained on two problems needed an average of only 8 moves to solve the transfer problem. Children trained on only one problem thus had learned a specific solution to a problem, whereas the children trained on two problems had acquired a more generalizable problem representation. A

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generalizable problem representation or schema (Gick & Holyoak, 1983) probably falls somewhere in between an isolated rule and principled understanding on the Brown et al. (1986) continuum.

A second finding from this and other studies is that there are often no differences in transfer performance as a function of age or intelligence (Brown & Campione, 1984). Differences related to age and intelligence do exist, however, in the amount of time (i.e., number of trials) it takes to formulate a generalizable problem representation. This is because as children get older they become better able to notice analogical relationships.

During the past year, we (Kamhi, Gentry, & Mauer, 1987) have used a similar procedure to collect data from 16 7- and 8-year-old language-impaired children and 16 age-matched controls. Two of the language-impaired children did not reach criterion within 30 trials. By comparison, no normal child needed more than 8 trials to reach criterion. The 16 language-impaired children who reached criterion needed significantly more trials than the normal controls. No differences were found in transfer performance. Language-impaired children, like normal children and adults, thus were able to develop a generalizable problem representation from training on two analogous problems. They just took longer than normal children to develop this generalizable problem representation.

Differentiating Among Types of Language Knowledge

There are many different kinds of language knowledge. In order to be an efficient language user, one must have knowledge of language structure (syntax), the meanings and sounds that compose utterances (semantics and phonology), and the social conventions that guide the use of sounds and meanings (pragmatics). There is little question that language knowledge, like conceptual knowledge, is represented in different ways and at different levels. There is also little question that the different kinds of language knowledge exist along a continuum that spans the range from highly restricted language rules with limited scope to unrestricted language rules of broad scope.

An excellent example of a continuum of language knowledge can be seen in children's development of two-word combinations. Drawing on the work of Braine (1976), Leonard, Steckol, and Panther (1988) provide examples of six different levels of knowledge that underlie children's two-word combinations. At the first level, the child learns a combination, such as "drink milk" as an unanalyzed whole or single unit. Neither of the words in the two-word combination "drink milk" combine with other words, nor are they ever used as single-word utterances. At the second level, the child uses some of the words in single- as well as two-word utterances. Leonard et al. (1983) refer to these utterances as memorized word combinations.

The next two levels involve positional patterns. At the third level, children produce what Braine calls a "positional associative pattern." The example Leonard et al. (1983) give is a child who uses the word "this" in combination with more than one word (e.g., "open this" and "take this"). At this level, the two-word combinations are not novel. At the fourth level, there is some invention or novelty to the
child’s ability to combine a particular word with different words. For example, the child might say “open box” and “open shoe” (i.e., untie). These combinations are termed positional productive patterns (Braine, 1976).

At the fifth level, the child develops a limited scope formula that incorporates primarily semantic criteria. Leonard et al. (1983) give an example of a child who said “off box” (remove lid) and “off present” (unwrap present). They noted that these two-word utterances refer to some act that changes an object from a more closed state to a more open state. The child’s word combination rule is written as “opening action + object-opened.” At the sixth level, the child develops the familiar action + object rule. In order to be credited with this semantic relation, the child must use the rule to express meanings with broad scope. The words used in combinations must be used in inventive ways and with consistent word order (Leonard et al., 1983, p. 27). Although Leonard et al. (1983) do not mention it, a seventh level reflecting the development of the grammatical form class V + 0 is also possible.

This example of the different levels of knowledge underlying children’s two-word combinations is meant to illustrate the continuum of knowledge associated with a particular language structure. The flexibility with which a child uses a particular language form is influenced by the scope of the language rule. Rules with more limited scope necessarily have more restricted use than rules with broader scope. Language rules with limited scope can be compared to the Brown et al. (1986) specific solution and isolated rules, whereas language rules with broad scope seem comparable to principled understandings and theories. Note that the continuum of language knowledge contains more levels (7 levels in the language example above) than the 4-level continuum of conceptual knowledge proposed by Brown et al. (1986).

**The Relationship Between The Original Learning and Transfer Situation**

The second factor that has significant bearing on the facility with which existing knowledge is applied is the similarity of the transfer situation to the original learning situation. When the environment reinstates enough similarity or identical elements in common with the occasions of learning and previous use, transfer often occurs automatically (Brown & Campione, 1984). When such similarity does not exist, researchers (e.g., Crisafi & Brown, 1983, cited in Brown & Campione, 1984) have found that transfer can be facilitated by telling the learner that this is an occasion for the application of a known rule. These findings suggest that noticing analogical relations among occasions, rather than applying or mapping knowledge across domains, is the major impediment to the flexible use of knowledge. In other words, once the analogy is noticed, the application of knowledge is fairly trivial.

Brown and her colleagues (Brown & Campione, 1984; Ferrara, Brown, & Campione, 1986) have found that transfer can be a metric for individual differences. Individual differences related to age and IQ exist in the degree of help individuals need to perform independently within some domain. Brown and Campione (1984, p. 185) outline some of the problem-solving behaviors exhibited by mature learners.
Mature learners prepare for transfer by regarding new problems as instances of a general class, not as new problems. They expect that what they learn may be relevant in other domains. They look for analogies, question assumptions, provide counterexamples to their own rules, and monitor their problem-solving behaviors. Younger and slower learners are marked by their inability to apply these behaviors spontaneously.

How applicable are these notions for language generalization and generalization problems? Metacognitive abilities, such as planning and monitoring problem-solving strategies, play an important role in transferring problem solutions. In contrast, metacognitive abilities play a minimal role in first language learning because it is not until around age 4 that children become able to reflect on and monitor their behaviors (e.g., Hakes, 1982). By 4 years of age, however, children have acquired most of the grammatical rules that characterize adult language. These points notwithstanding, some language-learning problems can be attributed to difficulty noticing that a particular language rule should be applied.

A good example involves the use of auxiliaries in question forms. The normative data (e.g., Klee, 1985) indicate that children begin using auxiliaries correctly in Yes/No and Wh-questions at the same point in development. Out of 18 children, Klee reported that 13 children showed less than a 20% difference in the use of auxiliaries in the two questions types. Normal children thus recognize the analogous relationship among question forms and develop an appropriate broad-based rule for the use of auxiliaries.

Clinical experience indicates, however, that many language-impaired children develop a more limited rule for auxiliaries in questions. They might use auxiliaries in Yes/No questions but not in Wh-questions or vice-versa. Alternatively, auxiliaries might be used correctly for certain Wh-question words or Yes/No question forms, but not for others. Consistent use of auxiliaries for only one question type would imply a failure to notice the similarity between question types. Inconsistent auxiliary use would most likely be caused by some type of performance constraint. The influence of performance factors on language use is considered next.

**Performance Factors**

As suggested earlier, there are three kinds of performance factors: (a) factors associated with communicative and physical contexts, (b) factors associated with emotional or affective states, and (c) factors that derive from the limited capacity of the human information processing system. The influence of context performance factors, such as the communicative setting and participants, have received the majority of attention in speech and language training programs and in the intervention literature (e.g., Guess, Keogh, & Sailor, 1978; Hart & Rogers-Warren, 1978; Hedge & McCann, 1981). The underlying assumption in this literature is that variability in communicative and physical contexts is primarily responsible for the difficulty a child has using a particular language form. Stated in behavioristic terms, the characteristics of the stimuli in the new contexts are not sufficiently similar to evoke the desired response. Proponents of this view assume that the learning problem lies in the generalization mechanism rather than in the knowledge base or in noticing the occasions to apply existing knowledge.
There are at least two other kinds of performance factors that interact with context performance factors. The first kind involves affective or emotional states. A good example of an affective performance factor is test anxiety. A student might have well-formed representations of knowledge, readily demonstrate this knowledge before and after the exam, but not be able to demonstrate this knowledge during the exam itself. Stage fright would be another example of an affective performance factor. Affective performance factors can also function to enhance performance, as in the case of the competitive or over-achieving child. Some individuals are known to perform better in stressful situations than in nonstressful situations.

The other type of performance factor reflects the limited capacity of the human information processing system. In order to work within the boundaries of a limited capacity system, it is sometimes necessary to sacrifice or trade-off performance in one domain because of the demands placed on the system by other domains. Linguistic trade-offs are well documented in the literature. For example, verb inflections are often first used with familiar vocabulary (Leonard, Steckol, & Schwartz, 1978), semantic complexity is higher in shorter utterances (Bloom, Miller, & Hood, 1975), and children are more likely to make speech errors and omit grammatical markers in longer, more complex utterances (Nakayama, 1987; Nelson & Kamhi, 1984). Naturally-occurring linguistic trade-offs, as opposed to those that are experimentally induced, are most prevalent in children younger than 3:0-years-old.

The relative influence of each of the three performance factors can be evaluated by analyzing the pattern of usage of the language form in question. The effects of affective and cognitive performance factors are generally clear-cut. This is not the case with context performance factors. A child who does not generalize use of a certain linguistic form to a variety of settings and listeners might have a context-specific representation of the language form in question or fail to notice occasions for use of the form.

I suggested earlier that performance factors might explain inconsistent use of the auxiliary in question forms. Of the three kinds of performance factors discussed, the data suggest that information processing constraints best account for inconsistent use of linguistic forms and rules. Language-impaired children are particularly susceptible to the influence of information processing constraints because it takes them longer to automatize the various processes involved in sentence production (e.g., Kamhi, Catts, & Davis, 1984).

Implications for Language Learning and Language Disorders

It should be apparent from the previous discussion that viewing language-learning problems as a problem in generalization is overly simplistic and has little explanatory value. Generalization problems are best viewed as a failure to acquire broad-based language rules and to flexibly apply existing knowledge. Such failure can be the result of (a) an inadequate or overly-limited representation of knowledge (b) a failure to notice the similarity of the transfer situation to the original learning situation, or (c) performance factors (primarily those that derive from information processing constraints).
Language-impaired children, like other children and adults, should have less difficulty flexibly applying language rules of broad scope than language rules of limited scope. Language-impaired children, however, will take longer and need more help in developing language rules of broad scope because they are not very good at inducing language rules or noticing analogical relationships among language forms and structures. These children also might be more reluctant than normal children to modify or discard existing rules that are immature (e.g., agent + action), but of relatively broad scope. For example, it might take a normal child 2–3 months to move through the seven levels of knowledge that characterize two-word combinations, whereas a language-impaired child might take as long as 12 months to move through the same seven levels. The challenge to the language clinician, therefore, is to structure language input in ways that make it easier for language-impaired children to generate linguistic rules of relatively broad scope. Connell (1987) and Johnston (1985) provide some concrete suggestions for facilitating rule learning in language-impaired children.

In contrast to the absence of individual differences in the flexible application of theories and principles, individual differences related to age and intelligence do exist in transferring isolated rules and specific problem solutions as well as in the degree of help children need to perform independently in some domain (Brown & Campione, 1984). These findings have particular relevance for language intervention because language-impaired children are often taught isolated rules of limited scope. Because isolated, limited scope rules are not flexibly applied, the clinician needs to help the child notice situations in which the rules should be applied. For children with some metalinguistic awareness (i.e., ability to reflect on language), clinicians might be able to point out the similarity between the initial learning and transfer situations. For children who have little or no metalinguistic awareness, transfer situations should be constructed to maximize flexible knowledge application. Situations that invite similar conversational acts and meanings should facilitate flexible knowledge application. Variations in listeners or settings should not impede flexible use of knowledge as long as the conversational acts and meanings are similar across occasions.

Implications for Speech Disorders

My comments thus far have focused almost exclusively on language learning and disorders. The ideas presented, however, are also relevant for understanding speech generalization problems. Consider a prototype child with a speech generalization problem. Tucker, age 4:9, correctly uses the /r/ sound in therapy but uses the incorrect form /w/ outside therapy. What kind of learning problem does Tucker have? To answer this question, one needs to know the level at which he is representing his knowledge of /r/. Several questions can be asked to address this question:
1. Is the correct speech sound used in only one context (e.g., with pictures)?
2. Is the correct sound used in spontaneous speech?
3. Are there occasions for use outside the therapy environment?
4. Are the transfer occasions similar in communicative and linguistic ways to the original learning situation?
For argument sake, assume that the answers to all of these questions are “Yes.” The target sound /r/ has been taught in multiple contexts and is used in spontaneous speech in the therapy room. Also, the occasions for use outside therapy resemble those in the therapy situation. In a descriptive sense this is clearly an example of a generalization problem. So, why isn’t Tucker producing /r/ sounds outside the therapy room? I would like to suggest that the problem many speech-disordered children have in flexibly applying speech knowledge stems from two factors: (a) the nature of the knowledge to be applied and (b) information processing constraints on the system.

The nature of the knowledge to be applied is, of course, phonological. Phonological knowledge, in particular, knowledge of the motoric movements and sequences involved in speech production, is less accessible than knowledge of other aspects of language, such as syntactic and semantic aspects. Children as old as 6 or 7 years still have difficulty performing tasks that require explicit knowledge of phonemic units (Kamhi & Catts, 1986; Van Kleeck, 1984).

Tucker, the prototype child with a speech generalization problem, has been substituting w/r for about 3 years. If we conservatively estimate that there are approximately 200 occasions per day to produce an /r/, Tucker has said w/r about 219,000 times by the time he is 5-years-old. Given that the w/r substitution is so well-established and automatic, we should expect to encounter considerable difficulty correcting this speech error, even if Tucker has an accurate underlying representation and is able to articulate /r/ correctly. For Tucker to correct his w/r substitution, he will have to allocate considerable attentional resources to monitor the speech production process. In therapy, the allocation of the necessary resources for speech monitoring has been encouraged. Outside the therapy environment, however, the attentional demands placed on the system by higher-level linguistic and conceptual factors leave little resources remaining to allocate for speech monitoring. Unable to continually monitor speech output outside the therapy environment, Tucker inevitably falls back on his well-established and highly automatic w/r substitution. The challenge to the speech clinician is to help children like Tucker learn to monitor speech productions without diminishing other aspects of language performance. An example of a self-monitoring procedure to facilitate speech generalization was recently reported in a study by Koegel, Koegel, & Ingham (1986).

Summary and Conclusions

In this article, I have focused attention on the knowledge and processes that underlie generalization behaviors rather than generalization behaviors themselves. I do not find it particularly useful, theoretically or clinically, to say that children with speech or language disorders have generalization problems. A generalization problem implies that there is some deficiency in the transfer mechanism or in the ability to apply or transfer knowledge from one domain to another. Children with speech or language impairments might be less flexible than others in applying knowledge. However, this inflexibility is underpinned by (a) deficient reasoning abilities that lead to difficulty acquiring language knowledge and noticing the
occasions in which existing knowledge should be applied; and (b) greater vulnerability to linguistic processing demands.

ACKNOWLEDGMENTS

I wish to thank Marc Fey, Larry Shriberg, Phil Connell, and Lynn Snyder for their helpful comments on earlier drafts of this paper. Some of the ideas in this paper were presented in a 1986 ASHA miniseminar on language generalization organized by Phil Connell.

REFERENCES


Received March 19, 1987
Accepted October 15, 1987