Relational Invariance in Language

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[play tape] We recognize these as different renditions of the theme of Beethoven's Fifth Symphony. Though the four notes be played in different keys, on different instruments, and at different speeds, we perceive them to be the same "tune". Through all these different versions is a common denominator, something invariant. What is it that is invariant? Certainly not the acoustic signal in an absolute metrical sense. What is invariant are the relations -- both "vertical" (paradigmatic) and "horizontal" (syntagmatic). The vertical relation held invariant is that the last note is a major third lower than the first three notes, which are of identical pitch. The horizontal relation held invariant is that the first three notes are eighth notes and the last is a half note. Often one criterion by which we judge the quality of a particular rendition of a musical composition is how faithfully the specified invariant relations are reproduced (see Jakobson 1971b:551-553).

I wish to show examples of invariance as the respected scientific principle that it is and show that invariance is important in language even though some linguists may disregard it.

During the seventy-five years from 1841 to 1916 invariance in algebra, geometry, topology and physics was exhaustively investigated. Mathematicians Boole, Cayley, Klein, Lie, Sylvester and hundreds of PhD candidates devoted years to the study of algebraic invariance. E.T. Bell, who includes a 48-page chapter on invariance in The Development of Mathematics, gives this colorful definition of invariance (Bell 1945:420): "Invariance is changelessness in the midst of change, permanence in a world of flux, the persistence of configurations that remain the same despite the swirl and stress of countless hosts of curious transformations." For example, in Euclidean geometry a triangle may be translated or rotated without changing any of its dimensions or internal relations (see fig.1).

Fig.1.
In other words, the dimensions and internal relations remain invariant under transformations of translation and rotation. Topology goes one step further to study what remains invariant in the triangle under transformations free of metrical constraints, i.e. when the triangle can be "stretched" in any way as long as none of the lines connecting the points that were vertices are "cut" (see fig. 2).

![Fig. 2](image)

Chemistry and biology offer still other examples of invariance. Water exists in three general states: ice, liquid water, and steam. The chemical invariant that underlies these different states is represented by the formula H2O. The relation between one oxygen atom and two hydrogen atoms that creates water remains invariant in the different contextual variations of ice, water, and steam. If water is subjected to conditions that break up the relation between the oxygen and hydrogen, we no longer have water. Chemists can understand and explain the behavior of water because they know its chemical invariant. Invariance is also fundamental in the biological sciences. Botanists classify certain plants as legumes if they possess the properties by definition invariant to legumes. In fact, classification of any kind is based on the recognition of a property (or properties) invariantly present in the objects classified together. G. W. Scott Blair states that "a physical property has really no significance unless it is invariant to changes in its defining elements, since it is only through such an invariance that it comes to be isolated as an independent concept" (Blair 1950:231). According to S. S. Stevens, "the scientist is usually looking for invariance whether he knows it or not" (Stevens 1951:20).

Some of the most impressive examples of the recognition and explanation of invariance come from physics. Sir Isaac
Newton (1642-1727) discovered that the falling of objects to the ground, the apparent motions of the sun and the moon, and the ebb and flow of the tides are just contextually different manifestations of one invariant property of matter -- gravity. He gave the mathematical formula which accounts for and predicts the details of gravitational attraction between bodies in space. Newton's laws of motion propose simple principles that underlie many apparently different phenomena in motion. According to Einstein, "Newton's aim was to find an answer to the question: Does there exist a simple rule by which the motion of the heavenly bodies of our planetary system can be completely calculated, if the state of motion of all these bodies at a single moment is known?" (Einstein 1927:201). In other words, Newton was looking for invariance.

A century and a half after Newton's death Faraday and Maxwell showed that light, electricity, and magnetism are just contextual variations of electromagnetic energy and can all be accounted for by principles common to all forms of electromagnetism. Once again invariance was discovered in apparently different phenomena. Like Newton, Faraday and Maxwell gave mathematical formulas to describe electromagnetic phenomena accurately.

Einstein's famous formula $E=mc^2$ announces mass and energy as mere contextual variants of each other. In his general theory of relativity (1916) Einstein incorporates the invariance covered by Newton's law of gravitation into the more universal principle of equivalence in which the effects of gravitation and the effects of acceleration are just variations of a more general principle. In the special theory of relativity (1905) Einstein demonstrated that there is no absolute motion but only motion relative to a given frame of reference. Neither, according to Einstein, is there absolute length nor absolute time, these being potentially different for observers in different frames of reference. In other words, Newtonian invariance of motion, length, and time is relative to the frame of reference of the observer.

What we have here is not the negation of Newtonian invariance but the widening of the scope of that invariance. Newton's laws show invariance in x number of frames of reference. Einstein generalizes beyond Newton's laws to be able to show invariance in more frames of reference than Newton does! From the more general point of view of Einstein's laws, some of Newton's invariants become contextual variations of other phenomena. The motivation for expanding the reach of invariance is that doing so increases our power of explanation. As Paul Hedengren says, "We judge the existence of an object by its explanatory usefulness" (Hedengren 1981).
Einstein further demonstrated that there is an invariant relation between space, time, and matter, which he summarized as follows (Pasachoff 1978:115): "It was formerly believed that if all material things disappeared out of the universe, time and space would be left. According to the relativity theory, time and space disappear together with the things." I understand Einstein to mean that time and space do not exist without matter [1]. James R. Newman interprets Einstein's work as a quest for invariance (Newman 1961:332): "Einstein spent his life searching for what is changeless in an incessantly changing world. He searched for unity in multiplicity. In his model of physical reality, space, time, energy, [and] matter are bound together in a single continuum."

We see, then, that invariance is a more familiar concept than we might have supposed and furthermore that it pervades all scientific endeavor. Progress in science is closely correlated with discovering "new" invariants or expanding old ones. With respect to the laws postulated by the scientist, we can agree with S. S. Stevens that "the wider their limits of invariance, the more useful they become, for in his scientific account of humanity the scientist seeks measures that will stay put while his back is turned" (Stevens 1951:21).

One kind of invariance that has become quite fashionable in linguistics in the past couple of decades is interlingual invariance, popularly known as language universals (Jakobson 1971b:571; van Schooneveld 1977b:2). Some characteristics that have been discovered to be universal or nearly so in human languages are: two opposing classes of words, nouns and verbs [2]; two syntactic functions, subject and predicate; the grammatical category of number, with the basic distinction of singular and plural; and the category of person, with the basic distinction of impersonal (third person) and personal forms (which distinguish first and second person) (Jakobson 1971b:581-582).

Let us turn now from interlingual invariance to intralingual invariance. A classic example of such invariance is the phoneme [3]. If you listen carefully to the /p/ sound in the words "pit", "sip", "play" and "pray" you can notice slight differences in the sound of the /p/. Despite these differences, English speakers perceive the /p/ in those four words as "the same sound." On the other hand, the words "pit" and "bit" are recognized as different words solely because /p/ and /b/ are perceived as different sounds. As ordinary speakers of English, we feel the differences between /p/ and /b/ to be significant (because they distinguish differences in meaning), and we say that they are "different sounds." In contrast, we feel the differences in pronunciation of /p/ in different words to be insignificant and we probably were not even aware of thes
before they were pointed out to us. Linguists call the differences in English between /p/ and /b/ "phonemic" differences, as opposed to the merely "phonetic" differences between the different /p/ sounds. Roman Jakobson characterizes "phonemic analysis" as "a study of properties [that are] invariant under certain transformations" (Jakobson 1971a:472).

An important fact about the phoneme is that it does not exist in isolation but is always part of a system of phonemes within a given language. Just as Einstein said that there is no absolute rotation but only motion with respect to a particular frame of reference, Saussure said that there is no absolute invariance of an individual phoneme but only invariance in the relation of that phoneme to the other phonemes in its system (Saussure 1916:111-120; Jakobson 1971b:420-423; Jakobson & Waugh 1979:13-18, 80-84, 92-117). Take for example the phonemes /p/ and /b/ in English. The words "pit" and "bit" can be distinguished whether you talk normally, shout, whisper, speak with food in your mouth, etc. The relation between /p/ and /b/ remains invariant in different contexts even though the actual pronunciation of say /p/ itself differs in those contexts. Of course, the /p/ is also pronounced differently by different people, yet all recognize it as the same phoneme because of its relation to the rest of the phonemes in their system.

Let us now consider this phonemic invariance from an acoustic point of view and use the vowels /a/, /u/, and /i/ as our examples. Since a spectrometer registers the most minute acoustic differences, the pronunciation of /a/ by different people, or even by the same person in different contexts, will show up as different on the spectrograph (see fig.3).

![Fig.3.](image-url)
The same is true of the vowel /i/ (see fig. 4).

Fig. 4.

and the vowel /u/ (see fig. 5).

Fig. 5.
However, if we look at the relations between /a/, /i/, and /u/, we see that despite the metrical acoustic differences in isolated phonemes, there is invariance in the relations between these three vowels (see fig. 6, from Skelton 1970:135).

![Formant 2](image)

Saussure's prediction of invariance in the relations between phonemes but not in individual phonemes is confirmed by acoustic evidence supplied by the spectrometer [4]. Relational, or in other words topological, invariance successfully explains the structure of the phonemic system, while metrical absolutism does not. According to E.T. Bell, "it seems not altogether fantastic to imagine that a few centuries hence the qualitative habit of thought will have superseded the quantitative in the growing parts of mathematics. Certain indications in science, and many in mathematics, point to the analysis of structure as the mathematics of the future." Stated roughly, it is not things that matter, but the relations between them; and if topology with its spacial visualizations of intricate relations between abstract 'objects' has made possible a rudimentary but still difficult analysis of relations, it may be the germ of the mathematics of the future" (Bell 1945:466-467). Jakobson has repeatedly emphasized the applicability of the topological approach to linguistics (Jakobson 1971b:155, 223-225, 581, 661; 1973:28, 77-78; 1980a:15, 38, 105; Jakobson & Waugh 1979:18, 69, 83).

When we speak of invariance in speech sounds then, we refer to invariance in the system of relations between individual
speech sounds in a given language. Since the invariance necessary for comprehension is in the relations of the speech sounds to each other and not in the acoustic signal of an individual speech sound itself, we can understand the same word spoken under very different circumstances. Verbal communication depends on this invariance for success. The phoneme is a good example of the fact that invariance and contextual variation do not exist without each other. Every utterance of a particular phoneme is different and yet that phoneme can carry out its communicative function because of the invariance it possesses.

When we leave the phoneme and go to the higher (i.e., more complex) linguistic units, e.g., morpheme, word, phrase, clause, sentence, and discourse, the picture of invariance changes because these units have meaning. Invariance at these levels is the invariance of meaning associated with a given combination of phonemes. Charles S. Peirce declared that every linguistic sign has a general invariant meaning, which is "all that is explicit in the sign itself apart from its context and circumstances of utterance" (Peirce 1960:5.474; Jakobson 1980a:35-37). Roman Jakobson's description of the Russian case system is a cogent argument for invariance of meaning in morphology (Jakobson 1971b:23-71,154-183). Jakobson shows the general invariant meaning for each of the cases in Russian. For example, although the genitive may have contextual variants such as the so-called "genitive of negation" and "genitive of possession," the genitive case also has an invariant meaning underlying all of its uses. Referring to the invariant as the "general" meaning and to the contextual variants as the "particular" or "combinatory" meanings, Jakobson says:

"The question of general meanings in case systems belongs to morphology while the question of particular meanings belongs to syntax, since the general meaning of a case is independent of its environment, while its particular meanings are defined by various combinations of surrounding words involving both their formal and their real reference. We may say that the particular meanings are combinatory variants of the general meaning" (Jakobson 1971b:35). "All the specific combinatory meanings of any case can be reduced to a common denominator. In relation to the other cases of the same declensional system every case is characterized by its own invariant general meaning, or value ("valour") to use Saussure's term" (Jakobson 1971b:156).

Other linguists that have studied invariance of meaning in lexical and grammatical morphology are Dwight Bolinger, William Diver, Erica Garcia, Talmy Givon, Anna Hatcher, Joan Hooper, Otto Jespersen, Robert Kirsner, C. H. van Schooneveld, Sandra Thompson and Linda Waugh (see Bolinger 1977:20). For example, in his book entitled Meaning and Form Dwight Bolinger discusses the invariant meanings of the
words any, some, not any, no, it, there, of, do, remind, and others, as well as infinitives, imperatives, and word order. In the preface of the book Bolinger states that this book "reaffirms the old principle that the natural condition of language is to preserve one form for one meaning, and one meaning for one form" (Bolinger 1977ix).

We have discussed two basic types of invariance in language -- invariance of sound and invariance of meaning. Invariance of sound is invariance of relations in a system of phonemes. Invariance of meaning associated with a given linguistic form is a characteristic of the linguistic units of a higher order than phonemes. Bolinger considers the "one-form-one-meaning" principle to be a "universal" and he points out that "it has exceptions, but as with all universals the exceptions are imbalances that a language tends to eliminate; we can no more live comfortably with precise synonymy than with the conflict of homonyms" (Bolinger 1977:9).

One common objection to invariance of meaning is supposed homonymy. Homonyms are reputed to be words with different meanings that share the same form. Let us look at three examples in English of such "homonyms": bachelor, table, and pen. Jakobson lists the major variant meanings of bachelor as (1) unmarried man, (2) lowest academic degree, (3) knight serving under the standard of another king, and (4) fur seal without mate during breeding time (Jakobson 1973:49). He recognizes that the referents are different, but the referents must not be confused with the word itself. The word has an intrinsic general meaning that can be applied to the different referents. Jakobson says "all the bachelors have the following in common: they are all adult beings but in one aspect incomplete": (1) adult man, but unmarried, (2) academic degree, but the lowest, (3) knight, but without a banner of his own, (4) fur seal, but without a mate during breeding time" (Jakobson 1973:50). The word table likewise has an inherent meaning that can be applied to referents as different as picnic table, aluminum table, multiplication table, and water table. Table means, as Waugh puts it, a flat surface on which things can be placed or arranged (Waugh 1979e:31; Robertson 1977:1). Imagine this conversation between two linguists, one skeptical of invariance and the other convinced of it. "The three words pronounced pen as exemplified in 'ball-point pen', 'pig pen', and 'pen' meaning penitentiary are homonyms, are they not?" "Perhaps, but there is a semantic notion common to them all, the idea of containment or control and the prescribed or controlled exit from the containment or release from the control. In all three cases something is under control by means of the pen, and if it gets out of the pen in some way other than the prescribed way the result is 'messy'." "Well, you may be right there, but that invariant meaning is too abstract to be useful in linguistics. It's
more productive to view the three pens as homonyms." This view of abstraction as unproductive or impractical contradicts the experience of science, whose progress is equated with increasing ability to explain phenomena by means of significant generalizations.

In Einstein's eyes abstraction is a powerful tool in the hands of the scientist. He writes that "before Newton there was no comprehensive system of physical causality which could in any way render the deeper characters of the world of concrete experience" and he points out that "today we are so accustomed to forming conceptions which correspond to ... [Newton's laws] that we can hardly realize any longer how great a capacity for abstraction was needed" to formulate them (Einstein 1927:201-203). Einstein emphasizes that "Western thought and research and practical construction" are firmly rooted in Newton's abstractions (ibid.) [italics added]. Today these abstractions are lauded for their beauty, simplicity, and practicality. In his search for invariance, Einstein makes even more abstract abstractions that Newton does. These abstractions might have seemed laughable if the predictions they made had not been verified. No one laughs at the atomic bomb. We venerate Newton and Einstein for their successful abstraction of invariance from contextual variation. Why not recognize the greatness of Saussure, whose predictions of invariance in speech sounds have been likewise verified? We cannot dismiss invariance with the charge of being abstract. I suspect that many in Newton's day could see no practical applications of his laws of invariance; today we take them for granted. Let us not disregard invariance in language just because we cannot yet see what such knowledge will lead to. Invariance is useful, productive, practical, powerful to the degree that it increases our ability to explain and predict linguistic phenomena.

Let me reemphasize the relational nature of invariance in language. Linguistic invariance is not metrically absolute. Both the invariance of sound and that of meaning are relational, or topological. Bell sees topology as the mathematics of the future, and Jakobson states that the topological approach is the only way to adequately account for linguistic phenomena. Edward Sapir concludes a paragraph on Einsteinian relativity and linguistic relativity with this sobering admonition to linguists: "What fetters the mind and benumbs the spirit is the ever dogged acceptance of absolutes" (Sapir 1949:159).

I have titled this paper "Relational Invariance in Language" instead of "Relational Invariance in Linguistics" because I think that although relational invariance is in language, it is not yet sufficiently in linguistics. When we wonder "Why bother with invariance in linguistics?" let us consider "What explanatory power would chemistry have if chemists did
not know that both ice and steam consist of H2O?" If invariance is so important in all the sciences, why is it not important in linguistics? A handful of linguists have asserted the importance of invariance in language and consequently in linguistics, but unfortunately they remain relatively unknown or ignored by the linguistic community at large. I am confident that when linguists take relational invariance seriously to the degree that physicists, mathematicians, and other scientists have, we will have equally impressive results.

NOTES

1. Compare this with Jakobson: "there is no signatum without signum" (Jakobson 1971b:260) and "in grammar there is no conceptual opposition without a corresponding formal distinction" (Jakobson 1971b:586).

2. In Sapir's terminology nouns classify their referents as "existents" and verbs classify their referents as "occurrents". (See Sapir 1949:123 and Jakobson 1971b:581.)

3. The term "phoneme" was first proposed by A. Dufriche-Desgenettes in 1873, endorsed by Louis Havet in 1874, and used by Saussure in 1878 in his book on Indo-European vowels. Baudouin de Courtenay and Kruszewski adopted this term in 1880 to mean a meaning-discriminating speech sound that exists in a system of such sounds in a given language (e.g., /p/ and /b/ are phonemes in English because they distinguish words like "pit" and "bit"). Baudouin de Courtenay coined the term "morpheme" in 1878 by analogy with "phoneme". The term "allophone", widely used in post-Bloomfieldian linguistics, was coined by Benjamin Lee Whorf. (See Jakobson 1971b:396-397,405,407,409.)

4. On the relational invariance in the phonological distinctive features and the spectrographic evidence of it see Delattre 1968 and Jakobson & Waugh 1979:80-95.

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