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Uzzi Ornan
Hebrew University of Jerusalem and Technion—Israel Institute of Technology, ornanu@gmail.com

Rachel Leket-Mor
Arizona State University, rachel.leket-mor@asu.edu

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Phonemic Conversion as the Ideal Romanization Scheme for Hebrew: Implications for Hebrew Cataloging

Author Biography & Related Information

Uzzi Ornan (born 1923) is a professor of Hebrew linguistics and natural language processing at the Hebrew University of Jerusalem and the Technion—Israel Institute of Technology, and a member of the Academy of the Hebrew Language. In 1944, Ornan was detained in a British detention camp in Eritrea, where he taught Hebrew grammar to his fellow detainees from Erets Israel. In 1947, still in the camp, he published his Grammar of Mouth and Ear. After the detainees were freed in 1948 the book was reprinted in abridged edition several times in Israel. In 2016, Ornan completed a thoroughly revised edition of the book, compatible with current progress of linguistics (Jerusalem: The Hebrew University Magnes Press). Associated with the Canaanite movement, Ornan established the League against Religious Coercion (1950) and has been active in the separation of church and state movement in Israel ever since. In recent years, Ornan has been chairing the nonprofit "I am Israeli", an organization that calls for recognizing all Israeli citizens as sharing an all-inclusive Israeli nationality.

Rachel Leket-Mor is the Jewish Studies librarian at Arizona State University Libraries. In her previous career as a Hebrew copy editor, she engaged with questions of language conversion on a regular basis in the course of her work, applying a variety of publisher-supplied language conversion schemes, both from Hebrew into Latin characters and from foreign languages into Hebrew characters.

Erratum

Changes made on p. 60 and p. 62 to reflect the online availability of the Ornan Hebrew Parser (OHP) application.

Phonemic Conversion as the Ideal Romanization Scheme for Hebrew: Implications for Hebrew Cataloging

1. Introduction: The Need for Romanization[1]

Converting Hebrew script into Latin characters is a standard procedure in many library systems around the world where catalogers generate records of Hebrew holdings not only for organizational and retrieval purposes but also to facilitate discovery of these materials. Similarly, conversion practices are exercised in everyday life in Israel, whether for producing street and road signs designed for non-Hebrew speakers, exporting goods outside of Israel, or issuing passports for Israeli citizens. The terminology used in this article follows the International Organization for Standardization (ISO) model, preferring the term "language conversion" over "transcription" and "transliteration" (both of which are methods of script conversion as explained below; Clews 1997); or, interchangeably, employs the more familiar term romanization.

As illustrated by Hebrew conversion practices throughout the generations, any script can be converted to any other script (Wellisch 1978; for conversion of Hebrew into different scripts, see Yuditsky 2013; Harvanien 2013; and Noy 2013), but the main language conversions done in this day and age are into Latin script, otherwise known as romanization.[2] Since Judaica and Hebraica libraries make extensive use of the Hebrew and Yiddish ALA/LC Romanization Table for managing Hebraica collections, this journal serves as a fitting forum for introducing a conversion system of Hebrew discussed in the ISO from 1989 to 1999 (FDIS 259-3).[3] The initial 1962 ISO (ISO/R 259) was briefly mentioned in Wellisch (1978, 27–28, 300) and Lazinger,

1 This article discusses the conversion of Hebrew into Latin script, but we believe that the approach described here may be applicable to the spelling and transcription of other languages. The complexities involved in the spelling of English have been criticized for many years, but even though a monetary award was guaranteed in 1822 to "anyone who could devise a suitable 'harmonic alphabet' (to bring harmony out the existing confusion of practices) in Roman script" and create a universal alphabet, such a solution has not been achieved yet (though the first two winners of the Volney Prize were German librarians who wrote about the necessary conditions for such an alphabet; see Kemp 1999; 2006, 401–402). With all due respect, we believe that the discussion in this article may result in a universal principle that may be applied to all languages, English included.

2 In some linguistic contexts, romanization refers to complete replacement of non-alphabetical scripts or non-Roman alphabets with the Latin alphabet, at times also as an act of ideological reform. Completely replacing the Hebrew alphabet with Latin characters was advocated as early as the 1890s by individuals such as Isaak Rosenberg, Itamar Ben-Avi (Eliezer Ben-Yehuda's son, who carried out his reform in some of his publications), and members of the Canaanite movement. For further reading, see Aytürk 2013; Raizen 1987.

3 Following ten years of discussions in the Standards Institute of Israel and the International Organization for Standardization (ISO/ TC46/ SC2), the standard for Hebrew romanization reached the FDIS stage ("Full report circulated: DIS approved for registration as FDIS"; see the ISO International harmonized stage codes, at http://www.iso.org/iso/stages_table.htm). The standard was accepted by members of the eighteen country representatives of the Second Committee for Hebrew. The committee secretary, Mr. Evangelos Melagrakis was supposed to circulate the FDIS standard for formal approval, but unfortunately he stopped responding to any communication efforts, and the committee Chair Mr. John Clews of Britain had to resign, resulting in the dissolution of the committee. The status of that standard (FDIS 259-3) has remained the same ever since (see ISO 1999 for the draft; for previous ISO Hebrew standards see ISO 259-1/2:1994, at http://www.iso.org/iso/home/store/catalogue_ics/catalogue_detail_ics.htm?csnumber=4162).

Adler, and Intner (1998, 31). The 1994 revision (ISO 259-2) and its implementation in European libraries was reviewed in Vernon (1996, 12–14) and compared with the ALA/LC Romanization of Hebrew (8–9):

> The primary difference between the ALA/LC romanization tables and ISO-based romanization tables is that ISO-based standards represent every phoneme in Hebrew or Arabic with a single roman letter or diacritic-letter combination, while the ALA/LC tables also employ digraphs in addition to single roman letters and diacritic-letter combinations to represent phonemes.

However, the revised 1999 ISO for the Romanization of Hebrew was never officially published, nor was it discussed in the context of library implementation (except for a brief mention in Sheynin [2009, 45] in the context of cataloging publications in Jewish languages). On this account, the article reports on the FDIS 259-3, clarifies the differences between phonemic conversion and the ALA/LC Romanization of Hebrew, demonstrates these differences (Table 2), and introduces an interactive web interface for reversal of romanized texts.

The study of Hebrew conversion schemes demonstrates that in many cases, the same Hebrew word is romanized in different ways (see the many romanizations for *Ḥanukah* in W. Weinberg 1976), thus creating not only undesired but regrettable situations.[4] Furthermore, some romanization schemes apply to Israeli Hebrew only, based on the assumption that modern-day Hebrew spoken in Israel is different from the historical language to the extent that it requires a special conversion treatment.[5] This article shows that there is no need to generate different romanization schemes for distinct historical periods of Hebrew. It should be noted that the ALA/LC Romanization of Hebrew rules also apply to Hebrew throughout its historical periods and do not employ specialized practices for Israeli Hebrew.[6] However, not all those who have a need for conversion of Hebrew agree on the same system, as evident in library records accessible via union catalogs such as OCLC's WorldCat. The resulting record duplication may cause patron confusion in both discovering and correctly citing library materials, in spite of the efforts involved in maintaining such resources as the Virtual International Authority File (VIAF; http://viaf.org).

A significant point should be made when considering an appropriate romanization scheme of Hebrew: this ancient language has gone through several historical periods during which its texts have been represented in different writing modes. Should vocalized text (Tiberian or Babylonian

[4] Citing Wellisch (1976, 15), Lazinger, Adler, and Intner (1998, 36) note that statistically, "Hebrew has one of the highest percentages of homemade schemes of all nonroman languages found in the world's libraries."

[5] Modern Hebrew linguists, certainly since Haim Rozen in the 1950s, employ a conversion system that follows the standard, "Ashkenazoid" (Blanc 1957, 399) pronunciation in Israel. This system can neither apply to older periods of Hebrew nor can it serve for reversal purposes. See, for example, W. Weinberg (1970, 2): "This paper concentrates on the romanization of Sephardic or Israeli Hebrew for English speaking users."

[6] Ornan has clarified his opinion in several articles regarding the nature of Israeli Hebrew: It is not a new language but a continuation of a generations-old language. The new observed changes are nothing but linguistic performances of Hebrew elements that have always existed in the language. See Ornan 2016; forthcoming.

vocalization) be romanized using a specialized method, distinct from a romanization scheme for partially vocalized or non-vocalized texts? Should texts be romanized according to the level of their vocalization, thus establishing a different romanization scheme for "plene" spelling (*ketiv male*)? And how would a unified Hebrew romanization reflect the varied pronunciations of the language in different traditions or historical periods? Our proposed conversion scheme accommodates all these occurrences of written Hebrew.

The ideal romanization should reflect all periods of Hebrew and apply to all types of Hebrew material in libraries. Linguists may formulate their own specialized conversion methods based on professional considerations and needs, resulting in various romanization schemes. But for our needs, Hebrew deserves a unified romanization that reflects its linguistic makeup, as expressed in both the written language and all its oral performances during all periods. Such a romanization scheme will not only reflect the different ways in which a Hebrew word may be written or spelled (vocalized; partly-vocalized; spelled with "plene" spelling), but also its varied pronunciations throughout history, taking into consideration prayer book versions and verbal communication in different communities, as well as current pronunciations in Israel, whether of native Hebrew speakers or of those who acquired the language later in life.[7] Such a unified romanization scheme can be formulated, as demonstrated in this article.

Moreover, the conversion scheme proposed here allows for full reversal of the romanized words via a set of computer programs developed along with the phonemic romanization scheme and is available online.[8] The web-based interface allows for importing texts formulated in phonemic romanization and reversing them into Hebrew script, both non-vocalized and vocalized. This interactive module makes the proposed scheme ideal for implementation in libraries for the benefit of both catalogers of Hebrew material and library users.

2. General Principles

It should be noted, before the complexities inherent to Hebrew conversion in general are described, that human languages differ not only in their word morphology and syntax but also in their phonemes and speech sounds. Although it may seem that distinctive languages share the same phoneme reservoirs, in reality these phonemes are sometimes realized differently in each of the languages since each language employs a different stock of phonetic features to perform these phonemes. Thus, when a word originating in language A is beginning to circulate among the speakers of language B, its pronunciation may be changed to reflect the sounds of language B rather than the phoneme(s) from language A. Therefore, foreign words adopted in Hebrew should be considered as Hebrew words for the purpose of romanization, and should be roman-

[7] Compare the different pronunciations (Sephardi, Ashkenazi, Yemenite) of biblical Hebrew in these recordings: http://torahreading.dafyomireview.com; http://www.aoal.org/hebrew_audiobible.htm#Kings2.

[8] See Vernon 1996, 9: "Hebrew and Arabic data romanized according to ISO standards are also theoretically more easily convertible back to the original script. It is important to remember, however, that even if an algorithm is created to convert Hebrew or Arabic romanized data to the original script, this would not mean that retrospective romanized data (whether in ALA/LC or ISO romanization) could simply be converted automatically."

ized using sounds and phonemes unique to Hebrew. For example, the English word "goal" is used in Hebrew as an exclamation for scoring in soccer, but the Hebrew pronunciation (*gol!*) is using the vowel [*o*] without the diphthong heard in the original English pronunciation [*ou*].

The two standard conversion methods are transliteration and phonetic transcription (W. Weinberg 1970). The former matches every written letter in the original language script with a comparable letter in the target language, while the latter attempts to find a comparable letter in the target language that denotes the sound heard in the converted language. The following sections review the general principles of each of these methods and examines their appropriateness for the romanization of Hebrew.

2.1 Adding Symbols for Speech Sounds

The main difficulty in matching alphabet systems is that the corresponding letters may not be sufficient or compatible with the inscribed sounds and phoneme reservoir of the original script. For example, the Latin letter *j* never existed in the Latin language, but when the need to denote this sound arose in French, the letter *i* was used as a base by lengthening its tail under the line to create a new letter. The same is true for the letters *u* and *w*: they were added on the basis of the Latin letter *v* to the alphabet of several languages using that alphabet, English included, although originally these letters did not exist in Latin.

In yet other languages, letters were added on the basis of existing Latin letters to denote the precise pronunciation, but these added letters included small differentiation indicators, called diacritics. In this way, the new letter indicated its resemblance to the sound expressed by the existing Latin letter and at the same time kept its distinctiveness. For example, letters marking some of the vowels in French have supplemented accents. Similarly, the difficulty to mark the sound *sh* in many languages was treated in Czech and some other languages by adding the Czech háček diacritic to the Latin *s* to create š. Other languages adopted a system consisting of digraphs (a combination of two letters) to mark the needed sound. In English, for example, the sound expressed by the Hebrew letter *Shin* is marked with *sh*, in French by *ch*, in German by *sch*, and in Italian by *sci* or *sce*.[9]

It is worth noting here that this approach is unsuitable for Semitic languages, Hebrew included, as their morphology is structured on the basis of roots and patterns. Each pattern is shaped with placeholders ("squares") for root consonants, and each root consonant has its own placeholder in the structure of the pattern. Therefore using two letters (digraph) instead of the original root consonant in that placeholder disrupts the basal pattern concept so fundamental in Hebrew. For example, review the Hebrew patterns □*a*□*a*□ and *ma*□□*e*□ (the squares stand for root letters), where each square placeholder is intended to be occupied by one consonant only. Now compare

[9] Until 1948, the ALA/LC Romanization of Hebrew was "based on German spelling, a practice which appears to go back to Cutter's recommendation to use *The Jewish Encyclopedia* of 1901–1905 as the basis for Hebrew romanization." One of the results was the romanization of the Hebrew letter *Tsadi* in the Latin *z* (Maher 1987, 10).

the words that include the Hebrew *Shin* by reviewing the two romanized word pairs ***sh****amar*/*gamar* (גמר/שמר) and *ma****sh****der*/*masmer* (מסמר/משדר). The employment of two letters instead of one to romanize the Hebrew *Shin* impedes the readers' ability to compare Hebrew words of the same pattern and thus may prevent them from obtaining important information. Furthermore, using two Latin letters in lieu of the original one Hebrew letter interferes with the algorithm used in the process of reversing the romanized version to reconstruct the original Hebrew words.

2.2 Romanization for All Hebrew Periods

The ideal romanization of Hebrew should apply to all historical periods with no exception. The Library of Congress advocates for this approach, too, but displays some bias in favor of Israeli Hebrew pronunciation.[10] The Aḳademyah la-lashon ha-ʿIvrit (Academy of the Hebrew Language), the body that makes official decisions regarding language policy in Israel, established two conversion tables in 1957 (Academy of the Hebrew Language 1957).[11] These tables, labeled "exact" and "simple", were generated for the purpose of their suitability for linguistic research[12] and not on the basis of linguistic traits or strata, such as Israeli Hebrew. Decades later, in deliberations that took place in 1994–2011 (Academy of the Hebrew Language 2012a), the Academy revised the "simple" conversion system for the purpose of road signage and geographical names (Academy of the Hebrew Language 2007), ultimately recommending multiple versions of this official variant (see detailed review in Gadish 2013).

Other conversion systems that were devised to describe Hebrew pronunciation traditions or dialects made use of advanced phonetic transcription apparatus. Works such as Ktzia Katz's 1981 study of Aram-Tsova (Aleppo) Jews were published in a periodical dedicated to the study of linguistic traditions of Jewish communities (Morag 1977–2004).

Additional Hebrew conversion systems are applied to different historical periods, as described in each of the volumes of the recently published *Encyclopedia of Hebrew Language and Linguistics* (Khan and Bolozky 2013, vii-viii):

[10] The bias in favor of Israeli Hebrew pronunciation is acknowledged in the introduction: "The following Romanization table attempts to represent the sound of Hebrew or Yiddish words but is applicable to all Hebraic languages. For Hebrew, it approximates the modern Israeli, primarily Sephardic, pronunciation" (Library of Congress 2011); "The ALA/LC Romanization system attempts to approximate standard Israeli pronunciation throughout the romanization process while at the same time reflecting the general principles of traditional Hebrew grammar" (Biella, Fryser, and Lerner 2014).

[11] In 1999, Prof. Zeev Ben-Haim clarified that, "the appointed committee suggested only one transcription at first, but it was rejected on the grounds that typewriters couldn't produce differentiation indicators (diacritics) at the time, resulting in provisional eased rules. The scientific secretariat devised two types of transcriptions, simple and exact ones, but should not have done so. It should have included the eased rules as comments . . . Indeed, there was a disagreement about the appropriate letter for transcribing the Hebrew letter *Tsadi* . . . but there were no two distinct transcriptions. What kind of a linguistic committee would suggest two transcriptions?"

[12] The original decision of the Academy included a cautionary footnote regarding the sufficiency of the "exact" transcription for linguistic research.

> A different type of transcription is used for the various periods of Hebrew. An attempt has been made to balance considerations of phonetic reality, language history, orthography and practicality. The transcription systems, therefore, are in many respects the result of compromise and inevitably are less than fully satisfactory from several points of view. No transcription system of Hebrew, however, can be fully satisfactory in all respects.

Indeed, these conversion systems are not fully satisfactory, and the advantage of establishing a unified system for all periods, versions, dialects, and pronunciations of Hebrew is clear, especially in light of the extensive use of Hebrew romanization for library records. It may seem impossible to generate such a unified, machine-readable and machine-reversible system, a system that reflects all periods and dialects of Hebrew as one continuous language without sacrificing any linguistic structures. None of the existing systems, the ALA/LC Romanization of Hebrew included, attempts to provide all these advantages. Nonetheless, this paper proposes such a conversion system after examining the solutions recommended by the two traditional methods for language conversion.

2.3 Phonetic Transcription as Basis for Romanization

One of the two standard methods practiced in language conversion employs the phonetic approach of transcription. This type of romanization is based on listening to the speech sounds made in the language for which the conversion is done and writing them down in the script of the target language. In phonetic transcription, the speech sounds of the transcribed language are recorded even without understanding their meaning. For example, a speech given in language A may be recorded in the script of language B, although language A is completely foreign to the transcriber. However, even trained transcribers may incorrectly represent the original script of the language they record in this method. For example, a transcriber who does not know Hebrew may record the first sound in the Hebrew words טביעה (*ṭevi'ah*) and תביעה (*tevi'ah*) as t, as they indeed sound the same in Israeli Hebrew. Employing a conversion scheme based on transcription does not allow for reversing the original script of the recorded language, which is one of the required features of an ideal romanization, certainly for library catalogs. Due to this flaw in the phonetic transcription method, it is unsuitable for generating a reliable script transcription of Hebrew. Furthermore, if certain speech sounds of a language have different pronunciations corresponding to different dialects or historical periods, then the transcriber may record each of them in another letter while they represent the very same letter in the script of the original language. Consequently the phonetic transcription method cannot generate a unified romanization that encompasses all Hebrew strata. Moreover, attributing a special or preferable status to any of the language dialects may be interpreted as discriminating against other dialects. The phonetic transcription method may then be indispensable for the study of particular dialect or dialects, but not for a description of multilayered languages such as Hebrew.

Another consideration is that phonetic transcription relies not only on the dialect of the speaker of the transcribed language but also on the reader of the final written product. For English speakers, the Hebrew *Shin* would have to be transcribed as sh while for French speakers, the

appropriate transcription would be ch; however transcribing the Hebrew *Ḥet* as ch would make French speakers believe it's the Hebrew Shin transcribed. At the same time, for the sake of Spanish speakers the Hebrew *Ḥet* would better be transcribed as j,[13] but that same letter would be read by French speakers as representing the sound of the Hebrew *Zayin*.

Phonetic transcriptions for Hebrew may vary then not only by the time period in which the original text was produced but also by the readers who need to read that Hebrew text in Latin script, such as library patrons in different countries or tourists visiting in Israel. Indeed, tourist phrasebooks use phonetic transcriptions, however a phrasebook for Spanish speakers from Argentina would be different than that for French or American English speakers. Each tourist phrasebook is meant for speakers of a specific language, representing a Hebrew stratum of a certain historical period (usually Israeli Hebrew, collating *Alef* with '*Ayin*, and *Ḥet* with *Kaf*). The same is true for any romanization that is based, even as partially as the ALA/LC Romanization of Hebrew, on phonetic transcription. When employed in library systems, such romanization schemes may lead to different readings of the same catalog records by library patrons across the globe. With the popularization of WorldCat search engine's public interface on the Internet,[14] it is important more than ever to employ a unified romanization to allow patrons not only search for library materials but also reconstruct the original Hebrew records when these are not part of the record.

Phonetic transcription should be then entirely dismissed as a basis for a general, unified romanization of Hebrew.

2.4 Transliteration as Basis for Romanization

The other conversion method is based on transliteration: each letter of the original script is replaced with an equivalent Latin letter. If such a letter is nonexistent in the Latin script, a new letter may be created. Adding diacritics is quite useful when creating new letters to transliterate Semitic languages, as demonstrated in section 2.1 above. In the case of Hebrew, the conversion may depend on the writing mode of the text. If the text is non-vocalized, then just transliterating the letters will be meaningless: the reader of the resulting converted word will not be able to make the vowels if they do not appear in the romanized version. But even if vowels are included in the Hebrew text, it's not always clear how to transliterate them. The letter *Vav* may be transliterated as the vowel *o* or *u*, but also as the consonants *v* or *w* (if the Hebrew word is transcribed from another language, for example the word processor Word). The letter *Yod* may be transliterated as *y* or *i* but also as *ei* or *e* and even *a* (in the word *stav* for example; סתיו).

Nonetheless, using a vocalized version of the same non-vocalized text for transliterating is problematic as well. Firstly, vocalized texts are quite rare in Hebrew, since they mainly serve for Bib-

[13] See Smith 2015 for a native speaker of Spanish who expected to find the Hebrew word *Ḥanukah* romanized as *Januca*. See also W. Weinberg 1976.

[14] The public interface of WorldCat, at http://www.worldcat.org, is now crawled by Google, and search results from global member library catalogs appear on the first page of results.

lical texts, poetry, and children's books, while the majority of texts are non-vocalized. Secondly, few Hebrew speakers master the art of proper vocalization and therefore it is not reasonable to require them to vocalize texts for the sake of transliteration. At the same time, transliterating vocalized poems or Biblical texts is not only possible but also prevalent in academic publications in foreign languages; finding the exact characters and diacritics may be the only tricky aspect in such transliteration. It is worthwhile noting here that vocalization signs are unneeded for the most part for recognizing word morphology in Hebrew, since many of them represent one preferable pronunciation among others in a specific context.

None of the described conversion methods is convenient, as each of them has its faults. It is probably for this reason that all romanization standards published by ISO are introduced with the same comment, recommending the use of either the transcription or transliteration approaches, or a combination of both, depending on the nature of the language romanized.[15] The ALA/LC Romanization of Hebrew includes some transcription elements in addition to its main transliteration approach.[16] In this article, we propose a romanization system that undertakes to bypass the shortcomings of both the transcription and transliteration approaches and can be applied to all Hebrew texts, periods, dialects or scarce accents.

3. We Utter Sounds—But Comprehend Phonemes

3.1 Terminological Differences between Observation and Theory

Like other scientific disciplines, linguistics differentiates between observational and theoretical items or entities. Concrete phenomena in the world around us can be observed by our senses, measured with instruments, and described in observational terms. Sounds of speech are observational entities. We can perceive them by our senses and/or by various instruments, and also we can measure them according to their phonetic features. But the essential features of a sound serve also as a perfect basis for the idea of the theoretical entities of speech, the phonemes. Phoneme can be defined as the group of satisfactory and needed phonetic features that members of a certain language group can recognize as a meaningful sound in any word of their language. The main point is that it is not possible to perform a sound only by the essential "satisfactory and needed phonetic features". When performing words, each separate sound is accompanied also with some other, not essential phonetic features. Therefore a phoneme as it is cannot become an observational entity. It exists only as a theoretical conception. When it is performed, it is a sound that contains many superfluous features. It may relate to a phoneme, but it is not a phoneme. It is so since each performed sound observed in speech also includes other features.

[15] "To carry out Romanization, the conversion of non-Latin writing systems to the Latin alphabet, either transliteration or transcription or a combination of the two may be used depending on the nature of the converted system." See for example the introduction for the romanziation of Japanese (International Organization for Standardization 2013).

[16] See Vernon 1996, 2: "Romanization refers to the rendering of the text in non roman scripts into roman (Latin) characters. Although romanization is sometimes referred to as transliteration, this term is not completely accurate for the Hebrew and Arabic script languages because the rendering usually involves the supplying of vowels rather than the simple letter-by-letter substitution that the term transliteration implies."

It is easy to perceive the not essential features, for example, when listening to people who exhibit a certain accent in their speech. The sounds uttered by such persons include superfluous phonetic features, but if the listener recognizes the sound as phoneme, it means that its essential features also are present and discernible in the accent speech. In all languages, even very different sound utterances of the same phoneme are perceived as the same phoneme, as long as the sound utterance retains the phoneme's essential features.

English speakers, for example, easily recognize a person who speaks with an Israeli accent, as the Israeli speech includes sounds that are not found in the speech of native speakers of English. When Israeli speakers utter the sound [d], for instance, the tongue apex interacts with the very front of the hard palate, next to the front teeth. When speakers of British English utter the sound [d], the tongue apex does not touch the hard palate at the same point, but about a centimeter deeper. English speakers understand the speech of Israeli speakers because the essential features of the sound [d] are shared in both languages: it seems that there is not much significance to the specific location of the tongue apex when it interacts with the hard palate, as it does not change the phoneme's essential features.

Sounds are observational terms. Even if uttered by different speakers with additional, not essential vocal elements. A sound must contain the essential features that make it recognizable as the phoneme intended by the speaker. It is due to these recognizable qualities of the sound that particular language speakers perceive the utterances of other speakers, even if they do not utter the very same sounds. For example, some Hebrew speakers utter the sound [r] by vibrating the tongue apex, some position the tongue apex near the hard palate but do not vibrate it, and some vibrate the back of the tongue. Whatever the way the Hebrew [r] sound is uttered, its phonetic features are preserved so that all speakers recognize it. The same is true for the different utterances of the sound [r] by speakers of British English and Scottish English.

3.2 The Essential Features of the Phoneme

Thus, certain essential features of a sound also serve as a perfect basis for the idea of the phoneme, a theoretical item, defined as the smallest unit of speech that can be used to make one word different from another word. Unlike sounds, which can be observed in human senses and studied in the lab, phonemes are theoretical constructs. As such, they can only be realized by recognizing the essential features of the sounds associated with them. Phonemes do not exist in the real world, since as theoretical constructs they cannot be performed. A realized phoneme is then always a sound, an observable item, which includes additional, supplemental features. Thanks to this approach, we can define each phoneme in each particular language.

This is how humans understand each other's speech: the ear hears sounds uttered by the other speaker and transfers them to the brain; the brain is looking for a phoneme and takes note of the essential features of the sounds and filters the not essential, supplemental features. Humans accept all the features of the sound, but it is not the whole cluster of these features that humans

understand as the meaning of a sound: meaning is attributed to sounds as humans perceive their essential features only, as a theoretical item, a phoneme.

It follows that it is the theoretical linguistic elements that do not change—the phonemes—which should serve for romanization, rather than the sounds or the letters. The sought-after romanization of Hebrew should not rely on transcription or transliteration, but on phonemic recording.

4. Separate Rules for Writing and for Reading

To record the phonemes, our system separates rules pertaining to Hebrew writing from those pertaining to Hebrew reading (or speaking), as the latter describe how the phonemes are performed. In fact, reading rules function in every living language, including Hebrew, and they are distinct from rules of writing. For example, in writing we differentiate between the Hebrew letters *Tav* and *Ṭet*. The reading rules of these letters do not make any distinction between them, and in fact students are taught to "pronounce the letter *Ṭet* like *Tav*," as well as "pronounce the letter *Ḳof* as *Kaf*," and even "pronounce the letter *'Ayin* as *Alef*" and even "pronounce the letter *He* as *Alef*" (Ornan 2008, 225).[17]

The benefit of describing distinct reading rules is clear. The reading rules may change from period to period or from Jewish community to community, but they do not alter the fixed writing rules. The reading rules may be described according to different time periods, diverse traditions of various Jewish communities, or specific pronunciations. For example, the rules for equal sounds of *Tav* and *Ṭet* mentioned above do not apply to the Hebrew pronunciation of Aleppo Jews (Katz 1981). However, in writing, these two sounds always take different shapes (letters). For this reason, our proposed conversion method deviates from both Hebrew writing modes as well as from various pronunciations in different time periods or dialects. The basis for this romanization is the phonemic structure of the word, its morphology, recorded by phonemes, not by its written forms nor by its pronunciations: the theoretical structure of the word dictates the most faithful phoneme recording, hence its most functional romanization.

5. Phonemic Conversion

The search for the ideal romanization of any language starts with its native script. In the case of Greek or Cyrillic alphabets, the task is quite easy—much easier than in our case of Hebrew—since both the Greek alphabet and the Cyrillic alphabet (used for some Slavic languages) represent adequately all the sounds and phonemes of these languages. Romanizing these languages is merely a task of matching the letters of the native script with the corresponding Latin ones. If the Latin alphabet cannot offer such a letter, it be marked with an added sign, as demonstrated above, be it an actual letter (W, U, J) or a diacritical mark (è, é, ë, š, ğ, ḥ, à, etc.).

[17] In Israel, indeed, there are speakers who pronounce the letter *He* as *Alef*, too.

The traditional Hebrew script is an utterly different matter: its standard, non-vocalized written mode, does not display all the word elements, while its vocalized mode displays too many phonetic signs that relate to the same phoneme, e.g. the phoneme *a* in *dag* which is *ḳamats* in absolute state (דָּג) but *pataḥ* in construct state (דַּג), thus will not be distinguished for phonemic romanization purposes. The Arabic alphabet presents similar problems when writing Arabic, Persian and other languages, although its vocalized mode is less detailed, it mainly serves for phonemic display.

We propose to completely bypass the problems caused by the Hebrew script by converting the original word phonemic structure, as seen in Figure 1.

The theoretical structure of the word is recorded by its phonemes, but the phoneme may be realized in more than one way, in different sounds. Thus what stands for the "spoken word" in Figure 1 may be different sounds in different historical periods or various dialects, or different word forms, such as absolute or construct state. However what stands for "the word's theoretical structure" is never changed. Marking the phonemes of the "word's theoretical structure" with Latin characters (with diacritical marks as needed) results in a fine, unified romanization system of Hebrew that applies to all historical periods, dialects, and pronunciations.

The resulted phoneme-based romanized word may be performed orally according to any desired reading rules. Once the reading rules for Yemenite, Djerba [ğerba], or any other pronunciation of Hebrew are applied, the word may be read accordingly. Israeli Hebrew reading rules may of course also be applied. Based on observed differences between the written and spoken language, the Israeli common pronunciation can be easily described.

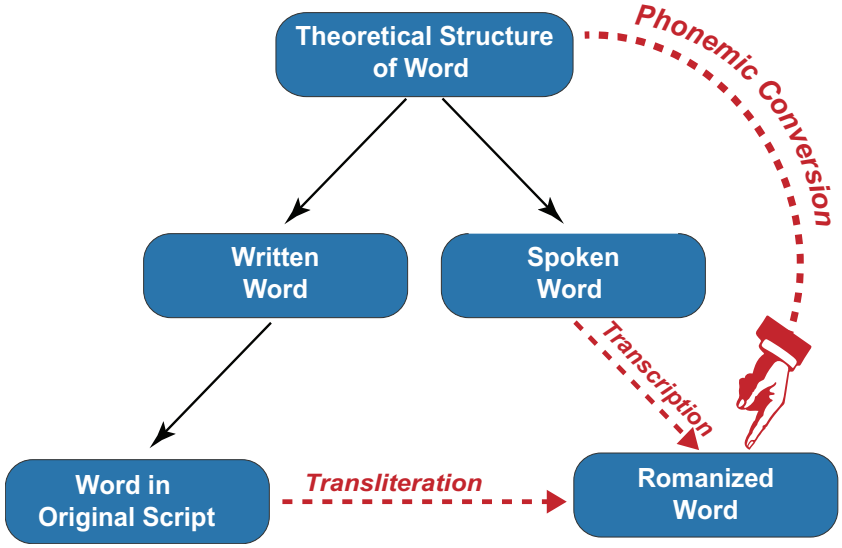

Figure 1. Phonemic conversion replicates the theoretical structure of the word and bypasses problems associated with transcription and transliteration

6. Phonemic Conversion Rules (Writing Rules)

6.1 Recording Hebrew Consonants and Vowels

6.1.1 The following table details the recommended romanization for Hebrew consonant letters. We should emphasize that the characters we use for phonemic writing are all signs that are used in linguistics. In addition, an auxiliary underscore is used in some cases, as described below.

Table 1. Phonemic conversion scheme for Hebrew consonantal characters. Unique Unicode characters are linked to http://unicode.org

Hebrew Letter	Latin Lowercase	Latin Uppercase
א	ʾ (02C0)	Ɂ (0294)
ב, בּ	b	B
ג, גּ	g	G
ד, דּ	d	D
ה	h	H
ו	w	W
ז	z	Z
ח	ḥ (1E25)	Ḥ (1E24)
ט	ṭ (1E6D)	Ṭ (1E6C)
י	y	Y
כ, כּ, ך	k	K
ל	l	L
מ, ם	m	M
נ, ן	n	N
ס	s	S
ע	ʿ (02C1)	Ɂ (0295)
פ, פּ, ף	p	P
צ, ץ	ç (00E7)	Ç (00C7)
ק	q	Q
ר	r	R
שׁ	š (0161)	Š (0160)
שׂ	ś (015B)	Ś (015A)
ת, תּ	t	T
ג׳	ǧ (01E7)	Ǧ (01E6)
ז׳	ž (017E)	Ž (017D)
צ׳	č (010D)	Č (010C)

6.1.2 The five Hebrew vowels are represented in Latin script with a, e, i, o, and u. The vowel "full *tsere*" is considered a sixth vowel, represented with a combination of e and i [ei], since in Hebrew script it is marked with the letter *Yod*. For example: *beiç*a (ביצה).

6.2 Conversion Rules

The following conversion rules, based on precise phonemic recording, should be used for scientific research. Library cataloging of Hebrew materials obviously falls under this category.

1. Non-phonemic vowels such as *sheva na'* (and *naḥ*), *pataḥ ganuv*, or auxiliary *segol* are not romanized. For example: *tappuḥ* (תפוח), *yeld* (ילד), *doʾr* (דואר), *klabim* (כלבים), *yladim* (ילדים).

2. *Dagesh* forte (*dagesh ḥazaḳ*) is romanized as two identical letters (doubled, or geminated, consonant). For example: *tikkon* (תִּכּוֹן; compare to *tikon* [תיכון]), *dibbur* (דִּיבּוּר; compare to *dober* [דובר]; see also section 7, Reading Rule #3 below.

3. Two consecutive, identical but not geminated consonants are separated by an underscore ("_") so they are distinguished and not mistaken for a geminated consonant. For example: *ḥogeg* (singular), but *ḥog_gim* (plural).

4. Prefixed particles, conjunctions, and prepositions ("service words": ב, ל, כ, ו, ה, ש, מ), appended in Hebrew script to the words they precede, are hyphenated in romanization. For example: *ha-bayt*, *mi*-šam. When more than one service word is affixed, they are separated by hyphens: *mi-ha-bayt*, *w-ba-ʾarç*. The *dagesh* forte (*dagesh ḥazaḳ*) in the letter following a service word is not doubled, unlike other occurrences of *dagesh* forte, for the sake of facilitating dictionary searches. For example: *ha-yom*, *ba-gann*.

5. The letter *Alef* in the beginning of a word is romanized with the appropriate character. For example: *ʾarç*.

6. As a non-phonemic vowel, *ḥataf* is not romanized. For example: *hlika* (הלִיכה), *ḥdašim* (חודשים, also חֳדָשִׁים), *ʾmunim* (אמונים).[18]

[18] Hebrew speakers who have no access to a Hebrew keyboard may benefit from employing a simplified version of this conversion scheme, mentioned in the FDIS 259-3 document of ISO. The following romanization rules include references to a simplified version, but do not pertain to libraries. The same characters are used in both versions although they are applied differently, as demonstrated below. These are the rules for the simplified version: Rule #1: Non-phonemic vowels may be added: *tappuaḥ*, *yeled*, *doar*, *kelabim*, *yeladim*; Rule #2: One character is sufficient but not for *Bet*, *Kaf*, or *Pe*; Rule #3: *ḥogegim*; Rule #5: Please note that ʾ (may be replaced by `) is a full character and not a diacritic; Rule #6: *halika*, *ḥodašim*, *emunim*.

Table 2. ALA/LC Romanization of Hebrew and phonemic conversion of Hebrew, compared; continued next page

Hebrew Features	ALA-LC Romanization of Hebrew *Unless in brackets, descriptions are cited or paraphrased from Biella, Fryser, and Lerner 2014*	Phonemic Conversion
Dagesh forte (*dagesh ḥazaḳ*)	Noted only to secure the romanization of פ, כ, ב as /b/ or /v/, /k/ or /kh/, and /p/ or /f/. There is no distinction in romanization between *dagesh ḥazaḳ* (*dagesh* forte) and *dagesh ḳal*.	Romanized as two identical letters, but is not marked in the letter following a service word. The letters פ, כ, ב are always converted to /b/, /k/, or /p/.
Service words	The definite article (ha-, he-), the conjunction (u-, va-, ve-), and certain prepositions (b, k, l, m) are written as prefixes in Hebrew script. In romanization these articles, conjunctions, and prefixes are separated by hyphenation from the words to which they are prefixed.	Prefixed articles, conjunctions, and prepositions ("service words"), appended in Hebrew to the words they precede, are hyphenated.
Service words, accumulated	Multiple prefixed articles, conjunctions, and prepositions are separated by only one hyphen from the base word unless one of the prefixes is the first word of a title.	When more than one service word is affixed, each of them is separated by a hyphen.
Diacritics	Diacritics used in systematic romanization are limited to the inferior dot (ỿ, ḥ, ṭ, ḳ), the acute (ś).	In addition to the inferior dot (ḥ, ṭ) and the acute (ś) diacritics, the caron (š, ǧ, ž, č) and the cedilla (ç) are used to form nonexistent phonemes in Latin.
Nonexistent phonemes in the Latin alphabet	[Romanized as a combination of two Latin characters: kh (כ), sh (ש), ts (צ).]	Romanized as one character: k (כ; the letter ק is romanized as q), š (ש), ç (צ).
Two consecutive, identical but not geminated consonants	[Auxiliary *sheỿa* (e) is inserted between them.]	Separated by an underscore ("_"), so they are not mistaken for a geminated consonant.
Diagraphs	A miagkĭi znak (' , also called "prime") is placed between two letters that represent two distinct consonants when the combination of these letters may otherwise be read as a digraph.	There are no diagraphs in this scheme.
The letter *Alef*	When the letter *Alef* is the first character in a word or the last character in a syllable, including at the end of a word, it is disregarded in romanization. Similarly, it is disregarded when it is used merely to indicate the presence of a vowel (as when used as an *em ḳeri'ah* or mater lectionis). Elsewhere, the *Alef* carries a vowel of its own, the special character *alif* (') represents the letter.	The letter *Alef* is always romanized with no exception. It is romanized with the appropriate diacritical mark, no matter what position it holds in the word.
The letter *Yod*	Romanized as "y" only when it is followed by a vowel.	Consonant *Yod* is always recorded as y. See under the Vowels row for when *Yod* serves as a vowel.

Hebrew Features	ALA-LC Romanization of Hebrew *Unless in brackets, cited or paraphrased from Biella, Fryser, and Lerner 2014*	Phonemic Conversion
The letter *He*	[Always romanized as h, both as consonant and vowel.]	Romanized as h when consonant, including when a *mapiḳ* is involved, but is not romanized at the end of words ending with a or e sounds.
Vowels	Vowels for Hebrew words and forenames, etc., are supplied on the basis of the vocalization in the most recent edition of Even-Shoshan's *ha-Milon he-ḥadash* in conjunction with the traditional grammars.	The five Hebrew vowels are represented in Latin script with a, e, i, o, and u.
"Full *tsere*" (long vowel)	[Treated as *tsere*, represented with e.]	Considered as a sixth vowel, represented with a combination of e and i [ei], since in Hebrew script it is marked with the letter *Yod*.
Sheʏaim	All *sheʏas* in Hebrew initial syllables are *sheʏa naʿ* and are transcribed as "e" regardless of pronunciation.	Non-phonemic vowels such as *sheva*, *pataḥ ganuʏ*, or auxiliary *segol* are not romanized.
Sheʏaim: exceptions	Two categories, where *sheʏa naʿ* results from "vowel reduction". 1. *Sheʏa* occurring between the second and third consonants of the plural forms of *benoni*; Verb forms of the *paʿal* / *ḳal*, *piʿel*, and *hitpaʿel binyanim* (stems), including all *sheʏas* following consonants with *dagesh ḥazaḳ*. 2. *Sheʏas* occurring between the second and third consonants of plural nouns in the construct state where the *sheʏa*'s appearance is also the result of vowel reduction. This category includes plural nouns with pronominal possessive suffixes built from the construct form.	No exceptions.
Ḥaṭafim	[Romanized as the vowel they resemble to.]	Not romanized, being non-phonemic vowels.

7. Reading Rules (Performing Rules)[19]

This section provides seven rules for reading phonemically converted Hebrew texts. Our rules demonstrate Israeli formal speech, as described in Table 1. Once romanized text is fed into our designated computer program, it may be decoded and reversed, as explained and demonstrated in Section 8. The examples following each of the rules are formulated according to linguistic standards, putting the word as it appears in the corpus between slashes and its performed form between brackets.

[19] Reading rules in some dialects should include some grammatical treatment, e.g. *kamats* in Ashkenazi pronunciation or *tsere* in Yemenite pronunciation.

1. The pronunciation of consonant letters is similar to the standard pronunciation of many known European languages, guided by the phonemic conversion scheme for Hebrew consonants (Table 1).

2. Each of the following three letters has two distinct pronunciations: *Bet*, *Kaf*, *Pe*. Their pronunciation is fricative ("soft") in the following cases:

a. When the letter follows a vowel and is not doubled (it is fricative, without *dagesh*). For example: /mibdaq/ > [mivdaq]; /šub/ > [šuv].

b. When the letter is at the end of the word (even if it is phonemically doubled). For example: /lebb/ > [lev]; /gabb/ > [gav], /śrok/ > [śrox].

c. When the letter occurs in a verb following an /a/ vowel that is canceled in inflection (e.g. */hadap/*, */yašab/* - [had**f**u], [yaš**v**a]); in grammar, when the letter takes the place of *lamed ha-po'al* (third consonant of the root) in the past tense inflection of the *pa'al* verb pattern (*binyan*) for feminine and plural third person, as well as the plural *benoni* of this *binyan*. For example (based on the inflection of *hadap*; *yašab*): /hadpu/ > [hadfu]; /yašba/ > [yašva]; /ṭorpim/ >torfim]; /šokbim/ > [šoxvim].

d. In the suffixes /kem/, /ken/, /ka/, the letter *Kaf* is always pronounced softly (fricative *Kaf*). For example: /beitkem/ > [beitxem].

e. Otherwise the letter is plosive, the default pronunciation, although in some listed cases it is fricative (most of them in patterns such as malk̲ut and naš̲kan).

3. Geminated consonants are pronounced as one consonant.

4. When the letters '*Ayin*, *He*, or *Ḥet* occur at the end of the word, not preceded by an [a] vowel, an unstressed [a] vowel is added to the vowel before them. For example: /ruḥ/ > [ru͡aḥ].

5. An unstressed [e] vowel is added in between the two consonants in *segolate* nouns—nouns that end with two consonants (Note that this is not the past tense verb.). Their penultimate vowel is stressed; an unstressed [a] vowel is added in between the two consonants if one of them is guttural; and an unstressed [i] vowel is added in between the two consonants if one of them is *Yod*. For example: /yeld/ > [yeled], /naʾr/ > [/naʾar] /bayt/ > [bayit].

6. An [e] vowel is added in words that start with two consonants, if the sonority of the first consonant is not lower (or equal) to the sonority of the second consonant.[20] For example: /lqiḥa / > [leqiḥa] (compare with /qpiça/ > [qfiça]: the two consonants q and f have the same degree of sonority, but the sonority of l is higher than that of q.

7. The last syllable is the one stressed in most of the words (including their inflections), except for verbs with *-ta*, *-ti*, and *–nu* verb suffixes and words read according to rules #4 and #5 above.

8. Reversal Rules

A requisite feature of any valid conversion scheme, and a required guideline for all ISO conversion schemes, is the ability to reverse the words into the original script. Since the 1960s, many of the Hebrew-to-Latin conversion schemes included a provision considering reversal module, however none of the schemes succeeded in developing a working reversal mechanism that did not require human intervention. All these conversion schemes were based on transliteration, i.e. reproducing the Hebrew characters with Latin ones, and most of them integrated transliteration as a means to represent, in Latin characters, the pronunciation of the Hebrew sounds. We described above the disadvantages of each of these methods.

As evident in research literature, Hebraica and Judaica librarians occupied themselves with questions related to the display of Hebrew script on electronic screens, romanization, and reversal strategies since the mid-1960s (for a literature review of reversal attempts, see Appendix). To be sure, typing and displaying Hebrew on any computer can be easily done today, but an accomplished, unequivocal reversible conversion scheme could still benefit cataloging procedures in libraries as well as readers who seek to make sense of Hebrew library records. To facilitate automatic reversal of phonemically converted Hebrew words, a set of computer programs accessible via an online interface is described below.[21]

8.1 Phonemic Romanization is Fully Reversible

Unlike previous conversion attempts, the Ornan Reverse Program (ORP) is based on the principles of phonemic conversion (Ornan 1993; 2003; 2008, and the updated ISO 259-3), which is fully reversible. The ORP is able to automatically reverse phonemically romanized words into non-vocalized Hebrew script based on specific reversal rules, as reflected in the phonemic

[20] Sonority is mainly defined as the relative loudness of a speech sound (Malmberg 1963).

[21] We would like to thank Prof. Alon Itai of the department of computer science at the Technion–Israel Institute of Technology and Head of Mila, for his help in establishing a series of programs to enable these devices, as well as Israel Gutter, Elazar Gershoni (now in Tel Aviv University), Yamit Bar-Shatz, and Oni Ornan (now in Canada) for their valuable assistance.

conversion scheme (Section 6),[22] however users are not required to apply the reversal rules as they are embedded in the program's algorithm. The online interface of ORP includes a virtual keyboard that eliminates the need of prior knowledge of Hebrew grammar or access to Unicode-based characters not available on standard keyboards. Another program, the Ornan Hebrew Parser (OHP), grammatically parses every written word in Hebrew script and suggests an appropriate phonemic conversion or several conversions, if the word may be read in more than one way. It is advisable to start out with the OHP program for phonemic conversion(s) and move on to the ORP to verify the convereted word(s).

8.2 The Ornan Reverse Program (ORP)

The interactive interface of the Ornan Reverse Program is divided into three separate windows (Figure 2). The window on the left features phonemically converted text, which is reversed into Hebrew script on the right window (the text is the Hebrew instructions, translated below). The bottom window consists of a virtual keyboard. As users type any phonemically converted text into the left window, the text is reversed on the spot into Hebrew script on the right window.

Figure 2. A screenshot of the ORP online interface, at http://www.mila.cs.technion.ac.il/ORP/

In addition to Latin characters available on any standard keyboard, phonemic conversion of Hebrew makes use of ten special, Unicode-based characters that are not part of standard key-

[22] Another program, Ornan Pointed Hebrew (OPH), re-converts slightly enriched romanized text into accurate pointed Hebrew. We do not include it in our present suggestion for phonemic conversion.

boards but are accessible via the virtual keyboard on the interactive platform. The ten characters are the following: ʾ, ḥ, ṭ, ʿ, ç, š, ś, and ǧ, ž, č (users should press the right, Hebrew side of the keys; see Table 1 for the full phonemic conversion scheme). Nevertheless, the application is also programed to accept replacement characters, available on any standard keyboard, for seven of the characters, as shown in Table 3. The remaining three characters (ǧ, ž, and č) have no replacements. The virtual keyboard also provides shortcut for particles and service words (i.e. prepositions, *she*- and the definite article *ha*-).

Table 3. Seven Unicode-based characters for Hebrew phonemic writing and their keyboard replacement key

Hebrew Character	Unicode-Based Character	Keyboard Key
Alef - א	ʾ	Grave accent `
Ḥet - ח	ḥ	**x**
Ṭet - ט	ṭ	**@**
ʻAiyn - ע	ʿ	Single opening quote ‘
Tsadi - צ	ç	**c**
Shin - שׁ	š	**$**
Śin - שׂ	ś	**j**

The following reversal rules spell out the phonemic conversion principles that are programed in the code of the ORP (see also Section 6). The reversal rules are listed here for those who may be interested in manually reversing converted script into Hebrew script:

1. Geminated consonants are reconstructed as one Hebrew consonant.

2. Consonants are reconstructed according to the phonemic conversion scheme for Hebrew consonants (Table 1).

3. The letters *a* and *e* at the end of words are reconstructed as the Hebrew letter *He*, with the following two exceptions where they are not reconstructed at all:

a. The *a* of the suffix -*ta* (past tense inflection of 2nd person singular masculine verbs; for example: *qibbalta*).

b. The suffix -*ka* and -*ha* (noun inflection). For example: suska, suseiha.

4. The letters *a* and *e* in the middle of words are not reconstructed at all.

5. The letters *o* and *u* are reconstructed with the Hebrew letter *Vav,* with very few exceptions in which they are reconstructed with the Hebrew letter *He*: *po*, ʾeipo, parʿo, šlomo.

6. The vowel *i* is reconstructed with the Hebrew letter *Yod* in the following cases:

a. When *i* is followed by one consonant letter followed by a vowel. For example: tinoq, ḥida (but migdal, ʾirgun – the consonant after i is not followed by a vowel: מגדל, ארגון).

b. When *i* is followed by a geminated letter. For example: çinnor, midda, zikkaron.

8.3 The Ornan Hebrew Parser (OHP)

The Ornan Hebrew Parser (OHP), at http://www.mila.cs.technion.ac.il/OHP/, analyzes the theoretical structure of Hebrew words and provides phonemic reading suggestions (one or more, if needed). The user may select the most appropriate suggestion based on the syntactic and semantic contexts provided in a book title or any other text, while considering cues provided by extratextual information. For example, in a phrase that relates to Shmuel Yosef Agnon who was awarded the Nobel Prize in Literature, the more plausible phonemic reading of the Hebrew word נובל would be *Nobbel*, not *nobel*. Every string produced by the parsing process of the OHP corresponds to a possible phonemic reading of the Hebrew word in question, starting with a phonemic conversion (first line) and continuing (second line) with a phonemic representation of the Hebrew characters (no vowels added) and the elements analyzed. Figure 3 below demonstrates all the possible readings of the words composing Moshe Shamir's book title, הוא הלך בשדות (*Hu halakh ba-śadot: roman*. Merḥavyah: Sifriyat poʻalim, 1947), although some of them are not reasonable in the context of the title. The word הוא may be read both as a pronoun (third person, masculine) or as the present tense, or *benoni*, of the verb היה (third person, masculine). The word הלך may be read both as a verb (=he walked; past tense, third person, masculine) and as a noun (=a wanderer; singular, masculine noun in absolute status). The word בשדות may be read as a plural noun in absolute state preceded by a preposition, both definite and undefined (= in fields; in the fields), as well as a plural noun in a construct state preceded by a preposition (=in the fields of). Additional reading of the word בשדות, very unlikely in this context however grammatically correct, is based on the Hebrew noun for she-demon (=in she-demons: in the she-demons; in the she-demons of).

Reading Hebrew book titles, as well as much longer phrases, may depend on the order of words and the syntactic connections among them, as well as extratextual context. The OHP may help with considering all these possible readings by analyzing the suggested phonemic conversions.

The Hebrew Word	1. The Word in Phonemic Conversion	2. POS	3. Lexical Entry	4. Status	5–6. Prefixes / Suffixes	7–11. Analysis of the Main Element	12–16. Analysis of Attached Pronouns	17. Attached Particles
.1 הוא	hu?							
	> hw?	P	hu?	a,	-, -,	r, 3, +, #, s	-,-,-,-,-	-,
.2 הוא	hu?							
	> hw?	$	hu?	a,	-, -,	-, 3, +, #, s	-,-,-,-,-	-,
.1 הלך	halak							
	> hlk	P	halak	-,	-, -,	p, 3, +, #, s	-,-,-,-,-	-,
.2 הלך	helk							
	> hlk	$	helk	a,	-, -,	-, 3, +, #, s	-,-,-,-,-	-,
.1 בשדות	b-śadot							
	>bśdwt	$	śade	a,	-, ot	-, -, +, #, p	-,-,-,-,-	b-
.2 בשדות	b-ha-śadot							
	>bśdwt	$	śade	a,	-, ot	-, -, +, #, p	-,-,-,-,-	b-ha-
.3 בשדות	b-śdot							
	>bśdwt	$	śade	i,	-, ot	-, -, +, #, p	-,-,-,-,-	b-
.4 בשדות	b-šedot							
	>bšdwt	$	šed	a,	-, ot	-, -, #, +, p	-,-,-,-,-	b-
.5 בשדות	b-ha-šedot							
	>bšdwt	$	šed	a,	-, ot	-, -, #, +, p	-,-,-,-,-	b-ha-
.6 בשדות	b-šedot							
	>bšdwt	$	šed	i,	-, ot	-, -, #, +, p	-,-,-,-,-	b-

Legend

1 Word in Phonemic Conversion

2 Parts of Speech (POS)
$ Noun
& Proper Name
P Verb
T Adjective
@ Number
Y Preposition
K Pronoun
V Subordination conjunction
S Auxiliary verb
H Quantity
X Coordinating conjunction
Z Gerund + Pronoun
M Verb + Accusative
Q Interrogative
N Relativizer
E Connector of nouns *shel* (Preposition)

3 Lexical Entry
The basic form of the word in the dictionary

4 Status (of K, T, $)
a Absolute
c Construct State: nomen regens (first word)
i Inflected form

5 Prefixes
(NOT attached particles, see #17)

6 Suffixes

7–11 Analysis of the Main Element
7 Tense (p: past; r: present; f: future; i: imperative; n: infinitive)
8 Person (1,2, 3; or -: all persons or irrelevant)
9 Masculine (+: yes, #: no)
10 Feminine (+: yes, #: no)
11 Number (s: singular; p: plural)

12–16 Analysis of Attached Pronouns
12 Person (1, 2, 3)
13 Masculine (+, #)
14 Feminine (+, #)
15 Number (s: singular; p: plural)
16 The attached pronoun

17 Attached Particles
Listed according to their order, separated each from its predecessor by one hyphen (e.g. ha-, še-, mi-, b-, k-, etc.), for example: mi-ha-bayt

Figure 3. Hebrew word parsing for the book title, הוא הלך בשדות

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Appendix: Previous Reversal attempts

While reversibility of romanized texts is not part and parcel of the ALA/LC romanization tables, the community of Judaica and Hebraica librarians acknowledged the need for such a reversible process as early as the mid-1960s, with the advent of library automation. The history of Hebrew reversible romanziation in American Judaica libraries up to 1990 was summarized in B. Weinberg (1991, 167–168), starting with Baruch Weitzel's proposal, presented at AJL's first convention in 1966, to establish a standard for transliteration of Hebrew. Next, a version of a "computer-compatible" transliteration for Semitic scripts was published by Goldman, Smith, and Tanenbaum (1971).[23] A strong supporter of reversible romanization, Herbert Zafren of Hebrew Union College (1969) followed with a presentation on "A letter-for-letter substitution" at AJL's fourth convention. As a result, Zafren was invited to join the American National Standards Institute (ANSI) Committee Z39 as AJL representative and chair its American National Standard for the Romanization of Hebrew subcommittee (ANSI 1975, Brandhorst 1979). Zafren's proposed romanization scheme was presented at AJL's seventh convention and summarized in an interim report issued by AJL (Association of Jewish Libraries 1972). ANSI recommended the use of four different romanization schemes, based on user needs (ANSI 1975), based in part on Goldman, Smith, and Tanenbaum (1971): General-Purpose Romanization; More Exact Romanization; Narrow Transliteration; and a Keypunch-Compatible Transliteration. The Narrow Transliteration, designed for scholarly purposes, and the machine-readable Keypunch-Compatible Transliteration were both reversible. As Vernon (1996, 14) pointed out, ANSI's reversible romanization "took a different approach than either the ALA/LC or the ISO tables. It mandated neither the

[23] Reviewed in Wellisch (1978, 308) and compared with ALA/LC and ISO 259 (323, Figure 5.1).

supplying of vowels nor the use of diacritic-letter combinations to represent phonemes without equivalents in the roman alphabet. Instead, this standard provided a corresponding one-to-one character transliteration."[24]

As reported by B. Weinberg (1991, 167–168), Vernon (1996, 15–16), and Lazinger, Adler, and Intner (1998, 40–44), ANSI's Keypunch-Compatible Transliteration was implemented at the New York Public Library (NYPL) in 1972, resulting in a print volume (1974) of the *Dictionary Catalog of the Research Libraries*' Hebraic section (Malinconico and Grutchfield 1977)[25] and over 2,000 Hebrew records loaded to, or cataloged directly in the Research Libraries Information Network (RLIN). The project was discontinued in 1988, after RLIN introduced Hebrew script capability (Aliprand 1992) and adopted the ALA/LC Romanization of Hebrew, because it was in use by most of the other Judaica libraries by that time. Still, it was due to the ANSI reversal attempts that the LC introduced diacritics to certain letters in the summer of 1976 (B. Weinberg 1991, 168).

Amnon Zipin, the then Jewish Studies bibliographer at Ohio State University Libraries in Columbus, Ohio also experimented with ANSI-based cataloging via the Ohio College Library Center (OCLC). Zipin (1978, 177–179) reported that following deliberations in 1975–1976, an OCLC committee recommended adopting the ANSI's Keypunch-Compatible Transliteration table and developing a computer application to reverse romanized words into Hebrew. Still, OCLC never implemented these recommendations. It was RLIN that first developed the capability of displaying Hebrew script, and the grant proposals that Zipin reported on (179), submitted to the National Endowment for the Humanities and Council on Library Resources, were not awarded. In Zipin's next paper (1984), he described his library's collaboration with OCLC on cataloging Hebrew and Yiddish material, using ALA/LC Romanization of Hebrew.[26]

In the mid-2000s, Joel Hahn of the Niles Public Library District in Illinois created transliteration macros for OCLC's Connexion client, one for Hebrew-to-Latin (Hahn 2005) to "automatically transliterate a field with Hebrew characters into Latin characters," and another one for Latin-to-Hebrew (Hahn 2006), to automatically "un-transliterate" fields with Latin characters into Hebrew characters. The macros are freely available for download on Hahn's homepage, at http://www.hahnlibrary.net.

[24] Vernon 1975, 12, is stating that ANSI's Narrow Transliteration could be "applied mechanically except for the position of *furtive patach* before the guttural and for the differentiation between *kamats katan* and *kamats gadol*, between *dagesh forte* and *dagesh lene*, and between *shva quiescens* and *shva mobile*".

[25] See details in B. Weinberg 1980, 347: "[…] in October 1974 data on Hebraica appeared for the first time in the Z39 computer-compatible transliteration system, since the photocomposition procedures could not accommodate Hebrew characters. It read from left to right and filed in the order of the Hebrew alphabet. Under author main entry, first works in the Roman alphabet and then works in the Hebrew alphabet were filed, since the computer's filing instructions where A–Z , 0–9, Hebrew mode. The Hebraica title index appears at the end of the A–Z sequence of the dictionary catalog."

[26] The current Jewish Studies bibliographer at The Ohio State University libraries, Joseph Galron-Goldschläger, reported that no internal documents pertaining to the ANSI-based cataloging practices are available (personal communication, 2016).

Finally, a few years ago David Bucknum of LC's Integrated Library System Program Office collaborated with Gary Strawn of Northwestern University to develop transliteration software that can reverse ALA/LC romanized words into Hebrew characters. According to Bucknum (personal communication, 2016),

> Transliterator is a Windows desktop application that interfaces with LC's cataloging desktop client to provide automated transliteration of MARC21 variable field data into parallel 880 (i.e. non-Latin data) fields. The application is currently configured to transliterate the following languages: Arabic, Belorussian, Bulgarian, Chinese, Greek, Hebrew, Korean, Persian, Pushto, Russian, Serbian Macedonian, Ukrainian, Urdu, and Yiddish. It is currently in use at the Library of Congress, the National Library of Medicine, and George Washington University.

Joan Biella, who worked with Bucknum in 2012–2013 to improve this application, added that, "We went through a great many drafts, and came up in the end with one that was very successful except in predicting where *imot ḳeri'ah* would turn up" (personal communication, 2016). Bucknum devised the following solution:

> The problem is the lack of diacritical markers for romanized vowels to indicate the presence of the *imot ḳeri'ah* or *matres lectionis* in the ALA/LC Hebrew Romanization Table. Our initial approach was to use an algorithm based on the most common situations where an *em ḳeri'ah* should be added . . . . Next, I wrote an application to create a module based on a more complex algorithm of consonant permutations. The result was a module 15MB in size, but still not completely accurate! Finally, I suggested the approach . . . . [of] adding a temporary marker (e.g. ū = u+0304, a combining macron) before a vowel to indicate the presence of an *em ḳeri'ah* in the resulting transliterated Hebrew text. This approach doesn't rely on an algorithm, but rather the cataloger's language expertise. The marker-vowel combination could be input with a macro to indicate that the *em ḳeri'ah* is present in the script, otherwise a vowel alone is not transliterated (e.g., |u = *Vav*, representing the vowel u).[27] Following the transliteration, all markers are automatically removed from the romanized text, leaving it in its correct form. (Personal communication, 2016)

Reversible romanization was lastly referred to in professional literature in Adler and Goldsmith (2011), who reviewed the two models for recording data in multiple scripts in MARC records, as described on LC's MARC 21 website:

[27] For comparison, see the following examples taken from a 2010 document sent by Bucknum: /kol/ (/כל/) vs. /kōl/ (/כול/); /tefilah/ (/תפלה/) vs. /tefīlah/ (/תפילה/); /tiḳūne/ (/תקוני/) vs. /tīḳūne/ (/תיקוני/); /be'ūrīm/ (/באורים/) vs. /bē'ūrīm/ (/ביאורים/). As explained above in several places, phonemic conversion bypasses the problems paused by different writing modes of Hebrew ("plene" or *ketiv male*, partly-vocalized, vocalized).

> "Model A" provides for original script and Romanized data, through use of the 880 fields for the original, non-Roman scripts. This is the standard that is employed by most libraries in the United States and also by OCLC. However, the records submitted by the National Library were created using "Model B." In "Model B" (simple multi-script records), "all data is contained in regular fields and script varies depending on the requirements of the data." OCLC was not equipped to accept records based on the Model B standard. (Adler and Goldsmith 2011, 85)

Citing a 2009 draft report on the question of romanization, put together by the Association for Library Collections and Technical Services' Task Force on Non-English Access, Adler and Goldsmith (2011, 86) stated that, "The Working Group concluded that it was 'premature' to make a general shift to 'Model B.' They felt that further research was necessary and recommended that automatic transliteration software be employed whenever possible."

The latter recommendation was hardly new, considering that four decades prior to its publication, B. Weinberg called for the use of romanization as a temporary measure, stating that (1974, 29): "Until we are ready to give up pronounceability for orthographic precision through either the original script or scientific transliteration, we will be violating the principal purpose of a catalogue, that of a *finding* list." Based on this understanding and the 1977 AJL discussions on romanization of Hebrew led by B. Weinberg, AJL and the Council of Archives and Research Libraries in Jewish Studies (CARLJS) adopted the following resolutions, that

> […] called upon LC and on bibliographic utilities, to preserve the script of the title page in bibliographic records. Until the technology for that process became available, the resolution called for the use of machine-reversible transliteration (letter-for-letter substitution) from the source script (e.g., Hebrew) into the target script (e.g., Roman). The assumption was that while work proceeded on the development of Hebrew capability for online catalogs, one could catalog in reversible transliteration that would later be converted by machine to the original script, i.e., Hebrew. (Zipin 1984, 53)

The practical results of these resolutions would have been the adopting of ANSI's reversal romanization tables had the Library of Congress approved them, but it favored the ALA/LC Romanization of Hebrew (Brandhorst 1979; Zipin 1984, 53; Weinberg 1991, 167–168; Vernon 1996, 15). When comparing ALA/LC Romanziation of Hebrew to ANSI's reversible romanization, Zipin (1984, 56) remarked that, "Reversible transliteration, which does not reconstruct missing Hebrew vowels, is much more cost effective, and allows a future machine conversion to original script display when the technology becomes available." Still, this road was not taken. However, it was due to the ANSI reversal attempts that the LC introduced diacritics to certain letters in the summer of 1976 (B. Weinberg 1991, 168). According to Vernon (1996, 17),

> The failure of reversible romanization to gain wide acceptance as a standard for Hebrew romanization—despite technically being closer to the original Hebrew in its reproduction of the Hebrew orthography—would seem to demonstrate that readability and pronounceability of romanized data are a high priority for libraries; if many libraries at that time had the option of displaying reversibly romanized data in their online catalogs in the original script, then perhaps this approach might have been more widely adopted.

Subsequent attempts to introduce reversal romanziation were unsuccessful as well. Citing librarian Jill Butterworth of the Division of Oriental and Other Languages at the Cambridge University Library, Vernon (1996, 9) reported on a 1995 attempt: [the library] "has been experimenting with producing Hebrew/Arabic script output from Hebrew/Arabic ALA/LC romanized records although they have not yet been able to fully automate the process, which presently requires editing of output."

Similarly, because of inherent limitations described on Joel Hahn's webpage, his two transliteration macros for OCLC's Connexion client (2005; 2006) are not much used by Judaica and Hebraica catalogers:

> In both cases, you will have to double-check the results, because the macro cannot handle every possible case and exception. This is in part because some vernacular characters on the transliteration tables are not yet valid for use in MARC records, and some valid MARC characters are not included in the Arial Unicode MS font (nor most other Unicode fonts); these will be transliterated by the macro as fill characters (a black rectangle). In these cases, you must manually edit the transliterated field before the record will validate. You may have to use character descriptions instead of the actual characters, as instructed in the Connexion help file . . . .

Finally, Aaron Taub of LC reported (personal communication, 2016), that the Transliterator application written by David Bucknum and Gary Strawn is used but occasionally by LC catalogers, mainly because of the manual work involved.

The question of reversal romanziation may seem irrelevant in the twenty-first century since many integrated library systems (ILS) have the capability of displaying Hebrew script. After all, the interest in this theoretical problem died away in the late 1980s, once Hebrew characters became available on computer screens. However, as an intellectual exercise but also as practical device, phonemic conversion provides the answer to the decades-long reversal romanization conundrum and may help libraries and users thanks to its bidirectional reversing capabilities.