

## Biblical Cantillations

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### Abstract

This paper presents an expository account of the biblical cantillations, a hierarchical punctuation system used on biblical verses. Although the biblical cantillations developed over a 1000 years ago, the theory underlying them requires the use of three modern disparate fields: Phrase-structured grammars, music, and the grammar of punctuation. Much of the theory is well understood but is generally not accessible to modern English readers because of both language and notation barriers as well as the three technical fields needed to understand the theory. In addition to the expository account presented in this paper, 1) we introduce a simple notational system, *immediately* accessible to an English reader that mimics the cantillations but does not require prior knowledge of other languages or special symbols; 2) we show how cantillation theory can be succinctly formulated using phrase-structured grammars; and 3) we relate cantillations to the still-forming musical theory of cadences.

### 1. Overview

A powerful teaching technique is to use a vignette, a punchy example, illustrating several techniques. The field of biblical cantillations is an example of such a vignette. Biblical passages, although an integral part of the traditional Sabbath synagogue services, are not *read* by Rabbis, but rather *chanted* by bible cantors, specially trained in the use of biblical cantillations, a complex, comprehensive, musical, hierarchical, notational system used to punctuate the Bible [6] (see figure 1 for an illustration). Although finalized over a millennium ago, this technical field is a gem that requires knowledge of at least three, modern, diverse, distinct disciplines to fully understand it: (1) the grammar governing punctuation, (2) the computer-science field of phrase-structured grammars, and (3) the theory of musical cadences.

In this paper, we first review the use of phrase-structured grammar to parse a sentence (Sections 2, 3). We then develop a simple cantillational notation (immediately accessible to an English reader) that uses simple rules and symbols to indicate the level of parsing (Section 4). Finally, we study the intensity of cadence of the musical notes associated with the five major cantillations (Section 5). We also point out possible directions for future research involving application of musical cadence theory to the cantillations.

This paper is an introductory expository paper of a very rich field. For purposes of brevity, we primarily focus on the five most frequent pausal cantillations used in the Pentateuch as chanted in certain European traditions. We also omit extensive discussion of rule exceptions, complicated compound sentence structures, connective cantillations and orthography.

### 2. English Punctuation

Throughout this paper, we use the relatively simple sentence presented at Genesis, Chapter 47, verse 10 (Gen. 47:10) [10] [6, p. 49]. This verse states

וַיְבָרֶךְ יַעֲקֹב אֶת־פַּרְעֹה וַיֵּצֵא אֶמְלָכֵנּוּ יַפְרָעָה  
 Jacob blessed **Pharoh**; he-went-out from-the-presence **of-Pharoh**.

**Figure 1.** *Gen. 47:10 in both Hebrew and English with punctuations, cantillations and hyphenations.*

We have bolded the English words in the above sentence that receive a punctuation mark at the end of the word. Rules that facilitate reading govern these punctuation marks. For example, the semi-colon after the first **Pharoh** alerts the reader to the compound sentence structure; the period after the second **Pharoh** alerts the reader to the completion of a unit of thought [11]. We have added hyphens in the English translations to indicate word-units of Hebrew. For example, “and-went-out” is three words in English but one word in the original biblical Hebrew. Similarly, “from-the-presence” is three words in English but one word in the original biblical Hebrew.

Unlike English where only some sentence words are punctuated, biblical cantillations require that *each* Hebrew sentence word receive either a cantillation or a hyphen between the word and its successor; hyphens typically occur with monosyllabic Hebrew words. Heuristically, the cantillation belonging to a word indicates either the degree of pausality required by a reader of the sentence, or else, indicates a required liaison / connection with following words. Therefore, to fully understand biblical cantillations we must first understand how a sentence is parsed. The next section presents rules governing parsing.

### 3. Phrase-Structured Grammar

In this section, we present basic phrase-structured grammars in simple lay terms [cf. 6, pp. 436 – 449]. The more technically oriented reader can find many formal accounts in the literature [2]. Since, the traditional mathematical method - first presenting definitions and axioms and then illustrating the power of the system - would be unappealing to the lay reader, we therefore suffice with presenting an example that we use to heuristically motivate definitions, notations, and methods. We begin with Table 1 that presents the parsing of the sentence, Gen. 47:10, presented in Figure 1.

Jacob blessed Pharoh; he-went-out from-the-presence of-Pharoh.					
Jacob blessed Pharoh			he-went-out from-the-presence of-Pharoh.		
Jacob blessed		Pharoh	he-went-out	from-the-presence of-Pharoh	
Jacob	blessed	Pharoh	he-went-out	from-the-presence	of-Pharoh

**Table 1.** *Phrase-structured grammatical development of the sentence, Gen. 47:10, presented in Figure 1.*

We briefly summarize the key points and ideas used to develop Table 1:

- The first row contains the original sentence presented in Figure 1. In phrase-structured grammar all analysis always starts with the *initial symbol*, **S**, which the reader can think of as meaning *sentence*.
- The 2<sup>nd</sup> row breaks, *rewrites*, or *parses*, the initial compound sentence into two simple sentences. We could formally indicate this with a *rewriting rule*,  $S \rightarrow SS$ , which heuristically corresponds to the following intuitive idea: A person wishing to write a sentence (**S**) has the option of writing a compound sentence consisting of two smaller sentences (**SS**).
- The first two cells in the 3<sup>rd</sup> row and the first 3 cells in the 4<sup>th</sup> row *parse* or *rewrite* the left-most simple sentence of the 2<sup>nd</sup> row using a **Verb-Complement-Complement** form where the **Verb** is *blessed*, the first **complement** is the **Subject**, *Jacob*, and the 2<sup>nd</sup> **complement** is the **direct object**, *Pharoh*. We could formally formulate this using *rewriting rules*:  $S \rightarrow sV$ ,  $V \rightarrow VO$ . This formalism, although slightly abstract corresponds to the following very basic idea, known to

every native speaker: A person wishing to write a sentence (**S**) has the option of using a **subject-verb-object** form asserting that some subject (**s**) did some activity (**verb, V**) to some object, **O**. (Note: English typically uses a **S-V-O** sequence, **subject-verb-object**, *Jacob blessed Pharaoh*; by contrast, the original Biblical Hebrew typically uses a **V-S-O** sequence, **verb-subject-object**, “*Blessed*” *Jacob Pharaoh*. This will not significantly affect our exposition).

- A similar analysis would apply to the rewriting that starts with the rightmost cell of the second row and terminates with the three rightmost cells of the last row. The heuristic here is that speakers have the option of writing a sentence by asserting that some subject (**s**) did some activity (**V**) following by an **indirect object** (which in this case indicates where the activity came from).
- Finally, at the last step, after a person decides on the appropriate sentence form - e.g. either a **subject-verb-object** sentence, or a **subject-verb-indirect-object** sentence or a **compound sentence** – the person would select appropriate *words*: thus the word *Jacob* would be selected for the **subject** and the words *blessed* and *went* for the **verbs**. The technical experts call the *words*, *terminal symbols*, since they terminate all rewriting activity and present the final sentence.

To recap: The formal process of phrased-structure grammars doesn’t really differ that much from what is informally taught in English grammar. The basic unit of thought is still the *sentence* (**S**). *Sentences* still consist of *words* (**Terminal symbols**). To get from the *sentence* to the actual *words* you would *rewrite* the sentence form using *rewriting rules* that allow you various sentence options such as compound sentences (**SS**), subject-verb-object (**sVO**) sentences etc. The process of going from the initial sentence symbol (**S**) to the final sentence of words is called a *derivation*. Each step of the *derivation* uses a *rewriting* rule. The *rewriting* rule simply tells you how to start with some form (**sentence, verb phrase** etc.) and convert it into smaller units. Interestingly, the *rewriting* rules in the phrased-structure grammar of the cantillations always have exactly two symbols on the right side of the rule. The use of formal symbols is particularly of interest to computer scientists since it enables them to talk to computers and tell them how to read and execute programs. However, we are only interested in cantillations; for our purposes, it is sufficient, as shown in Table 1, to think of a *derivation* as a repeated breaking down of a sentence into smaller units until we arrive at the terminal words.

#### 4. Cantillation Orthography

Our goal in this section is to use Table 1 that parses the sentence, Gen. 47:10, presented in Figure 1, in order to *cantillate* this sentence, that is, in order to give grammatical punctuations on each sentence word that indicate the degree of pausality or connectiveness of that word in the sentence. A close examination of figure 1, presenting the cantillation of verse Gen. 47:10, shows quarter circle markings below the Hebrew text on the top line. These quarter circle (and similar) markings are the cantillation symbols that guide a cantor in chanting the biblical verse. The actual symbols used in the cantillations are included in the Unicode character set, symbols **0591** through **05AF** in the Hebrew alphabet block (cf. [6, p 397]). However, the typical English reader, unfamiliar with biblical cantillation marks, would find it difficult to follow an exposition on these cantillations due to the requirement of learning a new set of symbols. Furthermore, unlike English, where punctuation marks are placed at the end or beginning of words (e.g. quotation marks) and on the same level of the word, in actual biblical texts, biblical cantillations can be placed above, below or at the same level of words and may be placed at the beginning, end or in-between words (*inpositive, prepositive, postpositive and interpositive*) [6, pg 397].

To remedy this problem we introduce a simplified but immediately understandable *special cantillation system*. We will use the informal approach we used in the previous sections, presenting an example and using that example as a vehicle for explaining the theory. The example – the cantillation of Gen. 47:10 from figure 1 using the *special cantillation system* – is exhibited in Figure 2 below.

To present the theory underlying this example we must first introduce the concept of *pausal strength*. By way of example, an English reader contrastively recognizes that a period indicates the completion of a sentence while a semi-colon indicates a stopping point within the sentence. In other words, the *pausal strength* of the period is greater than the *pausal strength* of the semi-colon. Similarly, the *pausal strength* of the semi-colon is greater than that of the comma. We could heuristically summarize this by saying that periods, semi-colons and commas have level 1,2 and 3 *pausal strengths* respectively. Similarly, an English reader recognizes a hyphen as indicating a *connective* punctuation function: Proper reading requires slightly pausing at each comma but connecting hyphenated words.

Jacob(C) blessed (L2t) Pharoh (L1); he-went-out (L2t) from-the-presence(C) of-Pharoh (L1t).

**Figure 2.** *The biblical cantillation of Gen. 47:10 (fig. 1) using the special cantillation system*

Using these concepts of pausal strength and connectivity we can explain the seven principles governing the cantillation of Gen. 47:10 using the parsing of this sentence exhibited in Table 1.

- The two main sub sentences exhibited on row 2 of Table 1 – *Jacob blessed Pharoh, He-went-out from Pharoh* – each receive an **L1** symbol after the final word of that sub sentence. Here **L1** indicates a *level 1* pausal strength. The “t” in **L1t** indicates that it is the terminal **L1** in the verse. The collection of words ending with the **L1** is conveniently called an *L1 unit*.
- If we have a sub sentence or sentence fragment ending with **L1** (or **L1t**) – for example *Jacob bless Pharoh* - then when that fragment is broken into two halves – for example, as shown on row 3 of Table 1, *Jacob blessed*, is the leftmost half, and *Pharoh* is the rightmost half - then the rightmost half retains the **L1** cantillation while the leftmost half is cantillated with **L2** (or **L2t** if it is the last **L2** in that **L1** unit).
- Similarly, the rightmost and leftmost halves of a parsed **L2** unit would receive an **L2** and **L3** (or **L3t**) respectively; the rightmost and leftmost halves of a parsed **L3** unit would receive an **L3** and **L4**.
- The only allowed levels of parsing are 1,2,3 and 4. If an **L4** unit is parsed then both halves receive an **L4**.
- Hyphenated words remain hyphenated (and don’t receive any extra punctuation marks)
- If a unit has only two words then the first word of that unit receives a connective cantillation that we indicate by a **C**. For example, *Jacob blessed (L2t)*, the first cell on row three of Table 1, is parsed into two halves with *Jacob* receiving a **C** cantillation and *blessed* retaining its **L2t** cantillation.
- The special cantillation symbols are placed after the last word of the unit they modify.

We close this section by presenting several further examples of cantillated verses. The reader who has grasped the principles presented above should be able to justify the parsing and cantillation involved. In certain cases minor modifications or exceptions to the rules occur:

- And-God (C) said (L2t) let-there-be-light (L1); and-there-was-light (L1t) (Gen. 1:4)
- The-Lord (L3t) visited (C) Sarah (L2t) as (C) he-had-said(L1);  
and-the-Lord (C) did (L3t) to-Sarah (L2t) as-he (C) had-promised (L1t) (Gen. 21:1)
- Now-there-arose (C)a-new-king(L2t) over-Egypt (L1) who (C) did-not-know (L2t) Joseph (L1t) (Ex. 1:8)
- The-Lord-called (L2t) Moses (L1); and-[God](C)spoke (L3t) to-Him (L2) from-the-tent (C) of-meeting (L2t) saying (L1t) (Lev. 1:1)
- Give-ear (C) O- heavens (L2t) and-I-will-speak (L1) ; and-let-the-earth (C) hear (L2t) the-words-of-my-mouth (L1t) (Deut. 32:1)

## 5. Music

Section 2 *presents* Gen. 47:10 of figure 1, Table 1 of section 3 *parses* this sentence using phrase-structured grammars, and Figure 2 of section 4 *cantillates* this sentence using the parsing presented in Table 1. In this final section we deal with the collections of *musical notes* associated with each

cantillation symbol. As indicated earlier in the paper, the cantor, using the cantillations and their associated notes, chants the biblical verses during synagogue services.

Melody is presented using **ABC** notation. **ABC** is a text-based musical notation that allows transcription of music without the traditional music clefs [1,7]. Some basic principles of **ABC** notation, sufficient for the purposes of this paper, are summarized in Table 2. During the presentation of this paper verses will be actually sung. For comparative purposes we also present below traditional musical notation.

A priori, the goal of the musical notes associated with each cantillation would be to indicate the degree of *pausal strength* or *connectiveness* of each cantillation unit. Some classical books on music theory are [5] and [9]. *Cadence* is the musical term indicating pausal strength. Cadential theory is poorly understood; a full theory of cadences remains an open problem. To emphasize this complexity we note that Blombach [3] who sought "to formulate a broad comprehensive definition of cadence containing the vital elements that distinguish cadence" which would "apply to any type of music, from the earliest to the most recent," [4], reviewed 81 definitions of cadence from pedagogical texts without coming to a definite conclusion.

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|--|
| <ul style="list-style-type: none"> <li>• Letters indicate notes e.g. C D E F G... a b c</li> <li>• Capital C indicates middle C</li> <li>• Octaves are indicated as follows C,D,E,F,...CDEF....cdef....c'd'e'</li> <li>• Sharps and flats are indicated by ^X and _X respectively</li> <li>• A header summarizes useful information such as:</li> <li>• <b>Q</b> (tempo), <b>L</b> (typical note length), <b>M</b> (meter),<b>K</b> (key signature), <b>C</b> (Composer), <b>T</b> (Title)</li> <li>• Rests are indicated by small <b>z</b></li> <li>• Lengthening and shortening of notes are indicated by e.g. X/2 X2, respectively</li> <li>• Bars are indicated by vertical lines</li> </ul> |
|--|

**Table 2.** Some basic principles of **ABC** notation (taken from [1])

Over and above the problem of defining cadential intensity, there are cantillation-specific problems further complicating the issue. First, unlike the text of the Bible which is basically agreed on [6, Part 4, pg. 360], there is no consensus on the musical notes associated with each cantillation. For example [6, p 15] brings disparate musical traditions from seven countries, Lithuania, Germany, Iraq, Dutch,... on the melody associated with one cantillation. A second complication is the propriety of applying the theory of cadence as formulated by Rameau to a collection of musical traditions that existed 1000 years beforehand and developed outside of the European tradition. A third complication arises from the fact that musical rests are a strong indicator of cadences. However, cantillation traditions do not give entire scores of notes but rather collections of notes associated with each cantillation; it is the cantor who weaves these cantillations together. Hence, rests are not attributes of the musical notes comprising each cantillation. In fact Jacobson lists "improper rest lengths" as a typical error in cantorial chantings [6, pp. 430-432]. Jacobson [6, p. 523] also notes that improvisation is an integral part of an experienced cantor's reading.

Therefore, in this paper, we suffice with a review of the more frequent cantillations and their cadential characteristics. Jacobson [6, p 412] based on Price's work [8] points out that five pausal cantillations cover 80% of the biblical cantillation occurrences. These cantillations, their **ABC** notation and musical notes, are presented in Table 3 and figure 3. Table 3 presents three groups of four cantillations. Each 4 bars of notes correspond respectively to the musical notations of the four cantillations in each group.

Table 3 and Figure 3 exhibit the following note sequences typical of cadences:

- **L1t**: L1t ends on a dominant-tonic, **GC**, a standard indicator of a permanent (authentic) cadence.
- **L1,L2**: L1 and L2 end on a **GD**, a jump motion to a note of the dominant chord.
- **L2t**: L2t ends on **DED**, a stepwise motion to a note of the dominant chord.
- **L3t**: L3t ends on a tonic chord **CGE2** but not on the tonic note.

Similar comments can be made on the following German tradition of notes for the cantillations listed in Table 3: **G, | C C G | E E E | D E C | z2 C | E E E | D C C | C C C | G2 z | z2 C | E E E | D C C | D C2 | z3 |**

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T: 5 most frequent Pausal Cantillations
N: The 5 most frequent cantillations are: L1, L1t, L2t, L2, L3t
Z: Russell Jay Hendel
C: Jacobson [6, pp. 634 - 635]
S: Jacobson [6, pp. 634 - 635]
M: 3/4
L: 1/4
K: Cmaj
% Music for cantillations C L3t C L2
G| G C C | GE2 | EEE | G D2 | z3
% Music for cantillations C L2t C L1
B, DB, | DED | DCA, | G, D2 | z3
% Music for cantillations C L2t C L1t
B, DB, | DED | DDB, | G, C2 | z3

```

Table 3. The 5 most frequent pausal cantillations and their ABC musical notation.

### 5 most frequent Pausal Cantillations

Jacobson [6, pp. 634 – 635]

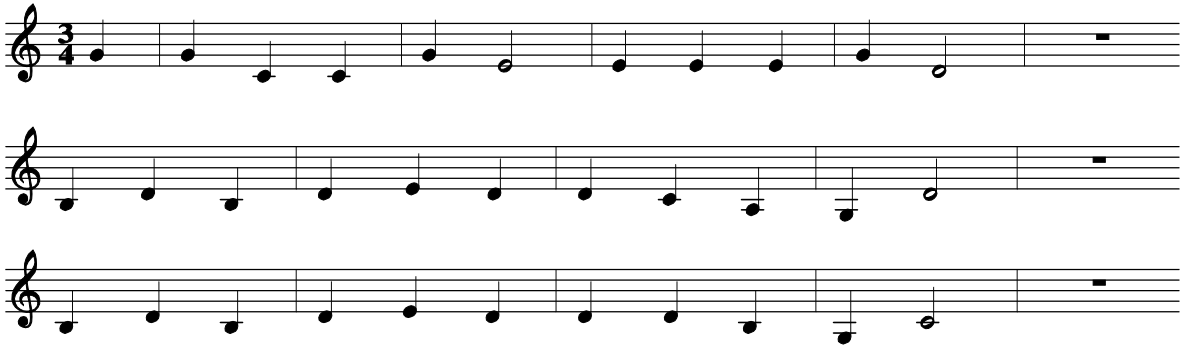


Figure 3: Traditional music notation for the cantillations presented in Table 3.

Thus the interaction between cantillation pausal strength and the rules governing musical cadences is a possible direction for future research.

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