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Three-Dimensional Crossword Puzzles in Hebrew*

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Whether or not three-dimensional crossword puzzles can be constructed depends to a large extent on the informational structure of a language. This shall be shown here on a sample.[1]

The conditions for three-dimensional crossword puzzles differ from the generally known square type only in one point: The letters of the words of every layer of the block must also make sense when they are read into the depth of the block; that is, all letter combinations can be read as words in the three directions of the cube.

Here we shall assume that all words of the cube puzzle shall be different, otherwise words of the patterns AAA or $ABA + BAB$ or $AAB + BBA$ could fill up any square or cube with three places per word. Moreover we shall assume that no empty places exist within the cube; so we may say that $2n$ words will be necessary for the square, or $3n^2$ words for the cube, each side of which has n places (or letters). In three-dimensional crossword puzzles with three places per word we consequently need 27 words.

A survey of the possibilities for constructing such puzzles will be obtained by the application of information theory (Moles, 1958; Shannon, 1948):[2] The information content of a symbol i varies inversely with the frequency of its appearance p_i; a suitable measure for its information value is its dyadic logarithm. Consequently the information content of a symbol i is $-\mathrm{ld}\ p_i$; the information entropy of all N symbols will then equal $\sum p_i \mathrm{ld}\ p_i$; its maximum $H_{\max}$ is ld N, if all symbols have the same frequency (Fucks, 1955). The average information entropy may

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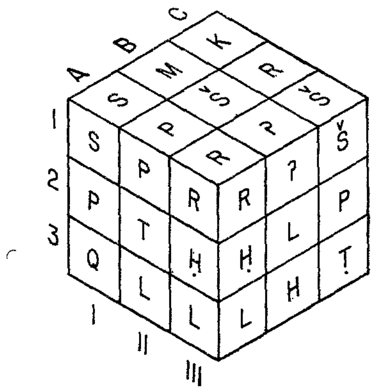
[1] The words are taken from biblical sources only.

[2] The phonological structure of Hebrew and Semitic has been dealt with by Harris (1941), Cantineau (1950), and Greenberg (1950). In this note only the informational approach is considered.



Block of crossword puzzles

A

	I	II	III
1	S	P	R
2	P	T	Ḥ
3	Q	L	L

B

	I	II	III
1	M	Š	ʔ
2	Ṭ	L	L
3	R	B	H

C

	I	II	III
1	K	R	Š
2	R	ʕ	P
3	ʕ	B	Ṭ

I

	A	B	C
1	S	M	K
2	P	Ṭ	R
3	Q	R	ʕ

II

	A	B	C
1	P	Š	R
2	T	L	ʕ
3	L	B	B

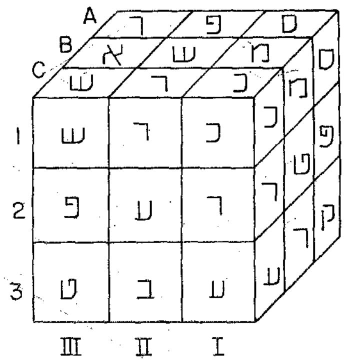
III

	A	B	C
1	R	ʔ	Š
2	Ḥ	L	P
3	L	H	Ṭ

The different layers of the block

FIG. 1

be regarded as a suitable measure which indicates the probability that there exist in a language the necessary words for a crossword puzzle. The information entropy of the three-letter words is not calculated for texts, as has been done before by Shannon (1951) and others, but for



Across

A (1) sēpher (book)
(2) petaḥ (gate)
(3) qālāl (smooth)

B (1) mašā' (pledge)
ṭālal (he covered with rafters)
rābāh (he increased)

C (1) k'rēś (belly)
(2) rāçaph (it dropped)
(3) çābhaṭ (he borrowed)

I (1) sāmakh (he supported)
(2) peṭer (first-born)
(3) qeraç (rag)

II (1) pēšer (explanation)
(2) tālaç (he was clothed in crimson)
(3) lēbhābh (heart)

III (1) rō'š (head)
ḥēleph (exchange)
lahaṭ (flame)

Down

A (I) sēpheq (abundance)
(II) pātal (he twisted)
(III) rāḥēl (ewe)

B (I) māṭār (rain)
(II) šālābh (joint-ledge)
(III) 'ālāh (oath)

C (I) kārāç (leg)
(II) rāçābh (hunger)
(III) šepheṭ (judgment)

FIG. 2

the dictionary, and only the transition probabilities of first to second and second to third letter have been used (Zwirner, 1936).

In order to compare the entropy $H_{\text{Hebrew}} = 3.73$ (bt/symbol) with $H_{\text{English}} = 0.83$ (bt/symbol) we introduce the relative information entropy $h = (H/H_{\max})$ (bt/binary element); then $h_{\text{Hebrew}} = 0.84$ and $h_{\text{English}} = 0.18$. In other words, the probability of finding the right words for crossword puzzles in Hebrew is about 4.7 times better than in English, while other Indo-European languages will come off still worse in comparison because most of them do not have even half as many three-letter words as English. The entropy H of Hebrew is so favorable that puzzles beyond the three dimensions could be realized; this is pointed out by the fact that some diagonals of the three-dimensional crossword puzzle, which serve as an illustration, provide meaningful words, such as PaḤ (snare), LaḤ (fresh), MiLāH (word), ŠaL (fault), BaL (not), RaBh (much), RaPh (he shook) etc. (see Fig. 1).

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