

LARGER LETTER TREES

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In *Word Ways* 2005-103ff., Eric Iverson presented some 4-letter trees, and some trees with 5-letter words. As invited by the editor, I take up the search from there. Throughout, I assume that all words in a tree must be different. The reader should sympathise if there are any errors, for tracing a vast number of almost identical words through many trees is even worse than proof-reading word ladders, and repeatedly reminded me of the famous motif from *Zork*: “You are in a maze of twisty little passages, all alike”.

There is a possible confusion when counting because each tree can be displayed in two ways: from left-to-right or vice-versa. Where not explicitly stated, assume that each tree is counted twice. The word that runs down the left-hand side of a tree I call a “lead word”, eg *SPICY* in the first diagram below. In general, a tree of n -letter words needs $2^{(n-1)}$ words woven from $n(n+1)/2$ letters. Letter trees need clusters of almost identical words.

5-LETTER TREES

These require 15 letters in a tree to spell out 16 words. Using a relatively modest vocabulary, I found 254 million trees (127 million each from two directions) as far as the one with a lead word of *BELAM*: each word in the vocabulary gives on average about 17,000 trees (double that if counting right-to-left as well). I therefore looked for constraints to reduce the numbers. Restricting the trees to headwords from the OED still gave almost one million trees (x2) from *BACUN* to *WRENK* — about 43 trees per word in the vocabulary. Restricting further to heterogrammatic words gave about 138,000 trees (x2), from *BLAIN* to *WRAST* — about 17 trees per vocabulary word. Applying the further restriction that no letter in the tree must be repeated, reduced the number of trees again to 223 (x2), from *CHALD* to *SWING*. None of the 15-letter sets in these trees would make a word, which is unsurprising as there are only 223 trees and the percentage of 15-letter words that are heterogrammatic is only around 0.01. Our 223 trees have no letter repeated (so all words are perforce heterogrammatic), and all words are OED headwords. The most common set of letters forming a tree is *ACDEHIKLNOPRSTY*. Thirty-two trees (16 x 2) can be formed from these letters. As mentioned above, each tree can be made from left to right or vice-versa by reading forwards or backwards along the following lines:

SHICK, SHICE, SHINE, SHIND, SHONE, SHOND, SHOLD, SHOLT, SPONE, SPOND, SPOLD, SPOLT, SPALD, SPALT, SPART, SPARY

SHINY, SHIND, SHILD, SHILT, SHOLD, SHOLT, SHORT, SHORE, SPOLD, SPOLT, SPORT, SPORE, SPART, SPARE, SPACE, SPACK
SHOLT, SHOLD, SHOND, SHONE, SHIND, SHINE, SHICE, SHICK, SPIND, SPINE, SPICE, SPICK, SPACE, SPACK, SPARK, SPARY
SPACY, SPACK, SPANK, SPANE, SPONK, SPONE, SPORE, SPORT, SHONK, SHONE, SHORE, SHORT, SHIRE, SHIRT, SHILT, SHILD

SPACY, SPACK, SPARK, SPARE, SPIRK, SPIRE, SPINE, SPIND, SHIRK, SHIRE, SHINE, SHIND, SHONE, SHOND, SHOLD, SHOLT
SPART, SPARK, SPACK, SPACE, SPICK, SPICE, SPINE, SPIND, SHICK, SHICE, SHINE, SHIND, SHONE, SHOND, SHOLD, SHOLY
SPICA, SPICK, SPIRK, SPIRT, SPERK, SPERT, SPENT, SPEND, SHERK, SHERT, SHENT, SHEND, SHONT, SHOND, SHOLD, SHOLY
SPICY, SPICK, SPINK, SPIND, SPONK, SPOND, SPOLD, SPOLT, SHONK, SHOND, SHOLD, SHOLT, SHELD, SHELТ, SHEAT, SHEAR

SPICY, SPICK, SPINK, SPINE, SPANK, SPANE, SPARE, SPART, SHANK, SHANE, SHARE, SHART, SHORE, SHORT, SHOLT, SHOLD

SPICY, SPICK, SPINK, SPINE, SPONK, SPONE, SPOLE, SPOLT, SHONK, SHONE, SHOLE, SHOLT, SHALE, SHALT, SHART, SHARD

SPICY, SPICK, SPIRK, SPIRE, SPARK, SPARE, SPALE, SPALT, SHARK, SHARE, SHALE, SHALT, SHOLE, SHOLT, SHONT, SHOND

SPICY, SPICK, SPIRK, SPIRT, SPARK, SPART, SPALT, SPALE, SHARK, SHART, SHALT, SHALE, SHOLT, SHOLE, SHONE, SHOND

SPICY, SPICK, SPIRK, SPIRT, SPERK, SPERT, SPELT, SPELD, SHERK, SHERT, SHELT, SHELD, SHOLT, SHOLD, SHOND, SHONA

SPICY, SPICK, SPIRK, SPIRT, SPERK, SPERT, SPENT, SPEND, SHERK, SHERT, SHENT, SHEND, SHONT, SHOND, SHOAL

SPICY, SPICK, SPIRK, SPIRT, SPERK, SPERT, SPENT, SPEND, SHERK, SHERT, SHENT, SHEND, SHONT, SHOND, SHOLA

SPIRY, SPIRK, SPINK, SPIND, SPONK, SPOND, SPOLD, SPOLT, SHONK, SHOND, SHOLD, SHOLT, SHELD, SHELT, SHEAT, SHEAC

One of the SPICY trees:

```

          S
        P   H
      I   O   A
    C   N   L   R
  Y   K   E   T   D
  
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and the SHINY tree:

```

          S
        H   P
      I   O   A
    N   L   R   C
  Y   D   T   E   K
  
```

Returning to trees made from OED headwords, but not constrained to be heterogrammatic, the most common lead words are SHOOP, SHOOF, SHOOD, and SHOON, each appearing in over 4,000 trees. There are no fewer than 154 trees using the letters AADEEEEIKLLNPRST, of which a few examples are:

SPANK, SPANE, SPALE, SPALL, SPILE, SPILL, SPIEL, SPIED, STILE, STILL, STIEL, STIED, STEEL, STEED, STEAD, STEAR

SPANK, SPANE, SPALE, SPALL, SPILE, SPILL, SPIEL, SPIER, STILE, STILL, STIEL, STIER, STEEL, STEER, STEAR, STEAD

SPARE, SPARK, SPANK, SPANE, SPINK, SPINE, SPILE, SPILL, STINK, STINE, STILE, STILL, STELE, STELL, STEAL, STEAD

SPARK, SPARE, SPALE, SPALL, SPILE, SPILL, SPIEL, SPIED, STILE, STILL, STIEL, STIED, STEEL, STEED, STEAD, STEAN

The third line gives this tree:

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          S
        P   T
      A   I   E
    R   N   L   A
  E   K   E   L   D
  
```

6-LETTER TREES

These require 21 letters in a tree to spell out 32 words. The vocabulary that yielded billions of 5-letter trees gave about 450,000 6-letter trees, with 3,589 different "lead words", starting at BAGNOS and ending at WINNOW. So, on average, each lead word starts 125 trees; and roughly one in every 50 words may start a tree, which is approaching a million times less productive than 5-letter words. The most popular lead words are: SPINNA, SPINNE, SPINNS, and SPINN'D, each starting between 2,000 and 3,000 trees.

There are just two trees with the largest number of headwords (approx. 24) from major dictionaries. They have lead words of PASSIM and PASSIO:

```

          P
        A   E
      S   R   N
    S   T   S   C
  I   E   I   E   I
M/O   R   S   E   L   F

```

The 32 words are:

PASSIM/O	PASSIR	PASSER	PASSES	PASTER	PASTES	PASTIS	PASTIE
	PARTER	PARTES	PARTIS	PARTIE	PARSIS	PARSIE	PARSEE
	PARSEL	PERTER	PERTES	PERTIS	PERTIE	PERSIS	PERSIE
	PERSEE	PERSEL	PENSIS	PENSIE	PENSEE	PENSEL	PENCEE
	PENCEL	PENCIL	PENCIF				

All words are main entries in the OED (PATTES, PARTES, PARSIS, PERSES and PERTES being plurals) except: PASSIO (hysterica passio), PERTIN (message 1290q), PERTEE (name, US Census), PERSIS (Achæmenian 1885q), PENSES (pense 1588q), PENSIS (OED pensy, or US Census), PENSIE (pensy 1806q), PENNIE (penny), PENNAE (coat 14 1585q).

Here is one of the 46 (2 x 23) examples with just one fewer headword. They all begin with P.

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          P
        E   A
      N   R   S
    T   S   T   S
  O   E   I   E   U
N   L   S   E   S   M

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Not obviously headwords in the OED: PENTOL (Web2), PENSES (penny 2 - old plural), PENSIS (see under pensy, also US Census), PENSIE (pensy quotes), PERSIS (Web2), PERTEE (US census), PARTIS (quotes under part), PASSEE (passé), PASSUM (pass).

Plurals of OED headwords: PERTIS, PERSES, PERTES, PARSES, PARSIS, PARTIS, PARTES

The 32 words are:

PENTON	PENTOL	PENTEL	PENTES	PENSEL	PENSES	PENSIS	PENSIE
PERSEL	PERSES	PERSIS	PERSIE	PERTIS	PERTIE	PERTEE	PERTES
PARSEL	PARSES	PARSIS	PARSIE	PARTIS	PARTIE	PARTEE	PARTES
PASTIS	PASTIE	PASTEE	PASTES	PASSEE	PASSES	PASSUS	PASSUM

If we try to make all the letters in the tree different (not possible with a 26-letter alphabet!), the closest we can get is 17 different letters. There are 16 such trees (32 if counting double), mostly beginning with C, but a few with S. Looking for quality among these 16 trees yields just one with as many as 14 headwords from major dictionaries.

The 17 different letters are: ACDEGHIKLNORSTUWY

S
H T
O A I
W U R N
E L E K C
Y L D S E G

Not obviously headwords in the OED: SHOWEY (flory 1782q), SHOWLD (retreating 1659q), SHOUED (shove A3 1529q), SHOUES (shove 4d 1629q), SHAUED (shave 3b 1412q), SHAUES (= shaves, planet-stricken 1615q), STAULD (stall 3 1555q), STAUUED (stave 1b 1615q), STAUUES (stave 1a 1398q), STARKE (a form of stark), STIRED (past pple of stire), STIRKE (a form of stirk), STINKE (a form of stink), STINCE (stink 1 725q), STINCG (a form of sting).

Plurals of OED headwords: STARKS, STIRES, STIRKS.

The 32 words are:

SHOWEY	SHOWEL	SHOWLL	SHOWLD	SHOULL	SHOULD	SHOUED	SHOUES
SHAULL	SHAULD	SHAUED	SHAUES	SHARED	SHARES	SHARKS	SHARKE
STAULL	STAULD	STAUUED	STAUUES	STARED	STARES	STARKS	STARKE
STIRED	STIRES	STIRKS	STIRKE	STINKS	STINKE	STINCE	STINCG

At the other extreme, the trees having fewest different letters have just seven different. There are 192 (384 counting both directions), all with lead words beginning PAR. The seven letters are AEIPRST. The one with most headwords has 12:

P
A E
R T R
I R T S
T A I E A
I E S E R E

Not obviously headwords in the OED: PARITI (a genus of tree, Web2), PARITE (parité, under parity), PARIAE (Myioborus pariae wisconsinensis, ITIS animal), PARRAE (Clepticus parrae bilinulatus, ITIS animal), PARRAS (membrillo 1947q), PARRIS (personal name, hongji 1862 or US Census), PARRIE (= parry, counter 1864q), PATRAE (Patræ, place in Greece, coalescence 2 1846q), PATRAS (Greek place and wine, Samos 1865q), PATRIS ("in nomine patris..."), PATTIS (pat 1 1400q), PATTIE (pattée 1572q), PETRAE (salpatre, "sal petræ"), PETRAS (= stones, load 2b 1409q, or US Census), PETRIS (partridge), PETRIE (pétrie), PETTIS (= peats, fother 1 1490q), PETTIE (a form of petty), PETTEE (gentleman 3a 14..q), PERTEE (US census), PERTER (comparative of pert), PERSEE (form of Parsee), PERSER (form of piercer), PERSAE (Persians, Web2).

Plurals of OED headwords: PARIAS (paria is a form of pariah), PERTIS.

The 32 words are:

PARITI	PARITE	PARIAE	PARIAS	PARRAE	PARRAS	PARRIS	PARRIE
PATRAE	PATRAS	PATRIS	PATRIE	PATTIS	PATTIE	PATTEE	PATTER
PETRAE	PETRAS	PETRIS	PETRIE	PETTIS	PETTIE	PETTEE	PETTER
PERTIS	PERTIE	PERTEE	PERTER	PERSEE	PERSER	PERSAR	PERSAE

PARTIAL 7-LETTER TREES

These require 28 letters in a tree to spell out 64 words. For these, I used a large vocabulary, including place names: large enough to contain a number of 11-squares. My search failed at the 37th word out of the 64 needed, as illustrated below (the smaller vocabulary failed at letter 23). 36 words out of 64 may not seem impressive, but 23 letters out of 28 may seem slightly better (82% compared to 58%!). Because I failed to complete a tree, trees cannot be counted from either direction, so all numbers in this section count each tree just once. I found 1,496 7-letter trees, with just 44 different lead words, each appearing 34 times. The best of the trees (ie those with most headwords from major dictionaries) have just one such word out of the 36, the rest being overwhelmingly place names: there are 306 such trees. Discarding those with many phrases leaves just 186, and one of these is illustrated below.

The 1,496 trees constitute just one per 451 words of vocabulary — but there is only 1 lead word per 15,000 vocabulary words, and all lead words fall in the range CHACOLE to CHARITY.

Note the central vertical “word” — CIOA (Centro de Investigaciones Otoaudiológicas). All 1,496 partial 7-letter trees have this word. Five- and six-letter trees both have 3-letter central words.

					C							
				A	H	A						
					I	I	?					
			C		M	T		?				
		O		A		O	A		?			
	R		N		R	T	G			?		
I		A		I		A	O	A			?	

Chacori, Bolivia, -19°32, -65°17
chacona (Web2)

Chacana, Bolivia, -16°53, -68°28

Chacari, Bolivia, -18°47, -68°46

Chamana, Peru, -12°04, -76°32

Chamari, India, 26°01, 79°34

Chamo-ri, North Korea, 39°23, 125°48

Chamota, Zambia, -14°12, 31°31

Chimana, Angola, -12°48, 14°19

Chimari (River), Guyana, 5°14, -58°07

Chimori, Bolivia, -18°53, -64°49

(Cano Manantial de) Chimora, Colombia, 9°57, -73°17

Chimota, Zambia, -14°12, 31°31

Chitori, Pakistan, 25°58, 68°29

Chitota, Colombia, 7°09, -73°06

Chitata, Angola, -13°45, 15°43

Chitago, Kenya, , S, -0°52, 34°52

Caimana, Angola, -14°26, 21°45

Caimari, Spain, 39°46, 2°54

(Parcelamiento La) Caimara, Venezuela, 9°21, -71°01

(La) Chacora, Honduras, 13°14, -87°04
Byrsopteryx **chaconi** nigrieventris (ITIS
animals)

Chacani, Mozambique, -22°18, 32°37

Chacara, Brazil, -21°41, -43°13

Chamani, Iran, 30°03, 52°39

chamara (OED chamberlain)

(Barranco de la) Chamora, Spain, 41°16, 1°13

Chamoto, Zambia, -14°20, 31°53

(Quebrada) Chimani, Peru, -10°41, -74°55

Chimara, Albania, 40°06, 19°44

Chimoto, Zambia, -15°02, 27°06

Chitora, India, 26°38, 75°42

(Rio) Chitoto, Mozambique, -22°37, 33°04

Chitato, Angola, -7°21, 20°49

Chitaga, Colombia, 7°09, -72°40

(Rio) Caimani, Bolivia, -20°07, -66°03

Place names are from the NIMA database. ITIS is the Integrated Taxonomic Information System of the USDA (Dept. of Agriculture).