NESTED WORD SQUARES

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In the May 1983 Word Ways, Helen Motamen describes a word puzzle contest she won in which the object was to construct a five-by-five letter array containing a maximum number of three-letter, four-letter and five-letter words across and down. By placing further requirements on this contest, one can convert it into an interesting logological problem: the construction of a five-by-five word square in which are nested four four-by-four and nine three-by-three word squares. In fact, there are a whole host of problems to consider. The five-by-five word square may be either single (the five different horizontal words are duplicated vertically) or double (there are five different horizontal words, and five different vertical words, ten words in all). If the five-by-five square is single, the embedded squares on the diagonal are also, but the nested squares located above or below the diagonal may be double or defective (contain two identical words in a row). If the five-by-five square is double, there are many possibilities for the thirteen nested squares: each one may be single, double, defective (contains two identical words in a row, or in a column) or hybrid (one or more, but not all, horizontal words match vertical words). The ideal solution — naturally, the hardest one to achieve — is to have a double five-by-five word square containing thirteen nested double squares, each one different.

D A M A N

The prize-winning Motamen array, given at the A N A N A right, does not qualify as a five-by-five word square M A L A R because it contains the repeated word ANANA. Her A N A N A hand search of Webster’s Third Unabridged (the con-N A R A S test dictionary) uncovered fewer than 600 fully-nested five-letter words (ones containing all four-letter and three-letter words, such as SPARK: SPAR, PARK, SPA, PAR, ARK), and she was unable to construct a legitimate word square from this stockpile. In view of the experimental support value of 455 calculated in "How Many Words Support a Square" in the May 1992 Word Ways, it appears that she was somewhat unlucky.

Or, it is entirely possible that her stockpile did contain a legitimate five-by-five square, but, working by hand, she failed to discover it.

If one enlarges the stockpile, the problem becomes easy, at least for the single five-by-five word square. We used a database of 15,719 five-letter words, containing all the Webster’s Second words in the Air Force Dictionary, all the words in the Official Scrabble Pl plus some from the official test dictionary. Testing then we found 1,562 words, sufficient that the would be enough to convert the contest into a completely different word. A single word, a potential prize-winning Motamen array, is given at the A N A N A right. The word ANANA, characteristic of the word in second through the 147th listed below, is not present in the dictionary.

The first five arrays, given at the A N A N A right, are double word squares, each one containing 13 nested squares: each one may be single, double, defective or hybrid (contains two identical words in a row, or in a column) or hybrid (one or more, but not all, horizontal words match vertical words).

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Scrabble Players Dictionary (1978), and Chambers Words (1985), plus some from the Oxford English Dictionary and Webster's Third. Testing them against 8,072 four-letter and 1,707 three-letter words, we found 1,244 of them to be fully nested. From these, the computer constructed 12,696 single five-by-five and 5,932 double ones. Interestingly, the support calculated from this data suggests that 188 randomly-chosen words from the 1,244-word stockpile ought to be enough to construct, on the average, a single five-by-five square; the corresponding support for a double square is 522. Fully-nested words are peculiarly amenable to square construction, making Motamen's failure to find one even more inexplicable.

A single word square with all nested squares single is, of necessity, a progressive word square (one in which each word in turn discards the first letter of the preceding word and adds a new letter at the end). Progressive word squares can be succinctly characterized by a sequence of nine letters: the five letters of the word in the top row, followed by the terminal letters of the second through fifth words. This is the basis for the summary of the 147 single word squares with all nested single squares, listed below. In each letter array, every sequence of nine letters represents a square. Read the array from left to right; when additional rows are encountered, one may follow either one (thus, BRASEREST, BRASHER and BRASHERET are all word squares). Any of the parenthesized letters or letter-groups may be appended to the start of a sequence (thus, BASHEREST and TRASHERES are both squares). The numerical indicator 37(13) says that there are 37 squares in the corresponding array, and the longest sequence of letters in the array is 13. Certain arrays intersect. The first five arrays share the word square HETHERET; the first four arrays also share the squares SHEHERES and ASHEHERES; the first two arrays also share the word square BASHETERES; the sixth and seventh arrays share AREASERES. Collectively, these word squares form four directed networks with no internal loops; the main network consists of all arrays but the final three. For details on directed networks, see "A Word String Network" in May 1991, and the three-part "Directed Word Chain Networks" in May and August 1991.

(B,C,D,F,G,L,M,P,TR,W)ASHEREST 37(13)
ST
(B,C,S)ABASERER 30(14)
HEDER
THERERST
RD
EST
K
BLASEREST
HEDER
REST
THERERST
What about nested squares in a double word square? The 5,932 double squares contain a wide variety of nested squares within them: single, double, hybrid, defective. None of the double five-by-five squares contains nine double three-by-three squares, but there are probably several hundred with eight double three-by-three squares, with the ninth either single or hybrid. It is hard to count how many there are because the fault can occur in many different places; however, by choosing to accept defects in this or that place and putting appropriate instructions into the computer program, one can find squares like the ones illustrated below. In the first two pairs, the hybrid three-by-three is part of a hybrid four-by-four; in the last square, there is one single three-by-three in addition to eight doubles, and the four-by-four squares are all double ones.

What are the prospects for extending this study to nested six-by-six word squares? It seems unlikely that any can be found within the Oxford English letter word set that is need.
within the confines of Webster's Second, Webster's Third and the Oxford English Dictionary. If one tests the 1244 fully-nested five-letter words for overlapping crashes (that is, form letter-sequence ABCDEF from fully-nested words ABCDE and BCDEF) and determines which of these are in fact six-letter words, one finds 230 of them, listed below. These form the raw material for a six-by-six nested square, but, judging from the support statistics calculated for five-by-five nested squares, it is clear that a considerably larger set is needed.

abaser brathe croose graped mother rooses souses tether
abashe bushe dashed grapes mouses rowers sowers thawed
agates cagers dashed grapes mowers sagest spales thawer
agenes carene dashes greese musers scales spanes themes
amates careere earest grapen nather scaped spared theres
amides carest eather gropes neared scaper sparer thouse
amused cashed eraser groups nevels scapes spares totems
amuser casher fashed grouts nooses scared spates spiers
amuses cashes fasher hairred paired scarer staker traped
ananas catell fashes hewers palays scares stakes trapes
areare chaine father hounes papern seared stales urease
areas chaisers ferest laches parent seathhe stapes vowers
asethe chaires flaked lamenti pashed sereset stared wagers
atokes chapes flaker lashed pashed sethen starer warent
aweiels shared flakees lasher peares severs staires warest
baches chares flamen lashes please shales strade washed
barest chaved flamer lather powers shapes stramp washer
bashed chawer flanes leared prosed shared strays washes
basher chides flemes leares proses shares swaged wareed
bashes chorses ferest leaser parent shawed swager wethen
bather choses gagiers levels raches sheder swages wether
blasty chouse galays leweset ragers shewel taches whares
booses chouts gamene looses rasher shewer tavers wheels
bother cleare garest loweres rashes shores taverse wherees
bowers clears gashed mashed rather shouts teared wholes
braked cleath gasher masher reared shower teasser whoops
braker copens gashes mashes releys shules teache whores
brakes cowers godsos merest revere skates tepees wother
brasen croons gooses mether revert soreest