REVERSIBLE SEVEN-SQUARES

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A reversible word square is one in which every row can be read backwards, and every column upwards — see especially the examples in the second section below. Every word must be either a reversible word such as REVILER (RELIVER in reverse) or a palindrome, which is a special kind of reversible word. In this article, the term *reversible word* does not include palindromes. In general, counts include valid rotations and reflections.

Squares from large dictionaries
Selecting words from large dictionaries (plus the Palindromicon) gave 63639 7-letter words, which included 54 reversible words and 228 palindromic words. Sadly, these yielded no squares with all rows different. Allowing row 1 to be the same as row 7, row 2 to be the same as row 6, and row 3 to equal row 5 yielded 1198 squares, over 90% of which consisted entirely of palindromes, and over 90% of which had four different words. No square had more than four reversible words. Seventy-eight squares had five different words, and there were no other number of different words. So words taken from large dictionaries cannot make squares with only reverse words, and cannot make a square with all words different.

Consider the great majority of squares made entirely of palindromes. Construct an example with the maximum number of different letters:

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A B C D C B A
B E F G F E B
C F H I H F C
D G I J I G D
C F H I H F C
B E F G F E B
A B C D C B A     all diagonals are AEHJHEA
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The constraints of palindromes and word squares mean only 10 different letters and 4 different words may be used, and all diagonals are the same palindromic string.

Concentrating on the 78 with five different words, note that they cannot consist entirely of palindromes, for that would require four different words. Not one has a word for any diagonal. Here is a selection:

M A R G R A M	precursor of marjoram		M A R G R A M	*vide supra*
A R E N E R A	(Quebrada La) Arenera*		A T E L E T A	41°51, 14°12, Italy
R E L I V E R	*or* REVILER		R E D E M E R	
G N I D I N G	Pal *or* GNIPING Pal		G L E N E L G	Scotland
R E V I L E R	*or* REVIVER		R E M E D E R	
A R E N E R A	*vide supra*		A T E L E T A	*vide supra*
M A R G R A M	*vide supra*		M A R G R A M	*vide supra*

* Colombia, 2°49, -76°31

M A R G R A M	vide supra		S E R E R E S	Pal
A T E L E T A	vide supra		E G E D E G E	Pal
R E G E N E R			R E L I V E R	or REVILER
G L E N E L G	vide supra		E D I F I D E	edify 2, 1591q
R E N E G E R	Web2		R E V I L E R	or REVIVER
A T E L E T A	vide supra		E G E D E G E	vide supra
M A R G R A M	vide supra		S E R E R E S	vide supra

Squares from unrestricted vocabulary, all rows different, no palindromes, and two diagonals
If, in an attempt to find better squares (eg without palindromes), we loosen the constraints on vocabulary, we find 4486 reversible words and 878 palindromes, which make a huge number of reversible squares — over 14 million alone with every row different. Half a million of these have no palindromes, but none are all-palindromic. Selecting from the half million just those with valid words for one or more diagonals, we find 246 with one diagonal, 12 with two diagonals, and none with all 3 diagonals (recall the NE-SW diagonal in any word square is palindromic, so counts as one). Sadly, the 12 with two diagonals all have the same word (AAAAAAA) for both. In each case below, the reversed square is on the right.

A K A K A L I	(Zangon) Akakali, Niger	I L A K A K A	-22°45, 45°20, Madagascar
K A R A L A K	25°47, 61°11, Iran	K A L A R A K	Kalarak (Kaur), Pakistan
A R A R A P O	(Estancia) A..., Paraguay	O P A R A R A	Oparara (Arch), NZ
K A R A G A T	(Verin-)Karagat, Azerbaijan	T A G A R A K	(Sungai) Tagarak, Malaysia
A L A G A D A	Alagada (Station), Nigeria	A D A G A L A	(Bir) Adagala, Chad
L A P A D A N	(Sal-)Lapadan, Philippines	N A D A P A L	4°26, 34°16, Kenya
I K O T A N A	Ikot Ana, Nigeria	A N A T O K I	Range, -40.94°, 172.68°, NZ

A K E S A K E	Ake Sake, Indonesia	E K A S E K A	4°52, 9°48, Cameroon*
K A L A M A K	49°36, 34°40, Ukraine	K A M A L A K	(Mogila) K..., Kazakhstan
E L A M I N A	El Amina, Morocco	A N I M A L E	mete, 1460q
S A M A R A T	25°41, 56°08, UAE	T A R A M A S	Greek, hence taramosalata
A M I R A W A	35°54, 47°17, Iran	A W A R I M A	-43.96°, 170.88°, NZ
K A N A W A R	Kanawa (Rapids), Guyana	R A W A N A K	38°10, 70°30, Afghanistan
E K A T A R A	madal, 1960q	A R A T A K E	Ara-take, Japan
		* Reserve Forestière d'Ekaseka	

A L A K A N I	8°14, 8°13, Nigeria	I N A K A L A	Ina Kala, Solomon Islands
L A W A N A T	Madaka L..., Cameroon	T A N A W A L	34°23, 72°54, Pakistan
A W A R I M A	-43.96°, 170.88°, NZ	A M I R A W A	35°54, 47°17, Iran
K A R A M A N	Karaman (Golu), Turkey	N A M A R A K	35°53, 51°04, Iran
A N I M A N A	-25°59, -65°58, Argentina	A N A M I N A	(Ponta) A..., Guinea-Bissau
N A M A N A M	N... Kulam, Sri Lanka	M A N A M A N	Manaman (Koue), Congo
I T A N A M A	-5°29, -79°22, Peru	A M A N A T I	-19°17, -62°26, Bolivia

A M A B A L A	(Mro) A..., Comoros,	A L A B A M A	"Heart of Dixie"
M A K A R U P	-4°19, 144°47, Papua N G	P U R A K A M	(Khao) Purakam, Thailand
A K A R A M A	15°52, 5°53, Niger	A M A R A K A	(Mont) Amaraka, Algeria
B A R A K I N	14°26, 30°10, Sudan	N I K A R A B	32°58, 70°47, Pakistan
A R A K A N I	42°36, 46°59, Russia	I N A K A R A	I-n-Akara, Niger
L U M I N A T	luminate, 1560q	T A N I M U L	21°31, -97°51, Mexico
A P A N I T A	19°31, -104°37, Mexico	A T I N A P A	24°10, -105°00, Mexico

A M A N A M O	(Rio) Amanamo, Venezuela	O M A N A M A	Oman-Ama, Australia
M A N I R A M	26°50, 83°19, India	M A R I N A M	sea-toad 1, 1558q (Latin)
A N A M O S A	42°06, -91°16, E Iowa	A S O M A N A	-2°09, -78°33, Ecuador
N I M A K A N	51°26, 132°44, Russia	N A K A M I N	(Tang-e) Nakamin, Iran
A R O K A R A	-6°25, 145°54, Papua N G	A R A K O R A	10°12, -3°20, Burkina Faso
M A S A R A M	29°34, 52°10, Iran	M A R A S A M	(Sungai) M..., Malaysia
O M A N A M A	Oman-Ama, Australia	A M A N A M O	(Rio) Amanamo, Venezuela

A N A N O K A	Ananoka (Loma), Bolivia	A K O N A N A	6°30, 1°46, Benin
N A N A R U P	Nanarup (Beach), Australia	P U R A N A N	Gauharwala P..., Pakistan
A N A C A R A	Web2	A R A C A N A	Aracana, Web2 bl
N A C A V A L	-12°18, 35°10, Mozambique	L A V A C A N	L... (River), Philippines
O R A V A L A	60°58, 26°36, Finland	A L A V A R O	A... (Obregon), Mexico
K U R A L A T	65°37, 25°02, Finland	T A L A R U K	Talaruk (Kaur), Pakistan
A P A L A T A	2°49, 23°43, Congo Dem R	A T A L A P A	7°25, 3°48, Nigeria

Squares from unrestricted vocabulary, all rows different, six palindromes, and three diagonals
Of the 14 million squares mentioned above, none are all-palindromic, but 1656 have 6 palindromes.
The non-palindrome is always the central word.

Of these 1656 squares, 1586 have no diagonals, and the remaining 70 have three diagonals. These
diagonals of necessity are all the same.

Try making a reversible square with six palindromes:
```
A B C D C B A
B E F G F E B
C F H I H F C
D G I w x y z    reversible word
C F H x H F C    x not I
B E F y F E B    y not G
A B C z C B A    z not D
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All diagonals are AEHwHEA. The palindromes work in pairs, the words within each pair differing
in the central letter.

Because a valid content may be read from four directions (top, bottom, left, right), the squares
below could be set out in other ways. Here is a selection, showing the reversed central word and the
diagonals at the end of each square:

A M A R A M A	NZ name, Pal	A S A H A S A	Pali, Pal
M A L A L A M	(Mangada) M…, Nigeria	S A L A L A S	family names, Pal
A L A B A L A	41°09, 42°36, Turkey	A L A L A L A	'alalala, Hawaiian, Pal
R A B A T E S		H A L A G E N	behold 3, 1067q
A L A T A L A	Armenia, 40°48, 45°24	A L A G A L A	Australia, -32°24, 147°42
M A L E L A M	Mal Elam, Pal	S A L E L A S	family names, Pal
A M A S A M A	4°58, 6°06, Nigeria	A S A N A S A	Pali, Pal
rev: SETABAR	(Loba) Setabar, Malaysia	rev: NEGALAH	(Kowtal-e) Negalah*
diags: AAAAAAA	shoe width, Pal	diags: AAAAAAA	shoe width, Pal

* 35°57, 65°51, Afghanistan

A M A T A M A	(Canada) Amatama*		
M A L A L A M	(Mangada) M…, Nigeria	S A S A S A S	towns, Uganda, Pal
A L A M A L A	7°11, 3°14, Nigeria	A Y A M A Y A	Bolivia, -17°34, -67°42
T A M A L E S	plural of tamal	S A T A T A S	towns, Bangladesh, Pal
A L A L A L A	'alalala, Hawaiian, Pal	A M A Y U N I	Laguna Amayuni, Peru
M A L E L A M	*vide supra*	S A T U T A S	towns, Bangladesh, Pal
A M A S A M A	4°58, 6°06, Nigeria	A Y A N A Y A	maggot in Uradhi, Pal
rev: SELAMAT	(Bahr) Selamat, Chad	S A S I S A S	towns, Zambia, Pal
diags: AAAAAAA	shoe width, Pal	rev: INUYAMA	35°23, 136°56, Japan
* Dominican Republic, 19°25, -71°40		diags: SYTYTYS	Finnish, Pal

A N A P A N A	Pali, Pal	S H A F A H S	in Syria, Pal
N A M A M A N	Nam Aman, Vietnam	H A R U R A H	(Jabal al) Harurah, Yemen
A M A R A M A	NZ name, Pal	A R I K I R A	NZ racehorse, Pal
P A R A T E S	parrot 4, 1597q	F U K S A I L	fuk
A M A T A M A	*vide supra*	A R I A I R A	(Jebel) Ariaira, Morocco
N A M E M A N	name-man, Pal	H A R I R A H	26°33, 53°59, Iran
A N A S A N A	-20°37, 47°19, Madagascar	S H A L A H S	family name, Pal
rev: SETARAP	(Sungai) S…, Indonesia	rev: LIASKUF	(Nuaf) Liaskuf, Indonesia
diags: AAAAAAA	shoe width, Pal	diags: SAISIAS	Robert Browning, La S…

A N A R A N A	14°03, -85°28, Honduras
N A M A M A N	Nam Aman, Vietnam
A M A S A M A	4°58, 6°06, Nigeria
R A S A R E S	razor 1a, 1599q
A M A R A M A	NZ name, Pal
N A M E M A N	name-man, Pal
A N A S A N A	-20°37, 47°19, Madagascar
rev: SERASAR	(Sungei) Serasar, Malaysia
diags: AAAAAAA	shoe width, Pal

Unmarked words are from the OED. Web2 is Webster's Second. bl = below line. Pal is the Palindromicon. Places are from the NIMA database.

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