DERIVED PALINDROMES

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Consider the word AEGAEN. Read that word from left to right, next move the N to the left word edge and read the new word NAEGEA from right to left. Since the palindromic reading of AEGEAN is only possible by transposing one of its letters, AEGEAN is a derived palindrome.

In the AEGEAN example, NAEGEA was created by moving the rightmost letter to the left word edge. In other words a palindrome can be derived by moving the leftmost letter in a word to its right edge, e.g. GNOMON ('Part of a sundial'). These two kinds of derived palindromes are referred to below as Type A and Type B respectively. But there is a third variety as well: Words with an even number of letters which are decomposable into two-part tautonyms (e.g. PAPA) can be classified as Type A or Type B. I refer henceforth to words like PAPA as Type C.

Type A: Move the rightmost letter to the left word edge	example: AEGEAN
Type B: Move the leftmost letter to the right edge	example: GNOMON
Type C: Move either the leftmost letter to the right edge or the rightmost letter to the left edge	example: PAPA

There is a particular variety of Type A derived palindromes I consider to be rather unspectacular, but which I list below nonetheless, namely, words consisting of a palindrome plus a regular inflectional ending, e.g. EKED, LEVELS.

Some of examples under investigation have been discussed in previous issues of this journal, but in a different context. See, for example, the articles by Lesslie Card and A. Ross Eckler ('Palindromic letter-sequences'; Word Ways, February 1974) and A. Ross Eckler ('Internal tautonyms'; February 1980). It will be clear from the examples I present below that derived palindromes as defined above constitute only a small subset of the type of examples discussed in those earlier publications. What is more, the earlier articles were not concerned with the three types of derived palindromes.

The purpose of this article is to present a relatively small set of examples illustrating the three types of derived palindromes described above. It is my hope that readers of Word Ways will be motivated to find additional examples. Section 1 concerns itself with palindromes derived by transposition of a single letter as described above. In section 2 I compare derived palindromes and conventional palindromes from the mathematical perspective. In section 3 I consider other types of derived palindromes.

1. Palindromes derived by transposition

The following examples are listed according to word length, from the smallest to the largest words. These items are palindromes derived by transposing a single letter from either word edge to the opposite word edge. Most of these examples can be found in the Official Scrabble Players Dictionary. Those words not listed in that source can be found in OED (online). The list I present below can easily be expanded with material from the latter source.

Three letter derived palindromes

Type B:

ABB	BOO	ELL	INN	ODD	TEE
ADD	BRR	ERR	JEE	OFF	TOO
AFF	CEE	ESS	LEE	PEE	UMM
ALL	COO	FEE	LOO	POO	VEE
ASS	DEE	GEE	MAA	REE	WEE
ATT	EBB	GOO	MOO	ROO	WOO
BAA	EFF	IFF	NEE	SEE	ZEE
BEE	EGG	ILL	NOO	SHH	ZOO

Type A:

AAH	OOF	OOT
AAL	OOH	
EEK	OOK	
EEL	OON	

Type A (regular inflection):

AAS
OOS

Four letter derived palindromes:

Type C:

BABA	GOGO	MAMA	YO-YO
CACA	HAHA	NENE	
COCO	JUJU	PAPA	
DADA	KAKA	TITI	
DODO	LULU	TOPO	

Type B:

AGOG	DELE	GURU	KATA	LIRI	MONO	RAJA	STET
BENE	DEME	HEBE	KAVA	LOBO	NADA	REDE	TORO
BOLO	DENE	HERE	KIWI	LOCO	NAJA	RETE	WERE
BOYO	DOJO	HOBO	KOBO	LOGO	NALA	ROTO	
BOZO	FEME	HOMO	KOLO	LUAU	NEVE	SEME	
CEDE	FETE	IMAM	KOTO	MERE	NIDI	SENE	
CERE	GALA	JAVA	KUDU	METE	NISI	SERE	
COHO	GAMA	JEFE	KURU	MIDI	PILI	SHAH	
DATA	GENE	JETE	LAVA	MINI	POCO	SOLO	
DEKE	GOBO	KANA	LAMA	MOJO	POLO	STAT	

Type A:

AGAR	ANAL	DIDO	FIFE	IRIS	NINE	RARE	URUS
AJAR	ARAK	DUDE	GAGA	IWIS	OBOE	SASH	VIVA
ALAE	AWAY	EDEN	GAGE	LILT	OBOL	SASS	VIVE
ALAR	BABE	EVER	IBIS	LILY	ODOR	SISS	
ALAS	BABY	EWER	ILIA	MEMO	PIPE	SUSS	
AMAH	COCK	EYER	IMID	MIME	POPE	TETH	

Type A (regular inflection):

ABAS	DADS	EVES	GAGS	MOMS	PEPS	TATS	VAVS
AGAS	DUDS	EWES	GIGS	MUMS	PIPS	TITS	WAWS
ANAS	EKED	EXED	HAHS	NUNS	POPS	TOTS	WOWS
BIBS	EKES	EYES	HEHS	PAPS	PUPS	ULUS	

Five letter derived palindromes:

Type B:

BELLE	GAMMA	MASSA
BENNE	HOLLO	MOTTO
CALLA	JINNI	POTTO
CANNA	KAPPA	SELLE
FEMME	LOTTO	VILLI
FESSE	MANNA	YOBBO

Type A:

ADDAX	ASSAI	EMMER
ALLAY	ASSAY	EMMET
ANNAL	ATTAR	TEETH
APPAL	BOOBY	TOOTH
ARRAS	COOCH	TOOTS
ARRAY	EGGER	

Type A (regular inflection):

ANNAS	EGGED	OTTOS
BABAS	ERRED	PEEPS
BOOBS	ESSES	POOPS
CACAS	KOOKS	TOOTS
DEEDS	NAANS	
EBBED	NOONS	

Six letter derived palindromes:

Type B:

ACIDIC	GNOMON	ROCOCO
ACINIC	HALALA	SEMEME
ANILIN	KRONOR	UNEVEN
ASSESS	MANANA	URETER
BANANA	PREFER	ZANANA
BREWER	PREYER	

Type B (three-part tautonyms);

BEEBEE	KOODOO	YOO-HOO
BOOBOO	MUUMUU	
BOOHOO	PEEWEE	
COOCOO	TEEPEE	
HOODOO	VEEPEE	
HOOPOO	VOODOO	

Type A:

AEGEAN	MINIMA
ARARAT	REVERE
DIVIDE	REVERY
GARAGE	TOROTH
KANAKA	TOYOTA
MADAME	

Type A (regular inflection)

AZULAS	KAYAKS	REFERS
BAZARS	KAZAKS	ROTORS
CIVICS	LEVELS	SEVERS
EBBED	MADAMS	TATARS
EGGED	MINIMS	TENETS
ERRED	RADARS	

Seven letter derived palindromes:

Type A:

CARRACK	NIMMING	TILLITE
FRETTER	NIPPING	TREKKER
GRAMMAR	SUFFUSE	
PRESSER	TANNATE	

Type A (regular inflection)

HALLAHS	MALAYALAMS
PULLUPS	NAURUANS
TERRETS	RACE CARS
MURDRUMS	ROTATORS

Type B:

KNAPPAN, CHALLAH

Eight letter derived palindromes:

The source for the first Type A example is the Meriam Webster Medical Dictionary.

Type A:

ADINIDAN
SELFLESS

Type B:

IGNITING	REDIVIDE
PRO-TUTOR	KAVAKAVA
RETINITE	

Nine or more letter derived palindromes:

DYSPEPSY
SINONISM
TARTRATE

Longest known example:

SENSUOUSNESS

It was noted above that Type A derived palindromes can be obtained by attaching regular inflectional suffixes (i.e. S or D) to palindromic bases. There are also Type B examples involving these regular inflectional endings. Here are the few examples I have found of four, five and six letter words belonging to this category:

Type B (regular inflection):

Four letters:		Five letters:	Six letters:
ASKS	OSES	USEES	ASANAS
ASPS	PSIS		
ISMS	USES		
ISTS	TSKS		

This type of derived palindrome has proven to be rather elusive because the base word without the inflectional ending is not a palindrome. Whether or not the list with words ending in S can be expanded is a question I leave open for readers of this journal. I also leave open whether or not there are examples of this type ending in D. To date, I have found none.

2. Some math

Readers may wonder whether or not the number of possible derived palindromes for any given word length is the same as the number of possible palindromes for words of the same length. In fact, the answer to this question needs to distinguish between words containing an odd number of letters and those with an even number. Consider by means of illustration the number of possible three letter palindromic words. In a language like English with an alphabet consisting of 26 letters, there are 26 possible choices for the letter occupying the first of the three slots, 26 possible choices for the second slot, but only one choice for the third, since that letter is identical to the first. We therefore have $26\times26\times1=676$ possible three letter palindromes. For three letter derived palindromes (Type A) we have 26 choices for the first slot, 26 for the third but only one choice for the second, since it will be the same as the first. There are therefore $26\times1\times26=676$ derived palindromes (Type A). The same procedure will also reveal that number of possible three letter derived palindromes of Type B is 676, although I do not demonstrate this here. Using the same procedure, the number of possible four letter palindromes is $26\times26\times1\times1=676$. Consider now the number of possible four letter derived palindromes (Type A): There are 26 choices for the first slot, 26 for the second, only one for the third (which is the same as the first) and 26 for the fourth. This means there are $26\times26\times1\times26=17{,}576$ possible four letter derived palindromes. I have summarized these figures in the following chart, which also includes the calculations for palindromes and derived palindromes consisting of two, five and six letters:

number of letters	type of word	possible number
2	palindrome	$26^1=26$
2	derived palindrome	$26^2=676$
3	palindrome	$26^2=676$
3	derived palindrome	$26^2=676$
4	palindrome	$26^2=676$

4	derived palindrome	26^3=17,576
5	palindrome	26^3=17,576
5	derived palindrome	26^3=17,576
6	palindrome	26^3=17,576
6	derived palindrome	26^4=456,976

(The numbers listed in the final column for 'derived palindromes' refer to only to derived palindromes belonging to Type A or Type B, but not to Type C. For the latter, the number of possible palindromes for any given word length is identical to the number of possible palindromes for words of the same length, although I do not show this here. The number of possible derived palindromes for Type A and Type B words involving regular inflectional endings is different from the numbers indicated in the final column of the chart because that type of example poses restrictions on the number of possible inflectional endings.)

Although the chart does not constitute a rigorous proof, it suggests that the number of possible palindromes will always be the same as the number of derived palindromes for words consisting of the same number of letters, provided that the number of letters is odd. If the number of letters is even, then the number of possible derived palindromes will always be equal to the number of possible palindromes of that letter type multiplied by 26.

3. Other types of derived palindromes

Since there are three logical ways of manipulating the sequencing of letters in any given word (deletion, insertion, transposition), it follows that there should be three types of derived palindromes, but within each of those three categories, a multitude of subcategories suggest themselves as well. For example, in section 1 I discussed palindromes derived by transposition of a letter at one word edge to the opposite end of the word, but there could be palindromes derived by moving the second letter to the right edge, the second letter to the left of the last letter, the third letter to the right edge etc.

Consider the three logical types of derived palindromes mentioned above. In the following I concentrate on palindromes derived by transposing, deleting or inserting a single letter at one edge of the word:

Type of derived palindrome:	Example:
Transposition:	AEGEAN
Deletion:	PREFER
Insertion:	TOO

Palindromes derived by deletion are easily obtainable from the examples presented in section 1: If the deletion of a consonant at the edge of a word yields a palindrome (e.g. PREFER > REFER), then the example involves a palindrome derived by deletion. In fact, the majority of the examples in section 1 cannot be included among the list of palindromes derived by deletion because the

omission of a letter at one edge of the word does not always result in an (occurring) palindrome. For example, the deletion of the G in GNOMON gives us NOMON, which is not an English word.

Similar generalizations hold for palindromes derived by insertion. In the example listed above, TOO is not a palindrome, but if the letter T is inserted at the right edge, then the palindrome TOOT has been created. Only a subset of the palindromes derived by transposition in section 1 also qualifies as palindromes derived by insertion.

I do not provide a list of palindromes derived by deletion or insertion. The curious reader will construct these lists for herself.

Palindromes derived by transposition are quite different from palindromes derived by deletion or insertion: The movement of a letter in the former must crucially occur after the act of reading the word from one edge of the word to the opposite edge, but before the act of reading the same word in the opposite direction has commenced. By contrast, palindromes derived by deletion or insertion can only be derived palindromes if the relevant change (deletion or insertion) takes place before one has read the word from left to right and then from right to left. The distinction between the two types of derived palindromes is illustrated in the following two examples. I state explicitly in the left-hand column the various acts and the order in which they must occur:

	'AEGEAN'
(1) Read word from left to right:	AEGEAN
(2) Move rightmost letter to left edge:	NAEGEA
(3) Read word from right to left:	AEGEAN
	'PREFER'
(1) Delete one letter at left edge:	REFER
(2) Read word from right to left:	REFER
(3) Read word from left to right:	REFER