REVERSIBLE HETEROGRAMS

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In my article "Statistics of Word Neighbours" in the Nov 1997 Word Ways, I showed that theoretical expectations matched actuality quite well for heterograms, words of a given length which had all letters different (Graph 2 in that article). In "Snakes and Ladders" I attempted to make ladders between heterograms which were also words when reversed. This article gives fuller results of my investigation into reversible heterograms. The lists can act as a crib for people constructing palindromic phrases!

The frequencies were:

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<th>Word length</th>
<th>3</th>
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<th>6</th>
<th>7</th>
<th>8</th>
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<td>% Heterograms</td>
<td>86</td>
<td>76</td>
<td>61</td>
<td>46</td>
<td>32</td>
<td>20</td>
<td>11</td>
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<td>% Reversible Heterograms</td>
<td>43</td>
<td>14</td>
<td>2.6</td>
<td>0.26</td>
<td>0.02</td>
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The figures in the last row should be halved to get the number of reversible pairs of words. Finding examples of lengths 9 and 10 seems to pose another Grand Challenge like that of the ten-square, but more difficult.

Although the prediction of the number of heterograms of a given length was quite successful, little success attended upon my attempt to predict the number of reversible heterograms. Suppose that we have a heterogram. We need one precisely defined set of letters to constitute its reversal, which may not be a word, so the probability of finding such a word is the number of words of that length divided by the number of possible letter sequences. We multiply the result by the number of heterograms to get an estimate of the number of reversal heterograms of that length. The results are always too low: by a factor of two for length 3, increasing to a factor of 60 for length 7. I conclude that the chance of finding a reversal of a given heterogram is larger than chance would indicate, and that the departure from chance increases with increasing word length.

I investigated the two letters at the beginning and the end of heterograms: the results, together with an explanation, are to be found in the table which accompanies this article. If every letter pair were equally common, each would occur $1/676 = 0.15\%$ of the time. The table records those pairs which occur about seven or more times as often as this. Two things struck me: the frequency of certain letter pairs

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departs more from the norm as word length increases, and endings depart more from the norm than beginnings. Of course, as word length increases, so the number of words with prefixes and suffixes can increase, giving more words with the same beginnings and the same (different!) endings.

Some letter pairs will appear more often than average, and some less. However, 21 (approximately) of the 26 letters of the alphabet are consonants, and many pairs of consonants such as CX, GV, JG or QZ do not occur. Even so, the number of letter pairs of the 676 (less the 26 doubled letters) that never occur at the start or the end of a heterogram is large. It grows from one-third in the case of four-letter heterograms, through half in the case of seven letters, to two-thirds in the case of ten letters. Thus there is a reason why some letter pairs in long words must occur frequently. Hence there are both negative reasons (large number of invalid pairs) and positive reasons (grammar) for the popularity of some starts and ends.

It is no surprise that the beginnings CO-, DI-, IN- and UN- are very popular, and HY- is explained by longer words beginning HYDRA-, HYDRO-, HYPER- and HYPO-. There are also simple explanations for the most common endings: -ED (past tense), -ER (agent of a verb), -ES (verb and plural), -IC (adjective), -LY (adverb), -NG (participle), and to some extent anything ending in S (plural and verb). The object was naturally to see which popular beginnings are also popular endings when reversed. These are marked in the table with asterisks: DE-, LA-, RA-, RE-, SC-, SP- and ST-. Of these, LA- was unexpected. At lengths 6 and 7, about 30 per cent of the reversible heterograms start with one of these seven doublets. These results may be some explanation for the results of the probability calculations noted above.

It was tricky to select the word pairs for the following lists. Roughly, I have included a pair only if at least one of the words is well-known or interesting. It turns out that approximately half of all the four- and five-letter pairs were thereby chosen, and a quarter of the three-letter word pairs. The reader with time to browse will find brief comments.

The words are to be found in the Oxford English Dictionary (OED), the Merriam-Webster Unabridged (Second Edition), the Official Scrabble Players Dictionary (OSPD), Stedman's Medical Dictionary or Pulliam and Carruth's The Complete Word Game Dictionary unless otherwise noted.

AmHer = American Heritage Dictionary
DOST = Dictionary of the Older Scottish Tongue
EDD = English Dialect Dictionary
F&W = Funk & Wagnalls New Standard Dictionary
PAW = Pears Advanced Word-Puzzlers Dictionary by Peter Newby
Roget = Roget's original thesaurus
SND = Scottish National Dictionary
TIC = The Times Index-Gazetteer of the World (1965)
TNWS = The New Welsh Dictionary by Evans and Thomas
Wyy=ppp = Word Ways year and page

Terminology: bl = below the line Webster's Second, fn = forename, Med. = medical, o. = obsolete, propr. = proprietary, vf = OED variant form

8-letter word pair (due to Dmitri Borgmann)
NICOLAUS (fn)—SUALOCIN (star)

7-letter word pairs (all)
DILATOR—ROTALID
NORITES—SETIRON?
LATIRUS?—SURITAL?
REKNITS—STINKER
NILEVAR (Med.)—RAVELIN
ROTANEV?—VENATOR

6-letter words (most)
ALERTS—STRELAS (PAW) AMENIC—CINEMA
AUBREY (fn)—YERBUA BRACED—DECARB
DECAPS—SPACED DECAR—TRACED
DEFRUT—TURFED DEGAMI—IMAGED
DELIAN—NAILED DEVAL—LAINED(PAW)
DERATS—STARED DE TROP—PORTED
DEWANS—SNAWED DIALER—RELAID
DORMIN—NIMROD DRAZIL—LIZARD
ECITON (F&V NSD)—NOTICE
ENAMOR—ROMANE
ENNACS (early computer, though just one ENIAC!)—SACAINE
ENISYL?—LYSINE
GOLFER—REFLOG
GULPER—REPLUG
LAITER—RETIAL (PAW) LANGER—REGNAL
LEVANS—NAVEL LEVINS—SNIVEL
LIGNES—SENGIL MANITU—UTINAM
NOSIER—REISON PERTIS—SITREP
RECAPS—SPACER REDIPS—SPIDER
RELATS (PAW)—STALER REPINS—SNIPER
REPOTS (as in snooker)—STOPER

5-letter word pairs (selection of about half)
AGNUS—SUNGA (bridge) AIDER—REDIA
ALETS (o.)—STELA ALSET (DOST)—TESLA
ANOLI—ILONA (fn) APRES—SERPA (o. Sherpa)
ARGIN—NIGRA ARTIC—CITRA (prefix)
AXONE—ENOXA BARES—SERAB
BORAK—KAROB (o. carob) BORED—DEROB (= rob!)
CARES—SERAC CARID—DIRAC (predicted position, gave me cobnut)
CARTS—STRACK (o. struck)
CODEM (Roget)—MEDOC (France)
DAMON (fn)—NOMAD! DARTS—STRAD
DECAL—LACED DECAP—PACED
DELIS—SILED DELIT (= delight)—TILED
DÉMAN (vf deem)—NAMED
DEMOS—SOMED (= samed)
DEPOT—TOPED DERAH—HARED
DEVAL (vf deval)—LAVED DEVAS (gods)—SAVED!
DEVOR (o. devoir)—ROVED
DEYAR (o. dairymen)—RAYED
DIBAR (o. diaper)—RABID DIETS—STEID (= stead)

AILED—DELIA (fn!)
ANGER—REGNA
ARTUS—SUTRA
BATIK—KITAB (= Koran)
CAINE—ENIAC (computer)
CRES—SERIC
DAIRT—TRIAD
DEBUT—TUBED
DEGAS—SAGED
DEMEL (= domain)—LAMED
DEMET—TIRED
DERAT—TARED
DEVOL—WOVED
DIALS—SLAID (= slid)
DILOS—SOLID
DIRES—SEMIC
DIAST—TRENCH
DIY—YARD
DIYING—YARDING

4-letter word pairs (selection of about half)

ABIR—RIBA (Royal Inst. Brit. Architects)
ABUT—TUBA
ADOS—SODA
AGIR (Roger)—RIGA (Latvia)
AGUR (o. augur)—RUGA
AMIR (emir)—RIMA
AMYS—SYMA
ARCO (music)—OCRA (o. okra)
ARON (o. arc/anum)—NORA (fn)
ASIL—LISA (fn)
ATES (o.)—SETA
ATON (Aten, god)—NOTA (Bene)
AVIS—SIVA
BACS (heart of cheque clearing in UK)—SCAB
BANS—SNAB (Scot)
BARK—KRAB (= karabiner)
BIRD—DRIB (drip)
BONK—KNOB (oh dear)
BRAG—GARB
BREY (= braye)—YERB
BUNS—SNUB
BUTS—STUB
CATS—STAC (= stack)
CLAT—TALC
CRAM—MAR (brandry)
CREM (0. cream)—MERC (Mercedes)
CROT (o.)—TORC
DAHS—SHAD
DALY—YLAD (= led)
DAWS—SWAD
DEIP (o. Scot deep)—PIED
DEN—is SNED
DEUS (0. dew etc)—SUED
DIAS—SAID
DINS (sixpence)—SNID
DOLS—SLOD
DORT—TROD
DRAG—GARD (= guard)
DRAY—YARD
DRON (o. drowm)—NORD (Roget)
DRUG—GURD (o. gird)
DUCS (obs or Fr duke)—SCUD
DYES—SEYD (= sayyid)
EBUR—RUBE
EGOL—LOGE
ELAY (o.)—YALE
EMIR—RIME
EMYS—SYMME
ENOS (proper salts)—SONE (unit of loudness)
ENOV (= ennoy)—YONE (o. yon)
ABLE—ELBA
ADLE (o. addle)—LEDA (& swan)
AEETS (edd)—STEA (edd)
AGOS—SOGA
ALEOH—TELA
AMOR—ROMA!
ANTE—ETNA
ARET—TERA
ARTS—STRA (= straw)
ASET (o.)—TESA (F&W = teesa)
ATPH—PITA
AUKS—SKUA (two birds)
AVIS—SIVA
AVON (river, coy, county)—NOVA
BAIL—SHAB
BARF (vomit)—FRAB
BENS (mountains)—SNEB
BLY—YALB
BOTS—STOB
BRAY—YARB
BUNG—GRUB
BURT—TRUB
CART—TRAC (basketry)
CIRÉ—ERIC
CNA (o. Canute)—TUNC
CRESW—WERC (0. work)
DEFY—YFED
DELFL—LED
DIAM (diameter)—MAID
DINE—ENID (fn)
DOLP (Scot. doup)—PLOD
DOPE—PROD
DOZE—EZOD (o. letter Z)
DRAW—WARD
DROW—WORD
DUAS—LAUD
EATST—STAE (in Sweden)
EDIT—TIDE
ELAM (var of helm, or country of Elamites)—MALE
EMAN (Med)—NAME
EMUS—SOME (o. some etc)
ENID (fn)—DINE
ENOW—WONE
ENUS—SUNE (o.)
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Note: Some entries are marked with a dictionary error symbol (!) indicating a potential error in the transcription or recording process.
| SNEW (snow) | SNOT—TONS! | SNOW—WONS (= once) |
| SOROK—TROS | SPAT—TAPS | SPAW (o. spa)—WAPS |
| SPAY—YAPS | SPET—TEPS (= taps) | SPEY—YEPS |
| SPLIT—TIPS | SPOT—TOPS | SPOW—WOPS |
| SPUT—TUPS | STEW—WETS | STOW—WOTS |
| SUEZ—ZEUS | SWAY—YAWS | SWET (o.)—TEWS |
| SWY (o.)—YEWS | TANU (acronym)—UNAT (o.) |
| TEAW (v. f. tew)—WAET (o. wet) | TEDY (v.)—Y-DET | TERU (= tar)—URET |
| THAW—WAHT (o. what) | TIEW—WEIT (o.) |
| TRAU (= throw)—UART (comms in PC) | TONY—YNOT (= I do not know) |
| REY—YERT (o.) | TRAW—WART |
| ULEY (o. oil)—YELU (o. yellow) | TREW—WERT |

### 3-letter word pairs (selection of about a quarter)

| ADO—ODA | AIM—MIA (missing in action) | AND—DNA |
| ANE—EN (fn) | AOB (meetings)—BOA | APE—EPA (Environmental Protection Agency) |
| ARK—KRA | AVE—EVA (fn or space walk) |
| AVO (meter or Hung. secret police)—OVA | AXE—EXA (18th power of 10) |
| BAD—DAB | BAM—MAB | BAN—NAB |
| BAP—PAB (Scot. unh.) | BAR—RAB | BID—DIB |
| BIG—GIB | BOG—GOB | BON (not a good word!)—NOB |
| BOR (heard many times in youth)—ROB | BOS (o. boss)—SOB | BOY—YOB! |
| BRO (= brother)—ORB | BUD—DUB | BUG—GUB (dubious word!) |
| BUN—NUB | BUS—SUB | BUT—TUB |
| CAP—PAC | CAR—RAC (Royal Automobile Club, or o. rack) |
| CAY—RAC (Women's Army Corps, or o. weak) | COD—DOC (abbr.) | COR—ROC |
| COS—SOC (as in Soke of Peterborough) | COT—TOC (letter t, or Table of Contents) |
| COW—WOC (o. woke) | CPU (computer)—UPC (barcode on foods etc) | CUD—DUC (Fr. or o. Duke) |
| DAH—HAD | DAM—MAD! | DAP—PAD |
| DAY—YAD (going, going, yad!) | DEN (also fn)—NED (also fn) |
| DEO (in excelsis)—OED | DEW—WED | DIG—GID |
| DIK (half a dik-dik, or o. dike)—KID | DIM—MID | DIN—NID |
| DIS (= disconnected)—SID (Di's Sid!) | DOG—GOD | DOM—MOD |
| DON—NOD | Dop—POD | DOR—ROD |
| DOT—TOD | DUM (o. doom)—MUD |
| EAT—TAE (Scot. toe) | EDO (language)—ODE | ELI (fn or o. oil)—ILE |
| ENO (proper. laxative)—ONE | ESU (electrostatic unit)—USE |
| FAN—NAF (negative have) | FAO (UN Food & Agricultural Organisation) | OAF |
| FAR—RAF (Royal Air Force etc) | FAY—YAF (o. gave) | FRO (= from)—ORF (= off, etc) |
| GAL—LAG | GAM—MAG | GAN—NAG |
| GAT—TAG | GAW—WAG | GAY—YAG |
| GEM—MEG (valuable woman) | GET—TEG | GIM—MIG (also MIG 21 fighter) |
| GIN—NIG | GIR—PIG | GIT—TIG |
| GOM—MOG | GOS (hawk etc)—SOG GOTT—TOG |
| GUP—PUG | GUT—TUG | HAP—PAH |
| IVO (fn)—OVI (prefix) | JAR—RAJ | KAT (o. qat)—TAK (Chamber's Scots Dict.) |
| LAP—PAL | LAS (= alas etc)—SAL (also fn) | LAV (atory)—VAL |
| LEM (o. learn or Lunar Excursion Module)—MEL | LET—TEL | LIM (o. limb etc)—MIL |
LIP—PIL  LIT—TIL  
MAP—PAM (can read her backwards!)  
MAT—TAM (-o' shanter)  
MEN—NEM (nem. con., or = name)  
MIR—RIM  MIT—TIM  
MOW—WOM (o. whom)  
MUT (= mutt etc)—TUM  
NAW (= no, know) —WAN  
NIS—SIN  NIT—TIN  
NOW—WON  NOY—YON  
NUT—TUN  OAT—TAO  
OWT—TWO  PAR—RAP  
PAY—YAP  PAZ (La Paz) —ZAP  
PEW—WEP (o. wap etc) PIR—RIP  
POT—TOP  POW—WOP!  
RAT—TAR  RAW—WAR  
ROS (fn, Scot county etc) —SOR (v. sore)  
RUS—SUR (o. sir)  RUT—TUR  
SET—TES (= 'tis)  SEW—WES (fn or o. was)  
SEY—YES (proposal?)  SIT—TIS (= 'tis)  
TAW—WAT (Thai temple etc)  
TAY (fish) —YAT (= yacht etc)  
TIZ (= tizzy) —ZIT  TOW—WOT (= what)  
WEY (unit of weight) —YEW  
MAN—NAM (am not, Vietnam etc)  
MAR—RAM  MAS—SAM  
MAW—WAM  MAY—YAM  
MEW—WEM  MHO—OHM  MIN—NIM  
MOP—POM  MOT—TOM  
MUN—NUM  MUS—SUM  
NAP—PAN  NAR (mostly o.)—RAN  NAT (also fn) —TAN  
NET—TEN  NEW—WEN  NIP—PIN  
NOS (o. or pl. or numbers) —SON  NOT—TON  
NUP (o.)—PUN  NUS (pl. or Nat. Union of Students) —SUN  
OLP (= alp = bullfinch) —PLO (Palestine Lib. Org.)  
PAS—SAP  PAT—TAP  PAW—WAP  
PER—REP  PET—TEP (= tap)  
PIS (pis aller) —SIP  PIT—TIP  POS—SOP  
PUS (also Permanent Under-Secretary) —SUP  PUT—TUP  
RAY—YAR (= yah etc) REX—XER (Med)  
ROT—TOR  ROW—WOR (= were etc)  
SAT—TAS (pl. or o.)  SAY—YAS (= yes)  SAW—WAS  
SEX—XES (W70-201)  
SIX—XIS (hyperon)  SOW—WOS (o. woes, call etc)  
TAX—XAT (Indian pole, Web3)  
TEY (o. tea, tie etc) —YET  TEW (o.)—WET  
TOY—YOT (= yet)  WAY—YAW