COLLINEAR WORDS

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In the February 1992 **Word Ways**, Christopher McManus introduced the concept of halfway words: trios of words where every letter in the middle word is midway in the alphabet between the corresponding letters in the end words (for example, AGE-JIG-SKI, where J is halfway between A and S, I halfway between G and K, and G halfway between E and I). Halfway words are a subset of collinear words, introduced by Charles Bostick in the November 1984 Kickshaws. Convert the letters of a word to their alphapositional values (A=1, B=2, etc.) and plot each n-letter word in Euclidian n-space; if the points lie on a straight line the words are said to be collinear. Bostick's example of a set of collinear words (a word line) was GYP-HUM-iqj-jmg-KID-LEA (lowercase "words" do not exist), one which contains no halfway word trios. This line can be characterized by the differences between corresponding letters in successive words: 1,-4,-3. (These are called direction numbers in projective geometry.)

Bostick tacitly imposed the additional restriction that all letters had to change from word to word (the set of words had to be mutually non-crashing); his intent, no doubt, was to eliminate uninteresting word lines such as BAT-CAT-FAT-HAT-MAT-PAT-RAT-SAT-TAT. Let us call word lines like these **normal** word lines, ones in which one letter remains the same **slanted** word lines, and ones in which all three letters change **skewed** word lines.

In any event, Bostick quoted Robert Ward's claim that, for three-letter words in Webster's Unabridged (Second Edition), there were only 31 sets of four collinear words and no sets of five.

When Dave Morice reintroduced the subject of collinear words to Kickshaws readers in May 1991, he subtly changed the rules, allowing the word line to be extended beyond Z ("around the world" so to speak). For example, Bostick's line becomes:

-dky-egv-fcs-**GYP-HUM-iqj-jmg-KID-LEA**-MAX-nwu-osr-POO-qkl-

Although in Euclidian geometry we expect a line to be extended indefinitely, in our finite space this cannot be. Actually, when extended, all lines become circles of 26 n-grams, regardless of word length (each word is the same as the one 26 words earlier and 26 words later). Word lines in which all differences are even numbers contain only 13 different words. Note that the words on a word line no longer necessarily are mutual non-crashers; letters will repeat if the differences are even (as qkl and dky in the

above example).

To distinguish Morice's generalization from the Bostick-Ward concept of collinear words, let us call them extended collinear words. As I show later in this article, Ward's claim can be bested under his rules. It can be more easily bested under Morice's less stringent rule. I exhibit the following (2,-2,1) skewed word line which has 11 collinear words:

EWK-GUL-ISM-kqn-MOO-omp-qkq-SIR-UGS-WET-ycu-aav-cyw-ewx-
GUY-isz-kqa-MOB-omc-qkd-SIE-ugf-WEG-ych-aai-cyj-

This may possibly be improved upon. If 1750 words (10 per cent of possible three-letter combinations) are scattered at random in word-space, I have calculated that on the average, 8 of the 475,228 possible word lines will have 11 or more words in them. (However, this model is probably valid only for the 420,472 skewed word lines, lowering the estimate from 8 to 7.)

Three-letter collinear words can be visualized with the aid of Morice's word cube, introduced in the May 1990 **Word Ways**. Extended collinear words can also be mapped within the cube but most lines will appear as a series of disconnected parallel segments which are hard to visualize as being collinear, let alone forming a closed loop. It is best not to attempt a three-dimensional presentation, but some two-dimensional ones from various angles will be given later.

A complete search for collinear words in my database of 1680 three-letter words taken from the OSPD, Webster's Second, Chambers and the OED revealed the following sets of five or more. The first five sets have no "gaps" (non-words) interrupting them; in the others, the gap lengths are given. All lines are skewed.

ARC COG ELK GIO IFS
BIB CLE DOH ERK FUN
OUF QRI SOL ULO WIR
DIM ELK FOH GRE HUB
FUB GRE HOH ILK JIN
AYS DUP (2) MIG PED SAA
CAM EEM GIO IMP (2) OYS
CUB (1) GOD ILE KIF (1) OCH
FAR HEP JIN (2) PUH RYF
FYS GUR (1) IMP (1) KEN LAM
FYS HUP (2) NIG PED RAA
HYL JUN (2) PIT REV TAX
NYS DUP (2) RIG SED TAA
BUT ERR HOP (1) NIL (1) TCH
AWS DUT (2) MOW (1) SKY VIZ
COW (2) FIN (1) HEH ICE JAB
DAI ECH FEG (1) HIE (2) KOB
ION (2) OIK (1) SEI UCH WAG
MOA (1) OKE PIG (1) REK (1) TAO
ONY POX (3) TST UTS VUR
RAB (1) TED UGE VIF (2) YOI

AWA COB (2) IRE (2) OUH QVI
DUG ESI (1) GOM (2) JIS (1) LEW
GUZ (2) MOW (2) SIT UGS WER
QUA (2) TOD UME (1) WIG (1) YEI
RER (1) TIT UKU (1) WOW (2) ZUZ
ANI BOH (2) ERE (2) HUB IVA
GJU HIS (3) LEK (2) OBE PAC
BAT (1) FER (1) JIP (2) POM (1) TSK
ICY JEW (1) LIS (2) DOM (2) RUG
JUS (2) MOM (2) PIG (1) REC SCA
PWN QUO (2) TOR UMS (3) YEW
AVO CUN (2) IRK (2) OOH (2) ULE
BAW (1) FEU (1) JIS (2) POP (2) VUM
BUY (2) HOS (2) NIM (1) REI (1) VAC
JUL (2) MOO (2) PIR (1) RET (1) TAV
DAD ECE (2) HIH (2) KOK (2) NUN
FED (1) HIH (2) KON (2) NUT (1) PYX
DUV (2) GOS (2) JIP (1) LEN (1) NAL
FAN (1) HEL (4) MOG (1) OSE PUD
HAW (1) JEU (1) LIS (2) OOP (2) RUM
HEP IGO JIN (5) PUH (1) RYF

HUZ (2) KOW (2) NIT (1) PER (1) RAP
MEU (2) PHO (2) SKI (1) UME (1) WOA
OUH PSI (1) ROK (4) WEP (1) YAR
BUN DSO (4) NIT (1) REV (1) VAX
HUS (2) KOP (2) NIM (1) PEK (1) RAI
APE KOF ENG (4) OIL (3) WEP
ADD CEE EFF (4) OKK (3) WOO
ADO (3) EHS FIT GJU (4) LOZ
AWL BUM (5) HIS (1) JEU (1) LAW
HYL (4) MOG (1) OKE (2) REB SCA
HET IFS (2) LIP (2) OLM (3) SPI
ODS PER (2) SHO TIM (5) ZOH
ODD PEE (2) SHH (5) YNN ZOO
ELS (2) HIP (3) LEL (2) OBI PAH
DAI (3) HIM (2) KOP (2) NUS OWT

DAW (1) FEU (1) HIS (2) KOP (3) OWL
DAL (1) FEN (1) HIP (2) KOS (4) PYX
FYZ (2) IST (1) KOP (3) OGH (2) RAB
KYS (4) PON (2) SIK (2) VCH WAG
AHA BIB (2) ELE (2) HOH (5) NUN
BIN (2) ELK (2) HOH (5) NUB OVA
FUN (2) IRK (5) OLE (2) RIB SHA
IRK (2) LON (5) RIT SHU (2) VEX
ABE (2) DEH (3) HIL (5) NOR OPS
ABO (2) DEL (2) GHI HIH (5) NOB
BOB (2) ELE (2) HIH (3) LEL (3) PAP
ING (4) NIL OHM (2) REP (3) VAT
AVA BUB (2) ERE (2) HOH (6) OHO
ARE (2) DOH (5) JIN (3) NER ODS
APE (6) HIL (3) LEP (2) OBS PAT

LAY MEW NIU OMS (1) QUO RYM
PAP (1) RER (1) TIT UKU (1) WOW (2) ZUZ
BYN CWM DUL (2) GOI (4) LED (1) NAB
FAR (1) HEP IGO JIN (5) PUH (1) RYF
AVO BUN (2) ERK (2) HOH ING (4) NIB
FOH (2) ILK (2) LIN MHO (2) PER (3) TAV
DAP (3) HEL (2) KHI (3) OLE (2) ROB SPA
ARS (2) DOP (6) KHI (2) NEF ODE (2) RAB

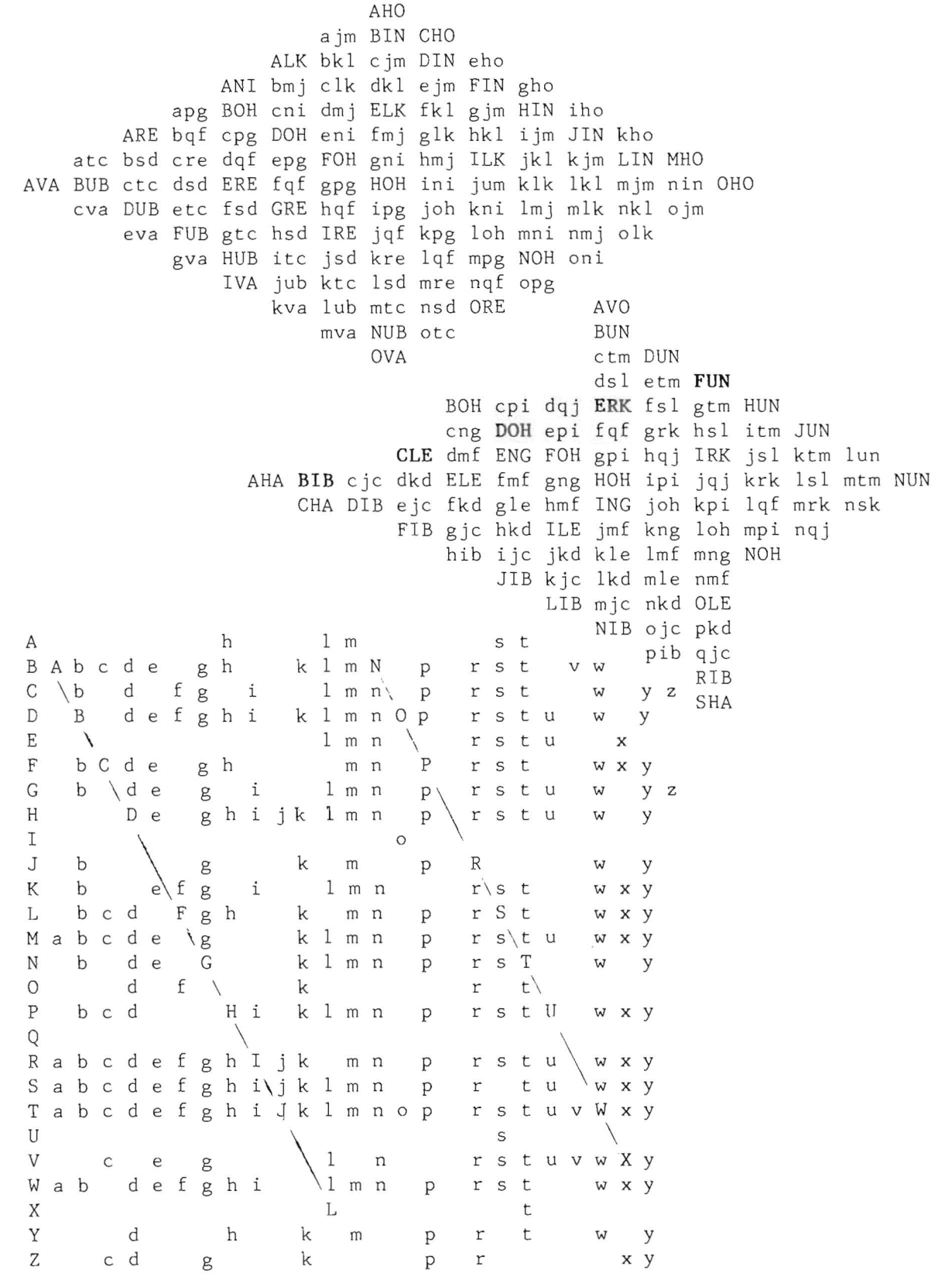
EWK GUL ISM (1) MOO (2) SIR UGS WET
ABB (1) EDD GEE IFF (2) OII (2) ULL (2) YNN

And now for some geometry. Several words and non-word 3-grams appear in more than one line. These are points of intersection of the lines. Two intersecting lines determine a plane. If three lines intersect at the same point, they may determine three intersecting planes, or all three lines may be coplanar. For the first of the following arrays, I chose two perpendicular intersecting lines, plotted one vertically and the other horizontally, and filled in the other 3-grams. Note how many of the fillers are words. My two chosen lines are not only perpendicular to each other, but both are at 45 degrees with the axes of the Morice word cube. All words in the array are coplanar.

The second array contains four lines from my computer search. Two of them, AVO to NIB and FUN to SHA, are parallel. Note how the no-gap BIB-CLE-DOH-ERK-FUN line shows up. The two planes given below are perpendicular to each other, intersecting along the BOH-DOH-FOH-joh-loh-NOH line. The horizontal lines in the second array progress 1,1,1; words in these lines are letter-shift words (see my article in the February 1990 **Word Ways**). In addition, words in the horizontal backbone of both planes are palindromes, and the two vertical backbones are reversals of one another.

The third array shows how extended collinear words appear on parallel lines in the Morice word cube. This is a face of the cube, in which the first letter of the word is given (in capitals) at the left, the second letter is always A, and the third letter appears in the array. The slanted word line BAA-DAB-FAC-, in

two parallel segments, is highlighted with capital letters.



Four-letter words are a less-fruitful source of word lines; I list below sets with four or more words, taken from a list of 7233 four-letter words. A high fraction of the words come from the OED (such as NYNY, meaning "ninny") or Chambers (MOOI), but there are a few all-OSPD sets, and probably quite a few all-Webster sets. Only one line containing five collinear words was found. Word space thins out as word-length increases.

ACUS GIRN MOOI SULD
AULA FROE KORI PLUM
AURA GOOF MILK SCIP
AVID FOLK KHOR PARY
BOGA CREE DUCI EXAM
LUTZ OOPS RILL UCHE
ALUR COTS ERST GURU
AULA GOOF MIRK SCUP
AVAS BOHU CHOW DAVY
BILL CLOW DORP ERUR
JACU MEET PIGS SMIR
MIGG PLEI SOCK VRAM
ARMS BOIN CLEI DIAD
AULS GOON MIRI SCUD
AVID BOLK CHOR DARY
BIRI CLOG DOLE ERIC
JAZZ MESS PILL SMEE
RIDS SLIM TONG URSA
DULY EROS FORM GLUG
AULA DROG GORM (1) MIXY
DIXY (1) FORM GROG HULA
PILA (1) RERE SCUG TAXI
BIRD (1) NOLL TRIP ZUFT
JIBB (1) NODD PREE RUFF
PURE (1) ROTO SLUT TIVY
CIVY GLUT KOTO (1) SURE
LEEK (1) NOGG OTHE PYIC
PYLL GUON (1) SMUR TIXT
CAVE EETH GIRK (2) MULT
HAJJ JELL LINN (2) RUTT
KAVA LETE MIRI (2) PULU

JAUN KETO LISP (2) OUPS PYOT

OUCH (1) SMIL (1) WEOP YARR
COLT (2) LURK OWTH RYVE
JACU LEET NIGS (2) TUMP
MHOS (2) SNIP UPGO WREN
RYVE SWTH TURK (2) WOLT
DULT (2) MIRK PETH SAVE
JEAT LIDS (2) RUMP TYPO
ODSO PERM (2) SHOG TINE
ACTA (1) GING (2) PREP SUBS
BABA DEDE (3) LULU NYNY
FYKE HUMF (2) NISI (1) RAWK
LATH (1) NIRL (2) QUOR RYNT
PYLA (2) SMOG TIPI (1) VARM
AYIN (1) GUMP (2) POSS SMUT
BLOW EMPT (1) KORN (2) TRUE
NYHT OUIR (2) RILL (1) TANH
PYNT QUOR (2) TIRL (1) VATH
ACTA (3) MOPE PROF SUNG
DAUB FETE HISH (3) PYOT
PYHY (3) TITI UEWE VAZA
BOIL (2) HILI (1) LENG (1) PAPE
FOZY (2) LITS (1) PEPO (1) TALK
MOJO (2) PIPI (1) RETE (1) TAXA
PLAK (2) SIGN TH1O (2) WEOR
COWL (2) FINO (2) ICER JABS
HOUF (2) NIRL (1) REPP (1) VANT
MOSS (2) PIMP (1) REIN (1) TAEL
OPIE (3) SLEM (2) VIBS WHAU
FOSS (2) LIMP (1) PEIN (1) TAEL
MOIL (2) PILI (1) RENG (1) TAPE
PANT (1) REPP (1) TIRL (2) WOUF