## CHINESE STEPLADDERS

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Word Ways readers are familiar with Lewis Carroll's word ladders. As a variation, Dave Morice suggested in the August 1989 Kickshaws a game which he called Stepladders. Two words join only if the letters which are exchanged are adjacent to each other in the alphabet.

Unfortunately, Morice's rule does not allow enough joins for an interesting analysis. If one is restricted to words from the Official Scrabble Players Dictionary, the largest four-letter word network contains only 14 words of the form (KLMN)(KLMN)(DE). Three other networks have 10 to 12 words apieces (RCD)U(DST)(DST) (DST)

To get around this limitation, I investigated word ladders in which the mandated distance between exchanged letters is other than one step. The one system that seems to work very well uses six steps and goes around the world through ZA (hence, Chinese Stepladders). This results in letters dividing into two groups of size 13, one with the vowels and the other without (call them V and C, respectively):

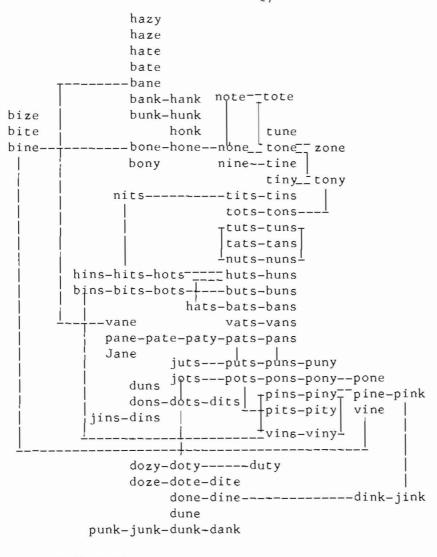
Vowels (V) -A-G-M-S-Y-E-K-Q-W-C-1-O-U-No Vowels (C) <math>-B-H-N-T-Z-F-L-R-X-D-]-P-V-

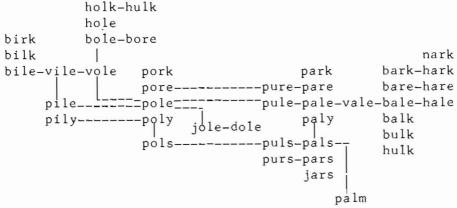
These parcel all four-letter words into 16 disjoint networks; there is no way (for example) that WORK can be transmuted into PLAY even if all four-letter strings were words. By far the most fecund network  $\overline{\text{is}}$  the one formed from words with the pattern **cvcv** (such as T1LE or FARM).

The largest connected network with pattern cvcv, with 98 words, is diagrammed on the next page. Its span is 20, PUNK-junk-dunk-dune-done-dote-doty-dots-jots-juts-puts-pats-paty-pate-pane-vane-bane bate-hate-haze-HAZY.

The second largest network has 42 words, followed closely by one with 39. The span of the former is 13 (HULK or BlRK to NARK), and of the second, 14 (LAZY, FAZE or RAZE to LATS). Next in size are three fragments with 18 to 21 words apiece; all are shown on the next two pages.

Can these networks be joined into a single network? ZONE can be joined to FINK (uniting the 98-word and 39-word networks) via ZONK (in 12000 Words) and ZINK (obsolete variant of zinc in Webster's Second). Similarly, RIFE can be joined to LONE (uniting the 39-word and 18-word networks) via RIZE (reformed spelling





of rise in Webster's Second), RITE, ROTE and LOTE. It appears very difficult to join the 42-letter network to any other one; a suitable word with F in the third position is the stumbling-block.

```
lazy
    faze----laze---raze
    fate----late
                      lute
                                       fine-fink
                                  lone-line-link-rink
               lank---lunk
                                       liny
               rank funk
                                  rins-lins-lits-lots-rots
                                       fins-fits ruts-runs
                                       fons
                                       funs-fans-fats-lats
              bids
    bads-buds-bods-hods-nods-tody-tidy
         boxy-body-bode-bide-hide-nide-tide
                        vide
                                  node
                                  nude
    ribs-libs-fibs
                                       lory
    robs-lobs-fobs
                             luxe-lure-lore-lire
    rubs
          fubs
                                       fore-fire-file-fife
    ruby
                                       fork
                                                      life
    rube-lube
                                       fo1k
                                                      rife
    robe-lobe
                                                      rile
    rove-love-live-five
                                                      role
opy_rope-lope
                                                      rule
    ripe
                                                      rale
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What happens to the network if words not in the Official Scrabble Players Dictionary are allowed? Augmenting the OSPD list with words taken mainly from the Oxford English Dictionary to form a list of 7053 words, my computer found a network of 648 words with pattern cvcv; a portion of that network is given on the next page. The network has a span of 43, from pavy to dods or pavy to five. A key shortcut, bode-boxe-bore, is not shown. The OED gives boxe as an alternate for box; without it, the bode-bore distance is 8, and the span 49. Perhaps the reader can find other shortcuts.

rare

Consider what happens if the mandated distance between letters is four instead of six. The alphabet again divides into two groups of size 13, with all the vowels in one group:

Vowels (V) 
$$-A-E-1-M-Q-U-Y-C-G-K-O-S-W-No Vowels (C)  $-B-F-J-N-R-V-Z-D-H-L-P-T-X-D-T-X-D-$$$

If only OSPD words are used, the largest network with pattern cvcv has a size of 37 (two pages ahead) and a span of 15: T1RE-tine-pine-line-hire-here-hare-have-lave-pave-pare-pere-peri-perm-TERM. However, using the augmented list, the largest network contains 277 words, a part of which is shown below. The link nele-nehe-nede is not shown, but is used as part of the span of 25, from bite to term. Nipe-nile, ripe-rile and pipe-pile links are also not shown, but they are not part of the span.

Finally, consider what happens if the mandated distance between exchanged letters is twelve instead of six. The two alphabet groups:

```
dods
           pods
duds-juds-puds
dads
           pads
     judy
dady-jady-pady
dade-jade-pade-vade-bade-hade
dude
                     bude-hude-nude
dode
                     bode-hode-node-tode
dide
           pide-vide-bide-hide-nide-tide-zide-fide-lide-ride
           pixe
dire
           pire-vire-bire-hire
                                    tire
                                               fire
dore
           pore-vore-bore-hore-nore-tore-zore-fore-lore-rore
                                                               lole
dùre-jure-pure
                     bure-hure-nure-ture fure-lure-rure
                                                               lofe
           pare-vare-bare-hare-nare-tare-zare-fare-lare-rare
                                                               loze
dale-jale-pale-vale-bale-hale-nale-tale
                                               fale-lale-rale
                                                               lote
                          hafe
                                                    lafe-rafe
daze
                vaze-baze-haze-naze
                                               faze-laze-raze
date
           pate-vate-bate-hate-nate-tate
                                               fate-late-rate
                                               fane-lane-rane
dane-jane-pane-vane-bane-hane-nane-tane
           pune
                     bune-hune-nune-tune
                                               fune-lune-rune
done-jone-pone-vone-bone-hone-none-tone-zone-fone-lone-rone
           pony
                                               fine-line-rine lite
           pons
           pohs
      jobs-pobs
                                                    liny
 dibs-jibs
                                               fins-lins
 divs
                                               fons
 dips
                                               fohs
           pips
 dops
                                               fobs
           pops
 dopy
                                               fubs-lubs-rubs
 dope-jope-pope
                                                         ruby
      jupe
                                                    lube-rube
      jape-pape
                                                    lobe-robe
           pave
                                                    love-rove
                                               five-live-rive
           pavy
                     nipe-ripe
     beta-feta
                                          dite-hite-lite-pite-tipe-
                          rite
                                          dete-hete-lete-pete-tete
bite-bete-fete-jete-nete-rete
                                          date-hate-late-pate-tate
     bate-fate
                     nate-rate-vate
                jape-nape-rape
                                          dape-hape-lape-pape-tape
      bale-fale-jale-nale-rale-vale
                                          dale-hale-lale-pale-tale
                     nele-rele-vele-zele-dele-hele-lele-pele-tele
      bele-fele
      bile-file
                     nile-rile-vile
                                          dile-hile-lile-pile-tile-
                                               hihe
      bide-fide
                     nide-ride-vide-zide-dide-hide-lide-pide-tide
                                    zede-dede-hede-lede-pede-tede
                     nede-rede
      bede
                                          dade-hade-lade-pade-tade
      bade-fade-jade-nade-rade
                                          daze-haze-laze
                     naze-raze
                                               have-lave-pave
     -bine-fine
                     nave-rave
      bire-fire
                     nare-rare-yare-zare-dare-hare-lare-pare
                                                                    pina
      bere-fere-jere-nere-rere-vere
                                          dere-here-lere-pere-pire-pine
     -bene-fene
                                                         peri
                                                                    tine
                     nene-rene-vene
                                                         perm-term
bani--bane-fane-jane-nane-rane-vane
beni bare-fare
```

```
diva-deva
                                                      iive
tire
          live-hive-dive
                                                      five
tine
pine-line-lire-hire-dire-dine
                                                      fire-fine-bine
               here-dere-dene
                                                                bene
       daze
               hare-dare
                                                      fare-bare-bane
     hade-haze-have
                                                                fane
                          para
     lade-laze-lave-pave-pare-tare
                                                                jane
               lava
                          pane
                                pere-peri-perm-term
               leva
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Vowels (V) -A-M-Y-K-W-1-U-G-S-E-Q-C-O-No Vowels (C) <math>-B-N-Z-L-X-J-V-H-T-F-R-D-P-
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The largest network based on the augmented list contains 263 words and the span is 21; e--s links are significant. There are more cyclic links in this network than in the others, hence the shorter span. Nats, bahs, vats, hots, hahs and vote are all 21 links from lale.

```
rode-
lale-laze
                                    rope
lole-loze
                                    robe
                                              tons-
     lope-zone-none---bone-pone-done-rone-fone-tone-hone-vone
             -nane---bane-pane-dane-rane-fane
                                                  hane-vane-jane
              naze---baze daze-raze-faze
                                                   haze
              nale---bale-pale-dale-rale-fale-tale-hale-vale-jale
                     bole-pole-dole-role
                                          tole-hole-vole
lobs-lobe
lops-lope-zope-nope
                     bare-pare-dare-rare-fare-tare-hare-vare
     lore-zore-nore---bore-pore-dore-rore-fore-tore-hore-vore
     lofe
                                    rofe
     lote
             -note---bote-pote-dote-rote
                                             tote-hote-vote
                     bate-pate-date-rate-fate-tate-hate
              nats---bats-pats-dats-rats-fats-tats-hats-vats
                      bahs-pahs
                                         fahs
                                                   hahs
             -nots---bots-pots-dots rots
                                             tots-hots
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These networks are related to letter-shift words, discussed in earlier Word Ways. "Letter-Shift Words in the OSPD" (February 1990), based on a smaller database, noted that shift distances of 4, 6 and 12 produced the largest number of shifted pairs. Here are a few ideal (minimum) stepladders between shifted word pairs:

4-step: fang-fank-fenk-ferk-jerk, luna-puna-pune-pure-pyre, sawn-sewn-sean-sear-wear, open-spen-spin-spir-stir 6-step: lion-loon-loot-root-rout, joey-joky-joke-poke-puke, gulf-gull-gall-mall-marl, buff-huff-haff-hall 12-step: zips-lips-libs-lubs-lube, gobs-gons-gone-sone-sane, boas-baas-bams-bame-name