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Take the word TEA and transfer the last letter to the start, obtaining ATE. Repeat this operation on ATE to get its present tense, EAT. A final transfer returns us to the original word, TEA, completing the cycle. It is not difficult to find other examples using rarer three-letter words; in the July 1975 Games & Puzzles, Darryl Francis exhibited five more based on the letters AIT, ASP, EON, ETH and ICH (all fifteen words can be found in Chambers Twentieth Century Dictionary).

Cycles of four four-letter words are somewhat harder to find. In Language on Vacation (Scribner's, 1965), Dmitri Borgmann pointed out MELA-AMEL-LAME-ELAM, and Darryl Francis added ASER- SERA-ERAS-ASE in the Games & Puzzles article. As far as I know, no one has ever published a cycle of five five-letter words using no repeated letters.

In studying the many different ways in which one word can be transposed into another, it is necessary to restrict oneself to isograms -- words with no repeated letters -- to avoid ambiguity. In the May 1970 issue of Word Ways, a type collection of the 119 different possible five-letter transpositions was presented, followed in November 1977 by 719 six-letter examples. This article extends the idea of these earlier ones, pointing out that all transpositions can be classified into groups of the type TEA-ATE-EAT, in which the same transposition applied repeatedly to each successive letter-arrangement eventually brings one back to the letter-arrangement starting the sequence. In particular, we consider the feasibility of replacing letter-sequences with words (as was done above) for four-letter and five-letter sequences. We call such groups of transposed letter-arrangements transposition rings. Note that the concept of transposition ring includes as a special case the iterated cyclic transposals discussed in Language on Vacation.

The number and variety of transposition rings increases rapidly with the number of letters. Besides the one already illustrated, there are three other three-letter transposition rings, all of length two: abc-acb, abc-cba, and abc-bac. For four-letter words, there are three rings of length four and four of length three:

- abc-dcba-cdab-dabc  
- abc-dbac-dcda-cdab  
- abc-dcda-badc-cdab
Note that the rings of length three consist of one fixed letter and three letters that cycle in the abc-cab-bca manner. The six transpositions not listed (abdc, adcb, acbd, dbca, cbad, bacd) are all in transposition rings of length two.

Notice that the rings of length four contain various subrings of length two: abcd transforms into cdab which then returns to abcd, and bcdab and dabc likewise interchange. In general, any ring with a non-prime length will factor into subrings.

Interestingly, words can be substituted into every one of the above transposition rings:

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DOLI-IDOL-LIDO-OLID
ANTE-NEAT-ETNA-TAEN
ARST-TSAR-RATS-стра
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TAEN, ARST and SAIT are found below the line in Webster's First Edition (and the Oxford English Dictionary); all other words are in Webster's Second or Third (ETNA and ELSA are capitalized). No doubt readers can find examples using commoner words.

The words in each ring of length four can be rearranged to form a Latin word square (Word Ways, May 1975) -- a word square in which each letter appears exactly once in each row and column. However, not all Latin word squares correspond to transposition rings of the same length; the famous Latin-language example above consists of two transposition rings of length two.

There are a considerably larger number of different transposition rings of five-letter words, including ten of length six:

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abcd-bcdea-cdeab-deabc-eabcd
abcd-cadeb-dceba-ebdca-beacd
abcd-dabec-edacb-cedba-bcde
abcd-ecabd-daebc-bedac-cdeb
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in the abc
dixed and the abcd-bdac
conjuncti

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GO is a to
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2 OPT
3 ASP
4 AST
6 LAS
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abcd, and

with a non-

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There are no rings of length two or three for five-letter words except for subrings embedded in larger rings. In the rings of length six, two letters exchange positions with each other and three other letters cycle in the abc-bca-cab pattern. In the rings of length four, one letter stays fixed and the other four letters cycle in the abcd-bcda-cdab-dbca, abcd-bdca-cdab-dbca, abcd-bcda-cdab-dbca patterns presented in conjunction with four-letter transposition rings.

As might be expected, it is considerably harder to replace these letter-arrangements with words; a number of partial results are exhibited below. At least in theory, the first of the six transposition rings of length five should be somewhat easier to solve than the others -- it uses only five of the twenty possible bigrams (ab, bc, cd, de, ea), whereas each of the other five use fifteen of them, inevitably leading to rare bigrams. This theory is borne out by experience; a reasonably satisfactory solution has been found for the first transposition ring of length five, but no more than three words have been fitted into any of the others of length five:

ANGOR-RANGO-ORANG-GORAN-NGORA

NGORA is a town in Uganda, given in the Times Index-Gazetteer; RANGO is a town in Tibet, given in the 1947 Encyclopedia Britannica World Atlas and in the 1939 Hammond's New World Atlas. The other three words can be found in Webster's Second or Third Editions. Some typical partial solutions for other transposition rings:

2 OPTER-toerp-etrpo-REPO-TROPE
   ASLET-LETSA-etal-eates-STALET

3 ASPER-easrp-REAPS-PRESA-sprae
   GROAN-agron-NAGOR-onarg-RONGA

4 ASTEL-ltase-ealts-SLEAT-TESLA

6 LASTE-esta-ATLES-SLET-teen

ASTEL and ASLET are found in the OED, and LASTE in Funk & Wag-
nalls Unabridged; OPTER (one who opts) appears in no dictionary, but is a plausible coinage. The other capitalized words are all in Webster's Second or Third Editions.

It seems to be a little easier to find words for the transposition rings of length six; several partial solutions of four or more words are given below:

1. ORANG-ROGAN-organ-ROGAR-ORGAN-RONGA
2. STARE-TERAS-safe-TEARS-TEARS-ESRAT
3. PALES-SLEEP-PLEAS-SALEP-PEALS-PEALS-SEALT
4. SEALT is found in Webster's First Edition.

The transposition rings for six-letter words are too numerous to reproduce here; they are of lengths six, five and four. It is not too difficult to find transposition rings into which three words can be substituted (ABLEST-TABLES-STABLE-establ-estab-blesta), but only one four-word example is known:

STINGE-TINGES-INGEST-NGEST-GESTIN-ESTING

GESTIN is an obsolete variant of *gesten* found in Webster's First Edition.

Frank Ruff participates in the 1995 crossword
"Non-Cr
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MCPO, N
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