An Anagram Classification System

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Anagramming -- the transformation of one word into another by rearrangement of its letters -- is one of the oldest forms of word play, dating back hundreds of years. It is somewhat surprising that no one has attempted a systematic classification of anagrams. Allan R. Ball's The Nuttall Dictionary of Anagrams (Frederick Warne, 1937) lists approximately ten thousand words which can be anagrammed into other words, but it does not point out that the number of essentially different anagrams is far smaller. For example, the transformation of PROSE into SPORE is exactly the same as the transformation of OLIVE into VOILE -- both can be represented by means of the transformation abcd -> dacb (to save space, one can simply write this transformation as dacb, understanding that one starts with the letters in lexicographic order). In fact, there are exactly 119 ways in which the letters abcd can be rearranged; in general, a word of n letters can be arranged in exactly $n!$ different ways.

Can these transformations be arranged in a systematic fashion? Mathematicians tell us that any transformation of the type described above can be broken down into a number of non-overlapping cyclic permutations of letters. For example, in the transformation dacb -> abcd, the letters c and d do not change their positions in the word, and the letter a is replaced by b, the letter b is replaced by a, and the letter e is replaced by d. In other words, the transformation dacb consists of two cyclic permutations of length one (the letter c and the letter d permute into themselves), and one cyclic permutation of length three (the letters e, c and d). Similarly, the transformation baed consists of one cyclic permutation of length two (the letters b and c), and one cyclic permutation of length three (the letters e, c and d). The first transformation can be identified as a (1) (1) (3)-anagram, and the second as a (2) (3)-anagram. For words of five letters, there are 10 different (1) (1) (1) (2)-anagrams, 15 different (1) (2) (2)-anagrams, 20 different (1) (1) (1) (3)-anagrams, 20 different (2) (3)-anagrams, 30 different (1) (4)-anagrams, and 24 different (5)-anagrams.
Can examples be found for all these anagrams? The reader should note that the transformation of PROSE into SPORE yields the dacbe anagram, but the transformation of SPORE into PROSE yields the bdcae anagram—in other words, one obtains two distinct anagrams from a single example. However, this is not always the case; the transformation of CORAL into CAROL is the same as the transformation of CAROL into CORAL; both yield the adcb anagram. If no cycle in the transformation is longer than two, only one distinct anagram results. In order that the anagrams be unambiguously illustrated, it is necessary to insist that all words have no repeated letters.

The following table lists one or two examples for each of the 119 possible transformations of five-letter words into other five-letter words. Whenever an example yields two distinct anagrams, they are listed next to each other.

(1)(1)(1)(2)-anagrams

- abced  PARSE-PARES, ANGEL-ANGLE
- abdce  TRIAL-TRIAL, UNITE-UNTIE
- abedc  CARET-CATER, MOLAR-MORAL
- acbde  SLATE-STALE, ABODE-ADHOBE
- acedb  SPRAT-STRAP
- bacde  ARME-RAFFE, AMPLE-MAPLE
- cbade  MATES-TAMES, MELON-LEMON
- dbcae  CRATE-TRACE, PEARS-REAPS
- ebcda  AURIC-CURIA, ERUCT-TRUCE

(1)(2)(2)-anagrams

- acbed  BALER-BLARE, CARET-CRATE
- adebc  TALON-TONAL, BELOW-BOWEL
- aedcb  PLANES-PENAL, FERAL-FLARE
- badce  AMEND-MANED
- baced  LUCRE-ULCER
- badce  AMEND-MANED
- baedc  INERT-NITRE
- cbaed  PARSE-PARES, PALES-LAPSE
- cdaeb  AMBLE-BLAME, ASCOT-COAST
- ceadb  CRUEL-ULCER
- cbede  EARLY-LAYER
- dcaeb  PARTS-TRAPS, CIVET-EVICT
- dceab  LEAST-STEAL
- ebda  EOSIN-NOISE
- ebcd  TONUS-SNOUT
- edcba  PARTS-STRAP, REBUT-TUBER
(1) (1) (3) - anagrams

abdec-abced STEAL-STALE, CHAIN-CHINA
acdb-eadbc BROAD-BORD, PEALS-PALES-PLEAS
acedb-aecbd PLEAD-PEDAL
bcade-cabde BRAID-RABID, SPATE-PASTE
bcdae-dacbe SCALP-CLASP, SPORE-PROSE
becda-eadcb SPARE-Pears, TRACE-REACT
chdaeb-ebadc ARGON-GROAN
chbead-debac SABER-BARES, DOZEN-ZONED
dbce-ebadc GROWN-WRONG, TRUCE-CRUET

(2) (3) - anagrams

badec-bad e NITER-INERT, VOTER-OVERT
bcaed-bcede GLARE-LAGER, STARE-ASTER
bdaec-daebc SPEAR-PARSE, OCEAN-CANOE
bedca-cadbe CHIME-HEMIC, SPINE-PENIS
cdaeb-cadeb TRINE-INTER, STONE-ONSET
cdeba-ebade TABLE-BLEAT, RELAY-LAYER
cedae-daebc AMBER-BREAM, ANGEL-CLEAN
cdea-ebadc TRACE-CARET, SLATE-TALES
dceab-badec EXALT-LATEX, BEAMY-MAYBE
deba-ebdca STEAM-MEATS, SPAT-TRAPS

(1) (4) - anagrams

acde-baecd LEAPS-LAPSE, BEAST-BASTE
acdeb-adbec SATYR-STRAY
adebc-eadbc SLATE-STEAL, BREAK-BAKER
bcade-bcde SPARE-PARSE, NAMED-AMEND
beads-cadeb CHIME-HEMIC, SPINE-PENIS
bdace-acdbe BARMY-AMBRY, KNEAD-NAKED
bdce-aedbc SPRAT-PARS, SCARP-CRAPS
bead-cadeb PANES-ASPEN
becad-cadeb SLATE-LEAST
cbde-bcdeb DEBAR-BEARD, DIVAN-VIAND
chbead-dabec SIREN-RINSE, SOWER-WORSE
chbae-cabed MATES-TEAMS, RAPes-PEARS
cebad-beacd DEBAR-BREAD, FIBER-BRIEF
dbea-beadc LEARN-RENAL
decba-ebdca SPARE-REAPS, LANCE-CEP AL

Dmitri has suggested that the (1) (3) anagrams be provided by the (1) (4) anagrams of green letters, providing the switch,abeac and ebacd and

The anagrams provided are easy to find.
### (5) - anagrams

<table>
<thead>
<tr>
<th>Anagram 1</th>
<th>Anagram 2</th>
<th>Anagram 3</th>
<th>Anagram 4</th>
<th>Anagram 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>bcdea</td>
<td>eabcd</td>
<td>STALE</td>
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<td>STRAP</td>
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<td>bcdead</td>
<td>abcde</td>
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<td>OTHER</td>
<td>TRHOE</td>
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<td>bdaec</td>
<td>caebd</td>
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<td>LAPSE</td>
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<td>cdeba</td>
<td>abcde</td>
<td>REACT</td>
<td>CATTER</td>
<td>RUNCIN</td>
</tr>
</tbody>
</table>

Dmitri Borgmann, in his *Language on Vacation* ( Scribner's, 1965), has suggested names for several of these anagrams. The (5)-anagrams bcdea, cdeab, deabc and eabcd are all cyclic transpositions; the (1)(2)(2)-anagram edcba is a reversal; the (1)(1)(3)-anagrams adbce and acdbe are anchored transpositions; and the (1)(1)(1)(2)-anagrams abedc, adcbe, cbade, aecdb, dbcae and ebcdab are metalleges (the switch of two non-adjacent letters in a word). If one extends the definition of metallege to include the switch of two adjacent letters, then the (1)(1)(1)(2)-anagrams abedc, abdc, abec and cbde are added; if one extends the definition of metallege to include the switch of three non-adjacent letters, the (1)(1)(3)-anagrams edcba and cbdea are added.

The construction of an analogous table of examples for six-letter anagrams is a far more ambitious task — it is necessary to find examples for 719 anagrams. As a start on this task, the table below provides examples for 100 of the 120 possible (6)-anagrams, the ones of greatest logological interest. All examples can be found in either *Webster's Unabridged Dictionary* (3rd edition) or the *Oxford English Dictionary*. The reader is invited to try and fill in the blanks, not an easy task.

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<tr>
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<tr>
<td>bcdefa</td>
<td>abcde</td>
<td>STABLE</td>
</tr>
<tr>
<td>bcdafae</td>
<td>abcdfed</td>
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<td>bceaf</td>
<td>dbceaf</td>
<td>CATION</td>
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<td>bceaf</td>
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<td>dbfced</td>
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<td>cabfde</td>
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<td>cabfed</td>
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<td>bdeafc</td>
<td>cabdfe</td>
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</tr>
<tr>
<td>bdefac</td>
<td>eafbcd</td>
<td>ENRICH</td>
</tr>
</tbody>
</table>
SPIREA- PRAISE
CRATES- RECAST
STREAK- TASKER
THORAL- HARLOT
PHENOL- HOPLEN, CRAPED- REDCAP
SCATHE- CHEATS, SCARED- CEDARS
WHINGE- HEWING, BOATER- ORBATE
ASCENT- STANCE
AISLED- IDEALS, SPLINE- PENSL
SLIDER- IDLERS, SLOWER- OWLERS
SPRITE- RIEPST, VASTER- STARVE
VELOUR- LOUVRE
DEPART- PARTED, LAMENT- MENTAL
CAMELS- MESCAL, HOUNDS- UNSHOD
ALCOVE- COEVAL, DEACON- ACNODE
LADIES- DEASIL
SERVAL- RAVELS, TURBOS- ROBUST
AMBLED- BELDAM, TOPERS- PRESTO
BETRIM- TIMBRE, ESCROW- COWERS
CARTED- REDACT, LAPPED- PEDALS
OLEINS- ESLOIN
REBATO- BOATER, SLATER- ARTELS
RECTAL- CLARET
SAILLED- IDEALS, SACKER- CREAKS
SNIPED- PIENDS
STAPLE- PALEST, STARVE- RAVEST
LIRATE- TAILER, RELAND- ALDERN
REACTS- CASTER
TREPAN- PARENT, DONATE- ATONED
PROBED- BEDROP, SERANG- ANGERS
ARMFUL- FULMAR, TEAING- INGATE
CANTER- TRANCE, LIFTER- TRIFLE
SANTIR- TRAINS
DISBAR- BRAIDS
STAGER- GREATS
MANGER- ENGRAM, RENTAL- ANTLER
TINSEL- ENLIST
SCRAPE- PACERS, STROVE- VOTERS
edf
ebf
edfe
What is repeated? Is it a number or a letter? It finds the ten-letter cycle. 24
Can the reader continue?
edfcba-fedbac RELUCT-CUTLER, RETOPS-POSTER
efbcda-fcdeab DIVEST-STIVED, RAGEST-STAGER
efdbca-fdecab DEARTH-THREAD

What is the longest \( (n) \)-anagram for which an example having no repeated letters can be found? Turning to Language on Vacation, one finds the ten-letter example PLASTERING-REPLATINGS, and the eleven-letter example CLIDOSTERNA-DECLINATORS. An eleven-letter cyclic transposal is given by SPECULATION-PECULATIONS. Can the reader think of longer examples?

QUERY

Take four ordinary dice and inscribe the 24 faces with 24 different letters of the alphabet (omit, say, Q and Z). If the dice are rolled out on a table, there is a certain probability that the four upper faces can be rearranged to form a word. How should the 24 letters be placed on the dice in order to (1) minimize, or (2) maximize the probability that a word can be formed? How does one maximize this probability if one is not restricted to 24 different letters (that is, can repeat letters)? This problem is related to Word Chess but appears to be more difficult.