WORDS FROM DICE

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Word games such as Boggle consist of letters on the faces of dice. Usually one rolls the dice and tries to form a word out of the upward-facing letters. However, another game leads to interesting logological challenges: draw the dice one at a time out of a bag, the first die then turned over to yield the first letter of a word, the second die to yield the second letter, and so on.

Let us fix ideas with a simple example—three dice with 18 different letters, the objective being to form a three-letter word no matter what order the dice are drawn. Almost any assignment of letters will do:

A O N D P C E R S L Y M I T H U D B

yields ART if the dice are drawn 123, ATE if drawn 132, RAT if drawn 213, ETA if drawn 132, TAR if drawn 312, and TEA if drawn 321. (In fact, only the four letters AERT have been used.)

It is still easy to arrange 24 different letters on four dice so that words always can be formed:

B C G L N P D E H I J S A K T V W X F M O R U Y

1234 pear 2134 spar 3124 also 4123 flirt
1243 pert 2143 spot 3142 aloe 4132 opts
1324 lair 2314 sago 3214 wily 4213 melt
1342 pare 2341 harp 3241 viol 4231 meal
1423 grit 2413 hula 3412 arch 4312 face
1432 lute 2431 soap 3421 trip 4321 rasp

The six letters BDJKNX were not used.

It is a significantly more difficult logological problem to arrange 26 letters and four blank spaces on five dice so that a word can be formed no matter the order in which the dice are removed from the bag. There are 120 different words to be found, corresponding to the 120 different orders that dice may be drawn. To maximize the number of theoretically-possible words, the letters should be allocated 6,5,5,5,5 to the dice, yielding 3750 combinations.

How should the individual letters be assigned? A reasonable strategy is to ensure that the best final-letter choices such as E, S, Y, N and R are allocated to different dice. Furthermore, vowels should be spread around, not concentrated on one or two dice, to minimize the occurrence of impossible consonant clusters. It turns out that it is just barely possible to find a complete set of 120 words if one is restricted to boldface entries in either the second or third editions of the Merriam-Webster Unabridged Dictionary (or in the Merriam-Webster Collegiate Dictionary). Plurals and past tenses of words are allowed, as are single words from two-word phrases such as KOL NIDRE or MINKE WHALE. RALO (pluralized below) is found only in the Measures section, it being a Yugoslavian measure of area. It was necessary to admit HIDRO-, a hyphenated prefix, but the line was drawn at reformed spellings!

The allocation used was
Note that J has not been used.

What allocation of letters to six dice generates the greatest number of words? With 720 words to be found, this is an extraordinarily difficult problem, best left to the computer. It seems unlikely that a complete set of words can be found, even using computer-based sources like the Oxford English Dictionary and the United States Board of Geographic Names.

One can generalize the dice problem by allowing letters to appear more than once, with the proviso that all words must be different. For example, what set of 36 letters produces the greatest number of six-letter words? A computer can be programmed to perform a hill-climbing strategy: find the number of words corresponding to a given allocation of letters, then change a single letter and see if a larger number of words result. Unfortunately, there are a very large number of ways one can change a single letter!

One can also generalize the dice problem by asking for that allocation of letters that minimizes the number of words formed with respect to a specified dictionary. For three-letter words, one can ensure that no Websterian words are formed by excluding the five vowels plus Y, plus a couple of common consonants. For four-letter words, after excluding a couple of common vowels such as A and E, one places the six rarest consonants on one die and the remaining vowels plus two common consonants on a second die. However, it is impossible to eliminate all Websterian words, even restricted to the Pocket Dictionary.