PAN-CRASHING WORD SETS

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Two words of the same length are said to crash with each other if they contain the same letter in the same position; thus, TORUS and SNOTJT crash because both have the letter U in the fourth position, but GUFAW and MAIDEN do not. FIGHT and MIGHT crash in several positions simultaneously.

Consider a list of words, all of the same length, such as might be obtained from a dictionary. What is the smallest set of words that can be taken from this list with the property that every word in the list crashes with at least one word in the set? To echo the title of this article, what is the smallest pan-crashing word set? For example, if the word list is ARE FOR THE HIS HER CAN ONE EAR WAS AND, a pan-crashing word set is WAS ARE HER: FOR crashes with HER, THE with ARE, HIS with HER, CAN with WAS, ONE with ARE, EAR with WAS (or HER), and AND with ARE.

In general, such a word set is not unique; there are many different ones that will do the job. In fact, there are likely to be many sets that collectively have no words in common.

Two general questions have motivated this study: (1) how does the size of the smallest pan-crashing word set vary with the length of the word? (2) how does the size of the smallest pan-crashing word set vary with the size of the original list? The second question is somewhat harder to investigate than the first, because large word lists are hard to compile and unwieldy to check for crashes, unless a digital computer is available.

More generally, one can abandon the requirement that the words in the pan-crashing set come from the words of the list. Instead, one can ask for the best set of letters in each position which collectively crash all the words on the list -- in the earlier example, (AH) in the first position, (A) in the second, and (ER) in the third. To avoid the trivial solution of (AB...Z) in one position, we require that two or more positions be represented with letters. Once this is satisfied, that letter set having the fewest total letters is judged the best.

For our word list, we have taken the Merriam-Webster Pocket Dictionary, allowing any word (other than those labeled as abbreviations) which appears there in boldface type; thus, common plurals, past tenses and gerunds not separately specified are excluded. From this dictionary, we have taken lists of three through eight letters.

The three- & four-letter words are the most interesting. In the three-letter words, the minimum pan-crashing word set is all ear good a ils ey e eye.

As the length of the word list increases, the size of the minimum pan-crashing word set increases, but only fairly easily for word length between seven and eight. For word length six, for which one considers for example,爱美 does not crash a ere, chore ledge, adieus bea, a reaway Ear, brev iary e.

A few words of length five, whose best strategy for vowels in a no penultimate, penultimate, or six-letter word set Dictionary was batEAx, pit, seqUOa and se, it is necessary that none of the are in the pan-crashing set.

Having considered lists of three through eight letters,
The three-letter pan-crashing word set is perhaps the most interesting one of all, for its length depends upon which edition of the Pocket Dictionary is used. The 1964 edition lists TNT and DDT as nouns (not abbreviations), despite the fact that they are capitalized and are pronounced by spelling out the letters; the 1974 edition adds at least two more, VIP and IOU. It is unfortunate that the size of the minimum pan-crashing word set apparently depends upon whether or not one considers IOU to be a word:

all ear goo ire nth out pen sly (1964 edition)
all eye IOU may out pro sea (1974 edition)

As the length of words taken from a given dictionary increases, the size of the minimum pan-crashing word set slowly decreases. For three-letter words, the minimum pan-crashing set is on the line between seven and eight words. Pan-crashing sets of size seven can be fairly easily found for words of length four, five and six, and sets of size six, for words of length seven and eight:

aeon does fiat maul once puny trio
chore lemon mousy naïad plous quail sleet
adieu beanie cocoon laurel queasy ritual Taoism
areaway Bedouin gaseous sataine thereon unquiet
breviary employee Ghanaian gorgeous playsuit sturgeon

A few words about methodology may be in order here. As the word-length became larger (five or more), trial and error revealed that the best strategy for constructing a pan-crashing word set was to make sure that E and Y appeared in the final letter position, and that the vowels A, E, I, O and U all appeared in the three preceding positions. It turned out that the number of words in the dictionary list not containing at least one of these letters in the appropriate position was quite small; for example, the eight-letter exceptions were amethyst, babushka, catalyst, draughts, paroxysm, penumbra, strength and triptych. These could be readily accommodated by picking matching letters in the early part of a pan-crashing word, or at the end of one.

It turned out to be important to look for pan-crashing words with vowels in as many of the three critical positions (penultimate, preantepenultimate) as possible. The reason that the pan-crashing word set decreased from seven to six for words of seven or eight letters was the sudden increase in words of this type: for six-letter words the only all-vowel trigram in boldface type in the Pocket Dictionary was adIEUs, but for seven-letter words the trigrams batEAUX, pitEOUs, serIOUs, bivOUAc, BedOUIn, liQUEUr, requIEm, seqUOia and sinUOUs all appeared. In order to construct a six-word set, it is necessary that three of the words have all-vowel trigrams, and that none of these trigrams crash with each other.

Having constructed pan-crashing word sets for dictionary lists of three through eight letters, it was not too difficult to adapt the method-
logy to find pan-crashing letter sets as well. Here are the best (minimum number of letters) sets known:

<table>
<thead>
<tr>
<th>letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 19 (aegiops) (aeiortu) (eotuy)</td>
</tr>
<tr>
<td>4 17 (aeiou) (aeiouy) (aeiouty)</td>
</tr>
<tr>
<td>5 22 (ae) (aeiou) (aeiouy) (aeiouty)</td>
</tr>
<tr>
<td>6 23 (ir) (aeiou) (aeiouy) (aeiou)</td>
</tr>
<tr>
<td>7 22 (a) (aeiou) (aeiou) (aeiouy)</td>
</tr>
<tr>
<td>8 20 (eu) (aeiou) (aeiouy) (ey)</td>
</tr>
</tbody>
</table>

These letter sets are not unique; other combinations with the same total of letters can be found.

What about larger dictionaries? Webster's Collegiate may not be enough larger than the Pocket Dictionary to furnish a good test of the effect of dictionary size, but Webster's Unabridged is so large that hand-searching for pan-crashing sets is extremely hard. (For five-letter words, a pan-crashing set of size seven has been proposed by Garry Crum in the May 1972 Word Ways -- AYOUS EOSIN I-HEAD MIAOU OUIJA SEUGH UAYEB -- but it is uncertain that this has been thoroughly checked against the Big Web.) Britshers have an advantage in studying the effect of dictionary size, for Chambers Twentieth Century Dictionary is intermediate in size between Webster's Collegiate and Webster's Unabridged. Kevin Rutherford of Derby, England has found the following pan-crashing word sets (1972 edition):

- aia cay eye IOU Leo ord pin ugh
- aery euoi ciao oye s soil taut unce
cleep falyry iyyar jeton pious quail souse
Aizoon ecurie feodal gaiety noyaus plaint queued
acantha bedouin dubious faraday pileate thereof unquiet
breviate epopoeia Ghanaian lifebuoy nauseous totalled

Apparently the size of the pan-crashing set does not depend strongly upon the size of the dictionary. His words possess an added property not required of pan-crashing word sets: they do not crash each other.

For pan-crashing letter sets, he found:

<table>
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</tr>
<tr>
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</table>

Pan-crashing word sets guarantee a crash between one or more members of the set and each word in the list. A related, but far harder, problem is to construct a unique pan-crashing word set: one for
which each word in the list has a unique crash pattern. For example, if EMBRYO crashes with the first, fifth and sixth words of the set but with none of the others, then no other word in the list is permitted to crash with only the first, fifth and sixth words. It is not hard to show that, if the list has between \(2^n-1\) and \(2^n\) words, a unique pan-crashing set must be at least of length \(n\); however, it is likely that the minimum possible unique set will actually be somewhat larger than this.

Alternatively, one can construct a list of \(2^n\) words having a unique pan-crashing set of \(n\) words. For example, if \(n\) equals three,

Examples for somewhat larger values of \(n\) ought to be possible to construct.

Suppose, finally, that the word list is selectively constructed so that the smallest pan-crashing set is identical with the list; how large a list can one find with this property? This problem is equivalent to one already formulated by Dmitri Borgmann in Beyond Language (Scribner's, 1967): construct a list of mutually non-crashing words. The best Pocket Webster examples (taken from the May and August 1973 issues of Word Ways) are:

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add bra car dew ebb fly gnu hit imp jog nth owl pyx run ski
use who
ammo czar etch fizz husk ikon know lynx newt ogle plum
raja twig Urdu whys spry yogi
angst bluff coypu drink ethyl fjord gizmo helve ictus lynch
oxbow psalm rumba sprig thegn udder wacky
asthma blazon cystic embryo freeze guffaw hiccup knobby
length madder oblong scruff toward uphill whilst
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