Bigram statistics for 205 five-letter words having single-solution anagrams

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To assist research in anagram solving, this paper presents bigram statistics for 205 five-letter words known to form single-solution anagrams. Imagery, concreteness, age-of-acquisition, familiarity, and meaningfulness values for these words have previously been published. The bigram statistics presented here include the bigram rank and GTZERO measures recently devised and tested by Mendelsohn (1976).

A considerable number of solution word attributes have been implicated in anagram solving. Research in this area needs large collections of words measured on relevant attributes so that suitable word samples can be drawn. Gilhooly and Hay (1977) presented imagery, concreteness, age-of-acquisition, familiarity, and meaningfulness values for 205 five-letter words taken from Olson and Schwartz's (1967) list of words having single-solution anagrams. The Gilhooly and Hay list did not include bigram measures, but some recent research (Mendelsohn, 1976; Mendelsohn, & O'Brien, 1974) has uncovered two influential measures based on bigram frequencies that should be taken into account in using such lists. This paper reports the relevant bigram measures for the words in the Gilhooly and Hay list.

The first of these new measures is the total bigram rank, allowing for bigram position and word length. Mendelsohn (1976) labeled this variable "BR." The measure is obtained using Mayzner and Tresselt's (1965) tables in the way explained by Mendelsohn and O'Brien (1974). For five-letter words, the method involves drawing up a bigram frequency matrix of 20 rows and four columns for each word. In the matrix, the rows represent the 20 possible bigrams that can be formed from five different letters and the columns represent the four bigram positions in a five-letter word. From Mayzner and Tresselt's tables the frequency of each of the 20 possible bigrams in each of the four positions is obtained. Then the number of entries in the matrix that have higher frequencies than the four correct entries is obtained. The resulting number is the BR score for the word. This measure was found to be highly predictive of anagram difficulty (Mendelsohn, 1976; Mendelsohn & O'Brien, 1974), in that low BR facilitated solution. Presumably, this was because the greater the relative frequency of occurrence of correct bigrams, within the set of bigrams that can be made from a given

word, the more likely the subject is to generate a correct bigram as a memory probe.

The second measure is the number of nonzero entries in the bigram frequency matrix. Mendelsohn (1976) found a separate negative effect on anagram solving for this variable (which he labeled "GTZERO").

The negative correlation between GTZERO and solution rate probably arises because the greater the number of nonzero entries, the fewer the bigram possibilities that can be ruled out and the larger the set of plausible bigrams to be searched for the correct ones.

Gilhooly and Johnson (1978) confirmed the importance of BR and GTZERO in predicting anagram difficulty and also found that rated age of acquisition and familiarity were correlated significantly with BR. Apparent age effects on anagram solving dwindled when BR was partialled out. Given the importance of BR and GTZERO, and their possible confounding with other variables, it follows that these measures should be taken into account in future anagram studies. However, as will be apparent from the foregoing description, the procedure for obtaining the BR and GTZERO scores by hand is tedious, time consuming, and prone to error. To overcome this problem a FORTRAN program (PROG.BR) was written that does all the necessary table searching and calculations for five-letter strings. The program was applied to the 205 words of the Gilhooly and Hay (1977) list to produce the bigram statistics listed in the Appendix. These additional statistics should add to the usefulness of the Gilhooly and Hay list, especially for anagram studies.

The program incorporates Mayzner and Tresselt's (1965) frequency data for all bigrams in Bigram Positions 1-4 of five-letter words. When a five-letter string is input, the program draws up the complete 20 by 4 bigram frequency matrix for that string. Optionally, the program will output any or all of the following, (1) the complete 20 by 4 matrix, (2) the correct bigram frequencies, (3) the total correct bigram frequency, (4) the BR score, and (5) the GTZERO score. The output of the program was checked against a sample of 80 hand-scored words and proved completely accurate.

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Table 1
Bigram Measures: Correlations and Summary Statistics

Bigram Measure		1	2	3	4	5	6	7
1	BFOT	1.00	.59*	.64*	.47*	.57*	-.60*	.01
2	BF1		1.00	.39*	.09	.01	-.35*	-.09
3	BF2			1.00	.07	-.02	-.42*	-.05
4	BF3				1.00	.07	-.39*	.05
5	BF4					1.00	-.25*	.09
6	BR						1.00	.44*
7	GTZERO							1.00
	Mean	148.86	31.71	41.67	30.64	44.83	52.04	37.90
	SD	108.96	39.90	52.30	38.99	59.43	31.87	7.97

*Indicates correlations significant at the .05 level, on a two-tailed test with $df = 203$.

Table 2
Correlations Between Bigram Measures and Word Attributes

	BFTOT	BF1	BF2	BF3	BF4	BR	GTZERO
Imagery	.15*	.14*	.11	-.00	.08	-.09	-.05
Concreteness	.14*	.12	.07	-.01	.12	-.05	-.04
Age of Acquisition	-.32*	-.20*	-.25*	-.09	-.18*	.35*	.13
Familiarity	.33*	.19*	.27*	.16*	.14	-.38*	-.10
Meaningfulness	.26*	.17*	.15*	.11	.16*	-.22*	-.03
Thorndike-Lorge Frequency	.43*	.19*	.36*	.23*	.19*	-.39*	.02

*Indicates correlations significant at the .05 level, on a two-tailed test with $df = 203$.

The program accepts any number of five-letter strings and a listing can be obtained from the author.

RESULTS AND DISCUSSION

In addition to BR and GTZERO scores, the frequencies of the four correct bigrams (BF1, BF2, BF3, BF4) and the total frequency of the correct bigrams (BFTOT) are presented for each word in the Appendix. Experimenters may wish to take these into account as well as the newer measure defined by Mendelsohn (1976).

The summary statistics and intercorrelations of the bigram measures are given in Table 1. The BR-GTZERO correlation matches that obtained by Mendelsohn (1976).

In Table 2 are presented correlations between the bigram measures and the word attributes previously reported by Gilhooly and Hay (1977). The relevant correlations closely match those obtained in the subsample of 80 words examined in Gilhooly and Johnson's (1978) anagram study. Notably, the correlation of BR with age is maintained in this larger sample at about the same level as before.

Appendix

The following is an alphabetical listing of the 205 words together with each word's frequency on Bigrams 1, 2, 3, 4 (BF1-BF4), total correct bigram frequency (BFTOT), bigram rank (BR), and GTZERO (GT0).

Word	BF1	BF2	BF3	BF4	BFTOT	BR	GT0
AGONY	19	0	66	13	98	60	45

Word	BF1	BF2	BF3	BF4	BFTOT	BR	GT0
ALBUM	38	0	0	0	38	120	40
ANKLE	4	0	0	59	63	129	47
APRON	6	0	5	1	12	149	51
BANJO	15	38	0	0	53	69	31
BATCH	15	47	14	126	202	35	32
BATON	15	47	2	1	65	90	46
BENCH	41	12	27	126	206	22	27
BERTH	41	10	32	66	149	57	37
BIGOT	13	101	2	8	124	48	38
BIRCH	13	70	3	126	212	29	29
BITCH	13	9	14	126	162	36	32
BLACK	18	56	51	37	162	15	30
BLADE	18	56	15	11	100	61	46
BLAZE	18	56	2	2	78	67	35
BLIMP	18	17	8	3	46	34	36
BLOCK	18	67	7	37	129	22	28
BRAND	49	50	38	51	188	12	37
BRAWL	49	50	0	0	99	68	32
BRICK	49	49	129	37	264	9	32
BRINE	49	49	142	27	267	35	48
BRINK	49	49	142	34	274	9	32
BUNCH	26	16	27	126	195	7	17
BUYER	26	0	3	253	282	58	31
CABIN	29	6	1	32	68	62	41
CABLE	29	6	5	59	99	73	44
CAIRN	29	21	12	6	68	82	54
CHAIR	40	33	40	73	186	35	44
CHALK	40	33	27	0	100	49	29
CHILD	40	194	90	160	484	5	29
CHIME	40	194	8	5	247	47	41
CHIMP	40	192	8	3	245	21	31
CHORD	40	78	36	23	177	21	34
CHUMP	40	4	3	3	50	32	22
CHUNK	40	4	59	34	137	15	21
CLAMP	43	56	5	3	107	46	36
CLASH	43	56	48	13	160	24	36
CLERK	43	12	152	1	208	54	39
CLOAK	43	67	4	20	134	42	41

Word	BF1	BF2	BF3	BF4	BFTOT	BR	GT0	Word	BF1	BF2	BF3	BF4	BFTOT	BR	GT0
CLOTH	43	67	11	66	187	35	38	IDLER	8	0	43	253	304	107	57
CLOWN	43	67	23	12	145	18	30	INDEX	1	21	41	0	63	92	42
CORGI	72	85	20	0	177	64	48	INPUT	1	0	0	92	93	120	44
COUNT	72	222	59	44	397	9	46	JUDGE	3	6	7	33	49	44	26
COUGH	72	222	8	6	308	26	31	JUICE	3	34	129	76	242	18	27
COVER	72	16	74	253	415	24	48	JOINT	2	65	142	44	253	29	40
CRAFT	20	50	0	3	73	81	41	KNAVE	13	1	19	45	78	77	40
CRAMP	20	50	5	3	78	60	39	KNIFE	13	2	2	0	17	112	39
CRANK	20	50	38	34	142	23	42	LARCH	36	51	3	126	216	34	36
CRAZE	20	50	2	2	74	82	40	LIGHT	36	101	94	95	326	11	33
CROFT	20	64	1	3	88	77	43	LIMBO	36	13	1	0	50	96	45
CROWD	20	64	23	3	110	40	35	LOGIC	23	2	7	18	50	65	40
CRUMB	20	14	3	5	42	28	26	LOVER	23	16	74	253	366	40	48
CRUSH	20	14	22	13	69	26	33	LUNCH	4	16	27	126	173	23	22
CRYPT	20	0	0	4	24	57	23	LYRIC	4	0	2	18	24	85	33
DEMON	15	2	1	1	19	128	49	MAJOR	38	6	10	27	81	51	39
DEPTH	15	4	6	66	91	61	38	MAKER	38	33	57	253	381	26	48
DIVOT	9	36	1	8	54	76	42	MATCH	38	47	14	126	225	27	35
DOUBT	18	222	7	2	249	47	37	MEDAL	16	1	10	35	62	104	52
DRAWL	25	50	0	0	75	87	38	MERCY	16	10	3	0	29	79	34
DRINK	25	49	142	34	250	14	39	MIDGE	36	9	7	33	85	52	43
DRUNK	25	14	59	34	132	8	33	MINCE	36	27	27	76	166	24	49
DUNCE	6	16	27	76	125	44	41	MINER	36	27	24	253	340	44	55
ENTRY	14	9	1	50	74	91	42	MIRTH	36	70	32	66	204	26	38
FAIRY	15	21	12	50	98	41	36	MIXER	36	3	7	253	299	60	43
FAITH	15	21	31	66	133	44	38	MONTH	48	32	22	66	168	31	31
FANCY	15	38	27	0	80	36	27	MOUTH	48	222	22	66	358	25	35
FAULT	15	7	131	15	168	57	44	NYMPH	1	1	4	2	8	28	14
FIGHT	63	101	94	95	353	9	28	ODIUM	3	0	0	0	3	154	43
FILTH	63	27	3	66	159	38	33	OPERA	2	26	152	2	182	98	56
FINCH	63	27	27	126	243	16	23	OPIUM	2	3	0	0	5	141	46
FLAKE	22	56	3	13	94	58	37	ORBIT	10	3	1	10	24	124	52
FLAME	22	56	5	5	88	73	44	OUNCE	6	16	27	76	125	46	46
FLANK	22	56	38	34	150	16	29	OVARY	0	0	102	50	152	79	40
FLASH	22	56	48	13	139	24	30	PANIC	30	38	1	18	87	55	44
FLASK	22	56	48	0	126	38	32	PERCH	2	10	3	126	141	71	39
FLIRT	22	17	12	26	77	59	41	PILOT	10	27	9	8	54	74	56
FLUKE	22	20	0	13	55	45	30	PITCH	10	9	14	126	159	37	40
FORCE	31	85	3	76	195	43	46	PIVOT	10	36	1	8	55	68	46
FORUM	31	85	2	0	118	71	39	PLANK	27	56	38	34	155	14	32
FOVEA	31	16	74	0	121	52	36	PLANT	27	56	38	44	165	13	40
FRAUD	16	50	0	7	73	67	42	PLUCK	27	20	12	37	96	10	21
FRONT	16	64	66	44	190	21	42	PLUME	27	20	3	5	55	57	43
FROWN	16	64	23	12	115	29	30	PORCH	31	85	3	126	245	28	38
FRUIT	16	14	4	10	44	75	46	PRANK	19	50	38	34	141	17	35
GAUZE	7	7	0	2	16	76	29	PRAWN	19	50	0	12	81	50	32
GLAND	15	56	38	51	160	20	41	PRIZE	19	49	2	2	72	74	40
GLEAM	15	12	75	6	108	72	46	PRUNE	19	14	59	27	119	37	45
GLINT	15	17	142	44	218	27	38	PYLON	0	0	9	1	10	104	35
GLORY	15	67	36	50	168	19	34	QUERY	27	10	152	50	239	20	24
GLOVE	15	67	17	45	144	27	39	QUILT	27	34	90	15	166	20	33
GNOME	0	9	1	5	15	119	45	RANCH	23	38	27	126	214	26	37
GRAFT	41	50	0	3	94	70	39	RHYME	0	0	0	5	5	105	30
GRANT	41	50	38	44	173	19	49	RIVET	50	36	74	18	178	48	52
GRAPH	41	50	8	2	101	49	37	ROWER	23	9	10	253	295	76	54
GRAVE	41	50	19	45	155	46	45	RUGBY	13	4	0	2	19	58	25
GRIEF	41	49	30	6	126	59	43	SCARF	7	0	102	1	110	73	32
GROUP	41	64	107	6	218	23	46	SCOUT	7	2	107	92	208	58	44
GUARD	14	3	102	23	142	51	51	SCRUM	7	1	2	0	10	94	32
GUILT	14	34	90	15	153	32	41	SCYTH	7	0	0	66	73	64	25
HAVEN	22	9	74	75	180	43	36	SHAWL	62	33	0	0	95	69	32
HAVOC	22	9	1	0	32	77	32	SNACK	0	1	51	37	89	70	38
HONEY	59	32	24	20	135	30	35	SQUIB	1	2	4	0	7	77	25
HORDE	59	85	12	11	167	57	44	STYLE	136	7	7	59	209	57	42
HOUND	59	222	59	51	391	9	33	TEMPO	20	2	4	1	27	110	53
HOUSE	59	222	22	149	452	19	37	THIEF	302	194	30	6	532	38	42
HOVEL	59	16	74	10	159	38	36	THUMB	302	4	3	5	314	33	21
HYENA	0	0	20	5	25	111	37	TOKEN	27	8	57	75	167	37	47

Word	BF1	BF2	BF3	BF4	BFTOT	BR	GT0
TRAMP	45	50	5	3	103	64	44
TREND	45	61	20	51	177	39	48
TRICK	45	49	129	37	260	9	42
TRUCK	45	14	12	37	108	16	34
TRUMP	45	14	3	3	65	48	36
TULIP	2	23	6	1	32	98	47
UNCLE	25	0	0	59	84	91	41
UNITY	25	2	31	23	81	47	38
VALET	4	31	43	18	96	77	47
VAULT	4	7	131	15	157	56	38
VENOM	1	12	1	2	16	114	43
VICAR	8	5	3	13	29	93	44
VIPER	8	1	19	253	281	84	47
VIRUS	8	70	2	0	80	84	36
VISOR	8	10	0	27	45	97	42
VISTA	8	10	16	0	34	109	43
VIXEN	8	3	7	75	93	72	36
VODKA	13	11	0	0	24	78	31
WALTZ	42	31	3	0	76	47	27
WATCH	42	47	14	126	229	28	33
WENCH	16	12	27	126	181	32	32
WHARF	187	33	102	1	323	22	23
WHEAT	187	263	75	7	542	24	41
WIDTH	9	9	1	66	85	48	28
WITCH	9	9	14	126	158	43	31
WOMAN	163	45	23	40	271	12	42
WORLD	163	85	44	160	452	2	36
WOUND	163	222	59	51	495	4	38
WRECK	16	61	8	37	122	30	34
YOUTH	26	222	22	66	336	27	34

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