63-3-2

401 878

2900-374-R

Memorandum of Project MICHIGAN

RESPONSE BIAS EXPLANATION OF WORD-FREQUENCY EFFECT

CATALOGED BY ASTIA
AS AD No. 401878

DANIEL H. CARSON

ENGINEERING PSYCHOLOGY LABORATORY
Institute of Science and Technology
THE UNIVERSITY OF MICHIGAN

April 1963

Contract DA-36-039 SC-78801

ASTIA
RECEIVED
APR 22 1963
TISIA

Best
Available
Copy

2900-374-R

Memorandum of Project MICHIGAN

RESPONSE BIAS EXPLANATION OF WORD-FREQUENCY EFFECT

DANIEL H. CARSON

April 1963

Engineering Psychology Laboratory
Institute of Science and Technology
THE UNIVERSITY OF MICHIGAN
Ann Arbor, Michigan

NOTICES

Sponsorship. The work reported herein was conducted by the Institute of Science and Technology for the U. S. Army Electronics Command under Project MICHIGAN, Contract DA-36-039 SC-78801. Contracts and grants to The University of Michigan for the support of sponsored research by the Institute of Science and Technology are administered through the Office of the Vice-President for Research.

Note. The views expressed herein are those of Project MICHIGAN and have not been approved by the Department of the Army.

Distribution. Initial distribution is indicated at the end of this document. Distribution control of Project MICHIGAN documents has been delegated by the U. S. Army Electronics Command to the office named below. Please address correspondence concerning distribution of reports to:

Commanding Officer
U. S. Army Liaison Group
Project MICHIGAN
The University of Michigan
P. O. Box 618
Ann Arbor, Michigan

ASTIA Availability. Qualified requesters may obtain copies of this document from:

Armed Services Technical Information Agency
Arlington Hall Station
Arlington 12, Virginia

Final Disposition. After this document has served its purpose, it may be destroyed. Please do not return it to the Institute of Science and Technology.

PREFACE

Project MICHIGAN is a continuing, long-range research and development program for advancing the Army's combat-surveillance and target-acquisition capabilities. The program is carried out by a full-time Institute of Science and Technology staff of specialists in the fields of physics, engineering, mathematics, and psychology, by members of the teaching faculty, by graduate students, and by other research groups and laboratories of The University of Michigan.

The emphasis of the Project is upon research in imaging radar, MTI radar, infrared, radio location, image processing, and special investigations. Particular attention is given to all-weather, long-range, high-resolution sensory and location techniques.

Project MICHIGAN was established by the U. S. Army Signal Corps at The University of Michigan in 1953 and has received continuing support from the U. S. Army. The Project constitutes a major portion of the diversified program of research conducted by the Institute of Science and Technology in order to make available to government and industry the resources of The University of Michigan and to broaden the educational opportunities for students in the scientific and engineering disciplines.

Documents issued in this series of Technical Memorandums are published by the Institute of Science and Technology in order to disseminate scientific and engineering information as speedily and as widely as possible. The work reported may be incomplete, but it is considered to be useful, interesting, or suggestive enough to warrant this early publication. Any conclusions are tentative, of course. Also included in this series are reports of work in progress which will later be combined with other materials to form a more comprehensive contribution in the field.

Progress and results described in reports are continually reassessed by Project MICHIGAN. Comments and suggestions from readers are invited.

Robert L. Hess
Director
Project MICHIGAN

RESPONSE BIAS EXPLANATION OF WORD-FREQUENCY EFFECT

ABSTRACT

The word-frequency effect observes that, when presented in equally noisy conditions, words occurring more frequently in the language are identified correctly more often than words occurring less frequently. The response bias explanation avers that this finding is due solely to the tendency to respond more frequently with the common, or more frequent, words.

In a test of this explanation of word-frequency effect, printed five-letter words with letter deletions simulating different noisy conditions were used. The results show that a response bias model denying stimuli any role accounts for practically all of the variance in the word-frequency effect at high noise levels. The model, however, is internally restricted, and its efficiency is artifactual. Another formulation, based on the Brown and Rubenstein model, will be tested in a future experiment. This new formulation is multiplicative instead of additive, and is no longer internally restricted.

A response bias model developed by Brown and Rubenstein [1] denies stimulus any role in producing the word-frequency effect and instead assumes that, if the amount of noise present is the same, the percentage of correct responses to words in a given word-frequency class will be equal to the percentage of correct responses to words from any other word-frequency class having the same probability of response. According to this model, the probability of correct response $p(C)$ is merely a constant function b of the probability that the response to a word from a given word-frequency class will be correct—that is, $p(S_i, R_j)$, where $i = j$. Because the stimuli have a flat distribution, all incorrect responses of a given word-frequency class will also have a flat distribution across stimuli from other word-frequency classes. Of course, as S/N increases, the probability that stimulus and response will agree in word-frequency class increases too, as does the probability of correct response.

By knowing that equal numbers of the stimulus words presented are taken from each word-frequency class—that is, $p(S_i) = 1/n$; by knowing the probability that a response will be from a given word-frequency class, $p(R_i)$; and by knowing a constant c, one can predict the increase in word-frequency effect, b/n.

In an experiment conducted to test the Brown and Rubenstein model, 64 printed English words five letters long were used as stimuli (see Table I). Sixteen words were selected at random from each of four word-frequency classes determined by Thorndike and Lorge [2]. Median word frequencies of the classes were 0.5, 5.0, 50, and 500 words per million. One, two, three, or four letters were deleted from each word, in the patterns summarized in Table II. Thus there were 256 different stimuli.

Four groups, of 40 undergraduate Ss each, filled deletions in the 64 different words. Each group saw a different deletion pattern for each word but worked on all deletion patterns. Ss were instructed to respond with 64 different words. This instruction reduced the number of common-word responses, flattened the distribution across word-frequencies, and provided a sharper test of the model.

Results are summarized in Tables III and IV, and in Figures 1 and 2. The following points are noteworthy. (a) The data determining the b values show an excellent fit; see, in Table III, the regression of $p(C)$ on $p(S_i R_j)$ from the diagonal cells. (b) Plotting the distributions of incorrect responses from each of the four word-frequency classes gives a nearly flat curve; see the column distributions in Table III. (c) As Table IV shows, the predicted and the obtained regressions are very similar (the obtained slopes were taken from the column marginals in Table III).

TABLE I. WORDS USED ACCORDING TO WORD-FREQUENCY GROUP (WORDS/MILLION WORDS) (FROM REFERENCE 2)

0.5	5.0	50.0	500
inapt	envoy	grief	marry
shent	rigor	organ	voice
getup	probe	stove	smile
natty	niche	twist	month
caulk	chafe	porch	began
plumy	farce	queer	water
atomy	react	quote	heard
chump	hoary	merry	small
mares	silky	major	order
ascot	clamp	linen	price
faker	moody	shock	point
evict	booty	cruel	light
codes	lorry	brick	carry
julep	shyly	tooth	force
yodel	gruff	dying	heart
bilge	inlet	wreck	start

TABLE II. SAMPLES OF ALL DELETION PATTERNS

P_ _ _ _	RE_ _ _	HE_R_	SHOC_
_E_ _ _	_T_M_	_OOD_	PO_NT
_ _O_ _	_ _ _TE	_A_ER	_RUFF
_ _ _L_	*Y_ _ _L	*D_I_G	
*_ _ _ _T			

*These patterns were used in the actual experiment, but were not indicated since they were not comparable to the others in Table II.

TABLE III. PROBABILITIES (× 100) OF STIMULI (ROWS) AND RESPONSES (COLUMNS) BY FREQUENCY INTERVAL, p(C) is underscored.

	0.5	5.0	50	500
0.5	1.26, 0.12	7.19	10.08	6.09
5.0	0.73	5.60, 0.36	11.58	7.23
50	1.01	6.01	11.74, 0.60	6.17
500	0.69	5.89	11.38	7.11, 0.92
	3.69	24.69	44.78	26.58

(a) One letter given

0.5	2.11, 0.56	7.43	6.78	5.28
5.0	0.89	8.04, 1.62	10.32	5.77
50	1.26	5.52	12.72, 3.90	6.21
500	0.32	4.87	9.67	10.60, 1.66
	4.58	25.86	41.69	27.86

(b) Two letters given

0.5	9.38, 8.36	5.86	7.58	1.10
5.0	0.12	13.72, 10.63	6.96	4.18
50	0.72	5.66	16.63, 12.17	2.62
500	0.60	4.05	5.20	15.53, 11.53
	10.82	29.28	36.37	23.43

(c) Three letters given

0.5	15.64, 15.52	4.24	3.28	0.92
5.0	0.00	22.96, 22.04	2.08	0.00
50	0.08	2.32	21.92, 20.40	1.04
500	0.04	0.48	3.72	21.28, 19.88
	15.76	30.00	31.00	23.24

(d) Four letters given

TABLE IV. PREDICTED (b/n) VALUES AND OBTAINED (COLUMN MARGINAL) VALUES OF REGRESSION SLOPES

	Number of Letters Given			
	1	2	3	4
b/n	0.012	0.066	0.132	0.207
b' (data)	0.012	0.085	0.140	0.355

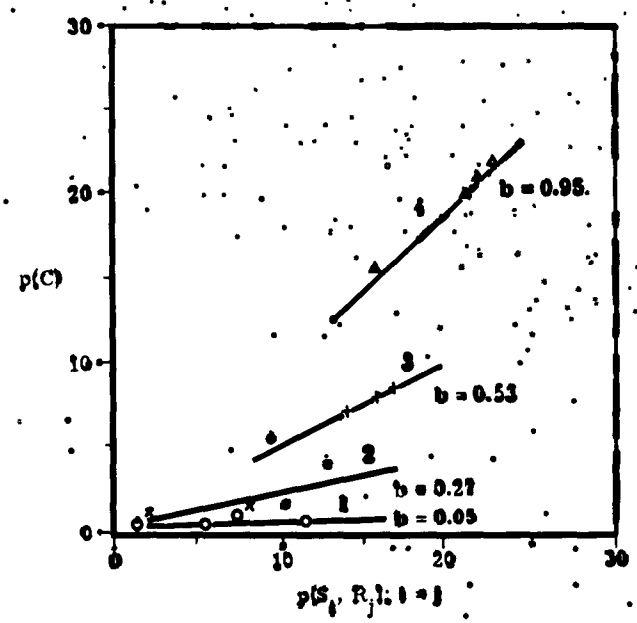

FIGURE 1. REGRESSION OF p(C) ON $p(S_i, R_j)$, FOR i = j. Internal parameter is the number of letters given in each word. p(C) = percentage of correct identifications, $p(S_i, R_j)$, where i = j, = percentage of response words agreeing in word-frequency class with stimulus words, $p(R_j)$ = percentage of response words in each word-frequency class.

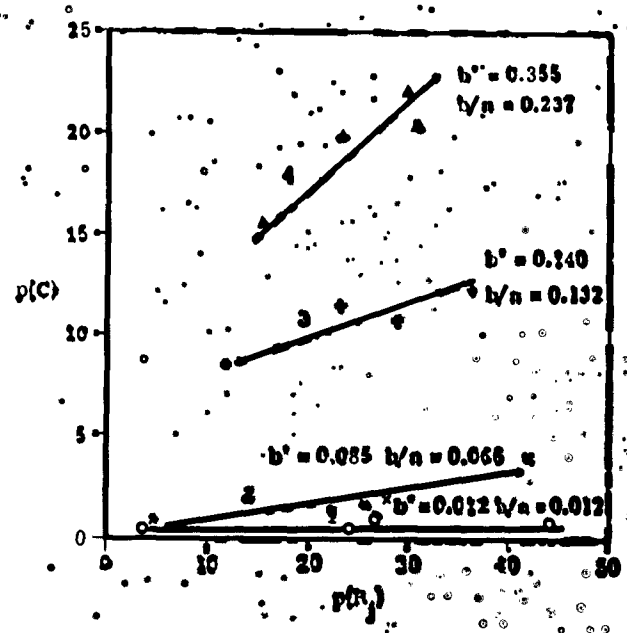

FIGURE 2. REGRESSION OF p(C) ON p(R_j). Interval parameter is the number of letters given each word. Slopes, b' and b/n, are the obtained and predicted values, respectively, given in Table IV.

REFERENCES

1. C. R. Brown and H. Rubenstein, "Test of Response Bias Explanation of Word-Frequency Effect," Science, 27 January 1961, Vol. 133, No. 3448, p. 280.
2. E. L. Thorndike and I. Lorge, The Teacher's Wordbook of 30,000 Words, New York, Teachers College, Columbia University, 1944.

PROJECT MICHIGAN DISTRIBUTION LIST 5
1 April 1963—Effective Date

Copy No.	Addressee
1	Commanding General U.S. Army Combat Surveillance Agency 1124 N. Highland Street Arlington 1, Virginia
2-3	Commanding General U.S. Army Electronics Command Fort Monmouth, New Jersey ATTN: AMSEL-RD
4-33	Commanding Officer U.S. Army Electronics R & D Laboratory Fort Monmouth, New Jersey ATTN: SELRA/ADT
34	Commanding General U.S. Army Electronics Proving Ground Fort Huachuca, Arizona ATTN: Technical Library
35-38	Director, U.S. Army Engineer Geodesy Intelligence & Mapping R & D Agency Fort Belvoir, Virginia (35) ATTN: Intelligence Division (36) ATTN: Research & Analysis Division (37) ATTN: Photogrammetry Division (38) ATTN: Strategic Systems Division (ENGGM-SSO)
39	Director, U.S. Army Cold Regions Research & Engineering Laboratory P. O. Box 282 Hanover, New Hampshire
40-41	Director, U.S. Army Engineers Research & Development Laboratory Fort Belvoir, Virginia ATTN: Technical Documents Center
42	Commanding Officer U.S. Army Research Office (Durham) Box CM, Duke Station Durham, North Carolina ATTN: Chief Information Processing Office
43	Assistant Commandant U.S. Army Air Defense School Fort Bliss, Texas
44	Commandant U. S. Army Engineer School Fort Belvoir, Virginia ATTN: ESSYA
45	Commanding Officer U. S. Army Intelligence Combat Development Agency Fort McHenry Baltimore 19, Maryland
46	Commanding Officer, U. S. Army Electronic Research Unit P. O. Box 205 Mountain View, California ATTN: Electronic Defense Laboratories
47	U.S. Army Research Liaison Office MIT-Lincoln Laboratory Lexington 73, Massachusetts
48-49	Office of Naval Research Department of the Navy 17th & Constitution Avenue, N.W. Washington 25, D. C. (48) ATTN: Code 463 (49) ATTN: Code 468
50	The Hydrographer U. S. Navy Hydrographic Office Washington 25, D. C. ATTN: Code 1640
51-52	Director, U. S. Naval Research Laboratory Washington 25, D. C. ATTN: Code 2021
53	Commanding Officer U. S. Navy Ordnance Laboratory Corona, California ATTN: Library
54	Commanding Officer & Director U.S. Navy Electronics Laboratory San Diego 52, California ATTN: Library
55	Commander, U.S. Naval Ordnance Laboratory White Oak Silver Spring, Maryland ATTN: Technical Library
56-60	ASTIA (TIPCR) Arlington Hall Station Arlington 12, Virginia
61-62	Commander Wright-Patterson AFB, Ohio (61) ATTN: ASD (ASRNCE) (62) ATTN: ASD (ASAPR-D) (63-64) ATTN: ASD (ASRNCE-1)
65-66	Commander, Rome Air Development Center Griffiss AFB, New York (65) ATTN: RAALD (66) ATTN: RAWIC (67) ATTN: RALSS
68-94	Central Intelligence Agency 2430 E. Street, N.W. Washington 25, D. C. ATTN: OCR Mail Room
95-96	Scientific & Technical Information Facility P. O. Box 5700 Bethesda, Maryland ATTN: NASA Representative
97-98	National Aeronautics & Space Administration Manned Space Craft Center Houston 1, Texas ATTN: Chief, Technical Information Division
99	Central Surveillance Project Cornell Aeronautical Laboratory, Incorporated P. O. Box 235 Arlington 10, Virginia ATTN: Technical Library
100	The Rand Corporation 1700 Main Street Santa Monica, California ATTN: Library
101	Research Analysis Corporation 6935 Arlington Road Bethesda, Maryland Washington 14, D. C. ATTN: Chief, Information and Control Systems Division
102-103	Cornell Aeronautical Laboratory, Incorporated 4455 Genesee Street Buffalo 21, New York ATTN: Librarian VIA: Bureau of Naval Weapons Representative 4455 Genesee Street Buffalo 21, New York

PROJECT MICHIGAN DISTRIBUTION LIST 5 (Continued)

Copy No.	Addressee
104	Columbia University Electronics Research Laboratory 632 W. 42th Street New York 27, New York ATTN: Technical Library VIA: Commander, Rome Air Development Center Griffiss AFB, New York ATTN: RCKCS
105	Coordinated Science Laboratory University of Illinois Urbana, Illinois ATTN: Librarian VIA: ONR Resident Representative 605 S. Goodwin Avenue Urbana, Illinois
106	The Ohio State University Research Foundation 1314 Kinnear Road Columbus 12, Ohio ATTN: Security Office VIA: Commander, Wright Air Development Division Wright-Patterson AFB, Ohio ATTN: ASRKSE
107-109	Jet Propulsion Laboratory California Institute of Technology 4800 Oak Grove Drive Pasadena, California VIA: NASA Western Operations Office 150 Pico Boulevard Santa Monica, California
110	Commanding Officer, U. S. Army Liaison Group Project MICHIGAN The University of Michigan P. O. Box 618 Ann Arbor, Michigan

AD Div. 28/1

Inst. of Science and Technology, U. of Mich., Ann Arbor
RESPONSE BIAS EXPLANATION OF WORD-FREQUENCY EFFECT by Daniel H. Carson. Memo of Project MICHIGAN. Apr. 63. 5 p. incl., tables, 2 refs. (Memorandum No. 2900-374-R)
(Contract DA-36-039 SC-78801)
(Project No. 3D5801001) Unclassified memorandum

The word-frequency effect observes that, when presented in equally noisy conditions, words occurring more frequently in the language are identified correctly more often than words occurring less frequently. The response bias explanation avers that this finding is due solely to the tendency to respond more frequently with the common or more frequent, words.

In a test of this explanation of word-frequency effect, (over)

UNCLASSIFIED

I. Title: Project MICHIGAN
II. Carson, Daniel H.
III. U. S. Army Electronics Command
IV. Contract DA-36-039 SC-78801
V. Project No. 3D5801001

Armed Services Technical Information Agency
UNCLASSIFIED

AD Div. 28/1

Inst. of Science and Technology, U. of Mich., Ann Arbor
RESPONSE BIAS EXPLANATION OF WORD-FREQUENCY EFFECT by Daniel H. Carson. Memo of Project MICHIGAN. Apr. 63. 5 p. incl., tables, 2 refs. (Memorandum No. 2900-374-R)
(Contract DA-36-039 SC-78801)
(Project No. 3D5801001) Unclassified memorandum

The word-frequency effect observes that, when presented in equally noisy conditions, words occurring more frequently in the language are identified correctly more often than words occurring less frequently. The response bias explanation avers that this finding is due solely to the tendency to respond more frequently with the common or more frequent, words.

In a test of this explanation of word-frequency effect, (over)

UNCLASSIFIED

I. Title: Project MICHIGAN
II. Carson, Daniel H.
III. U. S. Army Electronics Command
IV. Contract DA-36-039 SC-78801
V. Project No. 3D5801001

Armed Services Technical Information Agency
UNCLASSIFIED

AD Div. 28/1

Inst. of Science and Technology, U. of Mich., Ann Arbor
RESPONSE BIAS EXPLANATION OF WORD-FREQUENCY EFFECT by Daniel H. Carson. Memo of Project MICHIGAN. Apr. 63. 5 p. incl., tables, 2 refs. (Memorandum No. 2900-374-R)
(Contract DA-36-039 SC-78801)
(Project No. 3D5801001) Unclassified memorandum

The word-frequency effect observes that, when presented in equally noisy conditions, words occurring more frequently in the language are identified correctly more often than words occurring less frequently. The response bias explanation avers that this finding is due solely to the tendency to respond more frequently with the common or more frequent, words.

In a test of this explanation of word-frequency effect, (over)

UNCLASSIFIED

I. Title: Project MICHIGAN
II. Carson, Daniel H.
III. U. S. Army Electronics Command
IV. Contract DA-36-039 SC-78801
V. Project No. 3D5801001

Armed Services Technical Information Agency
UNCLASSIFIED

AD Div. 28/1

Inst. of Science and Technology, U. of Mich., Ann Arbor
RESPONSE BIAS EXPLANATION OF WORD-FREQUENCY EFFECT by Daniel H. Carson. Memo of Project MICHIGAN. Apr. 63. 5 p. incl., tables, 2 refs. (Memorandum No. 2900-374-R)
(Contract DA-36-039 SC-78801)
(Project No. 3D5801001) Unclassified memorandum

The word-frequency effect observes that, when presented in equally noisy conditions, words occurring more frequently in the language are identified correctly more often than words occurring less frequently. The response bias explanation avers that this finding is due solely to the tendency to respond more frequently with the common or more frequent, words.

In a test of this explanation of word-frequency effect, (over)

UNCLASSIFIED

I. Title: Project MICHIGAN
II. Carson, Daniel H.
III. U. S. Army Electronics Command
IV. Contract DA-36-039 SC-78801
V. Project No. 3D5801001

Armed Services Technical Information Agency
UNCLASSIFIED

AD

printed five-letter words with letter deletions simulating different noisy conditions were used. The results show that a response bias model denying stimuli any role accounts for practically all of the variance in the word-frequency effect at high noise levels. The model, however, is internally restricted, and its efficiency is artifactual. Another formulation, based on the Brown and Rubenstein model, will be tested in a future experiment. This new formulation is multiplicative instead of additive, and is no longer internally restricted.

UNCLASSIFIED

DESCRIPTORS

Verbal behavior
Applied psychology
Reaction

UNCLASSIFIED

AD

printed five-letter words with letter deletions simulating different noisy conditions were used. The results show that a response bias model denying stimuli any role accounts for practically all of the variance in the word-frequency effect at high noise levels. The model, however, is internally restricted, and its efficiency is artifactual. Another formulation, based on the Brown and Rubenstein model, will be tested in a future experiment. This new formulation is multiplicative instead of additive, and is no longer internally restricted.

UNCLASSIFIED

DESCRIPTORS

Verbal behavior
Applied psychology
Reaction

UNCLASSIFIED

AD

printed five-letter words with letter deletions simulating different noisy conditions were used. The results show that a response bias model denying stimuli any role accounts for practically all of the variance in the word-frequency effect at high noise levels. The model, however, is internally restricted, and its efficiency is artifactual. Another formulation, based on the Brown and Rubenstein model, will be tested in a future experiment. This new formulation is multiplicative instead of additive, and is no longer internally restricted.

UNCLASSIFIED

DESCRIPTORS

Verbal behavior
Applied psychology
Reaction

UNCLASSIFIED

AD

printed five-letter words with letter deletions simulating different noisy conditions were used. The results show that a response bias model denying stimuli any role accounts for practically all of the variance in the word-frequency effect at high noise levels. The model, however, is internally restricted, and its efficiency is artifactual. Another formulation, based on the Brown and Rubenstein model, will be tested in a future experiment. This new formulation is multiplicative instead of additive, and is no longer internally restricted.

UNCLASSIFIED

DESCRIPTORS

Verbal behavior
Applied psychology
Reaction

UNCLASSIFIED