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Normative data for 144 compound remote associate problems

EDWARD M. BOWDEN and MARK JUNG-BEEMAN
Northwestern University, Evanston, Illinois

We have developed and tested 144 compound remote associate problems. Across eight experiments, 289 participants were given four time limits (2 sec, 7 sec, 15 sec, or 30 sec) for solving each problem. This paper provides a brief overview of the problems and normative data regarding the percentage of participants solving, and mean time-to-solution for, each problem at each time limit. These normative data can be used in selecting problems on the basis of difficulty or mean time necessary for reaching a solution.

We have developed 144 simple problems for use in our research on the experience of insight in problem solving. These problems were patterned after items in the Remote Associates Test (RAT) developed by Mednick (1962). Our goal in the present article is to make these problems available to other researchers along with normative information regarding the relative difficulty of each problem. These normative data can be used in the selection of problems according to difficulty or mean time necessary for reaching a solution.

Mednick (1962) developed the RAT as a means of measuring creative thought without requiring knowledge specific to any field. He constructed two college-level versions of the test, each consisting of 30 items (Mednick, 1968; Mednick & Mednick, 1967). Each item consists of three words that can be associated with a solution word in a number of ways; thus, for example, the three words SAME/TENNIS/HEAD are associated with the solution MATCH by means of synonymy (*same* = *match*), formation of a compound word (*matchhead*), and semantic association (*tennis match*). Reaching a solution requires "creative thought," because the first, most related, information retrieved in solution attempts is often not correct, and solvers must think of more distantly related information in order to connect the three words. Problem solvers' success on items from the original RAT reliably correlates with their success on classic insight problems (Dallob & Dominowski, 1993; Schooler & Melcher, 1995).

The data were collected while the authors were at the Department of Neurology, Cognitive Neuroscience Section, Rush Medical Center, Chicago, IL, and the Department of Psychology, University of Pennsylvania. We thank Sylvia Beyer for many helpful comments during the writing of this paper, Stella Liu for collating the 30-sec time limit data, and Kim Hassenfeld for help in developing the remote associates problems. Address correspondence to either author at Department of Psychology, Northwestern University, Evanston, IL 60208 (e-mail: e-bowden@northwestern.edu or mjungbee@northwestern.edu).

For the most part, the RAT and RAT-like problems have been used in the study of problem solving and creative thinking (e.g., Ansburg, 2000; Beeman & Bowden, 2000; Bowden & Beeman, 1998; Bowden & Jung-Beeman, 2003; Bowers, Regehr, Balthazard, & Parker, 1990; Dallob & Dominowski, 1993; Dorfman, Shames, & Kihlstrom, 1996; Schooler & Melcher, 1995; Shames, 1994; Smith & Blankenship, 1989). They have also been used in a variety of innovative ways, including in the study of psychopathologies (e.g., Fodor, 1999), affect (e.g., Mikulincer & Sheffi, 2000), and success and failure experiences (e.g., Vohs & Heatherton, 2001), and as an alternative to illusory feedback (e.g., McFarlin & Blascovich, 1984). In addition, Hebrew, Japanese, and Jamaican versions have been implemented (Baba, 1982; Hamilton, 1982; Nevo & Levin, 1978).

Although RAT items are not as complex as classic insight problems, they exhibit the three properties of insight problems that distinguish insight solutions from noninsight solutions: (1) They misdirect (or fail to direct) retrieval processes. (2) Solvers often cannot report the processing that has led them to the solution (Ben-Zur, 1989). (3) Upon solving RAT items, solvers often have the Aha! experience (Bowden & Jung-Beeman, 2003). This third property is considered the central defining feature of insight problems. Thus, solving RAT-like items appears to involve the same component processes critical for, and the same phenomenological experience of, insight solutions to more complex problems.

In general, researchers using classic insight problems have faced two difficulties. Typical (classic) insight problems are usually complex, so that participants are able to attempt few such problems (occasionally only one) in an experimental session. The use of only a few problems greatly reduces the reliability of the data collected. Furthermore, the complexity of typical insight problems can lead to the confounding of variables, which hinders the clear decomposition of the component processes of problem solving. Compound remote associate problems have

several advantages over classic insight problems: (1) They can be solved in a short time, so that many can be attempted in a single experimental session of 1 h or less. (2) They are simpler than classic insight problems, thus allowing better control of possible confounding variables. (3) They have single-word, unambiguous solutions, making scoring of responses easier. (4) They are physically compact, so that they can be presented in a small visual space or short time span. These features allow for better control and measurement of timing variables (e.g., measuring the time between presentation of the problem and production of a solution, controlling timing of hint presentation or timing of solution presentation for solution judgment tasks, etc.) and display variables (e.g., position of the problem and/or solution on the screen). These features also allow for the use of various paradigms (e.g., priming, solution recognition, and hemispheric differences paradigms).

METHOD

Participants

Participants were 289 students from the University of Wisconsin, Parkside, the University of Illinois, Chicago, and the University of Pennsylvania.

Materials

Mednick's (1962) original versions of the RAT contained 30 items each, and the solution word for each item was sometimes associated with the words in a triad in several different ways. We wanted a greater number of problems than were available in the original RAT. We also wanted to present participants with a more consistent task—that is, the solution word would always be related to the triad words in the same way. To this end, we created our own set of problems, so that the solution word was associated with all three words of the triad through formation of a compound word (or phrase) (e.g., AGE/MILE/SAND form the compounds STONEAGE, MILESTONE, and SANDSTONE with the solution word STONE). Solution words were never repeated or used as problem words; problem words were sometimes repeated (e.g., *house* is repeated six times). The result was 144 compound remote associate problems. We provide normative data for the solvability of these items in the Appendix.

Procedure

The participants were tested individually. They were told that they would see three stimulus words and that they should attempt to generate a fourth word, which, when combined with each of the three stimulus words, would result in word pairs that make up a common compound word or phrase. The participants were given five practice problems prior to the experiment itself. Each trial began with the participant fixating a cross positioned at the center of the screen. So that the participant could see all three words with minimal eye movement, the problem words were then presented simultaneously in normal horizontal orientation above, at, and below the center of the screen. The participant tried to produce the solution word within a time limit. In the six experiments there were three different time limits (2, 7, and 15 sec). Immediately following the production of a solution, or the end of the time limit, the participant was shown a lateralized target word for 180 msec and was either to read the word aloud quickly or to judge whether the word was the solution to the problem. Only data regarding problem solution within the time limit are presented in this article; data regarding reading or judgments of the target words, and details of the procedure, are presented elsewhere (Beeman & Bowden, 2000; Bowden & Beeman, 1998). The problems were presented by a Macintosh computer in 24-point Times font, black on a white background.

In two other experiments (one using electroencephalography [EEG] and one using functional magnetic resonance imaging [fMRI] procedures), participants tried to produce the solution word within a 30-sec time limit. In these two experiments, each trial began with a central fixation cross; then the three problem words were presented simultaneously in normal horizontal orientation above, at, and below the center of the screen. The problem stayed on the screen until it was solved or the time limit expired. No target words were shown following the solution or time limit.

There were several potentially important differences between these two experiments and the previous six. Both EEG and fMRI procedures create less than optimal conditions for problem solving, so the results may underestimate participants' performance under better conditions. Because of the need for scalp electrode placement and the use of 186 problems, this EEG experiment involved very long sessions (up to 4 h).[1] To minimize eye movement, the problems were presented in a smaller font than in the previous experiments (14-point Arial font, yellow on a black background). In fMRI experiments, the scanner creates a noisy environment and participants' heads are held in position with cushions in an effort to eliminate head movement artifacts. In addition, participants in this fMRI experiment saw 124 of the 144 problems and did a line comparison task after each problem-solving trial.[2]

Despite these differences in procedures, there was a high correlation for percentage of participants solving the problems in the EEG and fMRI experiments [$r(124) = .80$]. Therefore, we combined the data for the 30-sec time limit from both the EEG and the fMRI experiments.

RESULTS AND DISCUSSION

Participants who had been excluded from previously published analyses (Beeman & Bowden, 2000; Bowden & Beeman, 1998) because they were left-handed or had solved too few problems were included in these analyses to give an accurate picture of the difficulty of the items.

We calculated the percentage of participants solving each problem within each of the time limits. We also cal-

culated the mean time-to-solution, in seconds, for the 7-, 15-, and 30-sec time limits.[3] These data are presented in the Appendix in descending order according to the percentage of participants producing a solution within the 15-sec time limit.

Correlations between time limits were calculated for the percentage of participants solving the problems. The correlation matrix is presented in Table 1.

These problems can be divided into two types: homogeneous, for which the solution word is a prefix (or suffix) to all three words of the problem triad, and heterogeneous, for which the solution word is a prefix (suffix) to at least one of the words of the triad and a suffix (prefix) to the other word(s) of the triad. Participants solved approximately the same number of homogeneous problems. For the 85 homogenous problems and 59 heterogeneous problems, the largest difference in percentage of participants solving was for the 15-sec solution period with mean percentages solved of 29% and 33% for the homogeneous and heterogeneous problems, respectively [$t(142) = 1.07$, $p = .29$]. Mean percentages solved were 7.8% and 7.9% within 2 sec, 23.0% and 22.7% within 7 sec, and 50.5% and 50.4% within 30 sec (all ps $> .91$).

We have used these problems to investigate hemispheric contributions to problem solving and the experience of insight. These problems have allowed us to use a visual-hemifield priming paradigm. In these experiments, participants attempt to solve problems, and after a time limit (or after solving), they read solution words faster than nonsolution words (solutions to other problems in the set). This solution priming is consistently greater when subjects read target words presented to the left visual field–right hemisphere (lvf–RH) than when they read those presented to the right visual field–left hemisphere (rvf–LH). Similarly, people could more quickly recognize, as solutions, solution words presented to the lvf–RH than those presented to the rvf–LH. These RH advantages increase when participants work on the problems longer (Beeman & Bowden, 2000; Bowden & Beeman, 1998) and when their seeing the solution words elicits a feeling of insight (Beeman, Haberman, & Bowden, 2002; Bowden & Jung-Beeman, 2003). We are now in the process of using these problems to investigate incubation, the effects of hints, and ways to interfere with and facilitate problem solving.

We have also used these problems to examine neural correlates of insight problem solving. Beginning approximately 1.3 sec before participants solve these problems, two brief EEG components differ when participants experience insight as opposed to when they do not experience insight. Source localization suggests involvement of cortical areas that mediate conflict resolution, which we have interpreted as overcoming blocking activation. This EEG is accompanied by a slightly slower, but still rapid, increase in alpha wave suppression (indicating increasing neural activity) localized to RH frontal and temporoparietal areas (Kounios et al., 2003). Similarly, changes in blood flow assessed by fMRI indicate that there is greater neural activity in the RH superior temporal sulcus for the final 2 sec before participants solve problems and experience insight than in the final 2 sec before participants solve problems without insight (Beeman, Bowden, & Haberman, 2002).

The problems presented in this paper are uncomplicated in the sense that each one has a single-word, unambiguous solution that is related to the three words in the problem in a single consistent way (i.e., forms a compound word or phrase), they can be solved quickly, and are physically compact. These features increase the reliability of the data, reduce the confounding of variables aiding in the clear decomposition of the component processes of problem solving, make scoring of responses easier, allow for control and measurement of timing variables and display variables, and permit the use of various paradigms. Similar problems have been used to study problem solving and creative thinking, psychopathologies, affect, and success and failure experiences, and as an alternative to illusory feedback. By providing solvability and time-to-solution data, we hope to encourage the further use of remote associate problems in these areas and in innovative ways.

Table 1
Correlations for Percentage of Participants Producing Solutions Within Four Solution Time Limits

	Time Available for Producing a Solution		
Time Limit	2 sec	7 sec	15 sec
2 sec	–		
7 sec	.93	–	
15 sec	.83	.91	–
30 sec	.71	.80	.83

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NOTES

1. Forty-two new problems were developed for the EEG experiment. Data from these new problems are not presented in this paper.

2. In the line comparison task, participants saw two sets of lines (e.g., **/ / ** and **/ \ /**). The task was to answer "yes" if both sets had the same number of left-leaning and right-leaning lines, or "no" if the sets had a different number of left-leaning and right-leaning lines. In this example, the answer is "yes."

3. Solution time data were not collected for the 2-sec time limit.

APPENDIX

			Maximum Time Allowed for Producing a Solution								
		2 sec $n = 89$	7 sec $n = 85$			15 sec $n = 76$			30 sec $n = 39$		
Remote Associate Items	Solutions	% of Participants Solving Item	% of Participants Solving Item	Mean Solution Time (sec)	*SD*	% of Participants Solving Item	Mean Solution Time (sec)	*SD*	% of Participants Solving Item	Mean Solution Time (sec)	*SD*
cottage/swiss/cake	cheese	52	84	3.28	1.25	96	3.96	2.37	64*	10.85	7.04
cream/skate/water	ice	34	76	3.42	1.16	92	4.04	1.87	90	4.12	3.58
loser/throat/spot	sore	22	61	4.19	1.49	86	5.38	3.02	82	6.31	4.06
show/life/row	boat	31	72	4.42	1.44	82	5.67	2.34	79	10.30	7.22
night/wrist/stop	watch	38	65	4.33	1.31	82	6.00	3.00	97	6.27	5.83
duck/fold/dollar	bill	31	69	4.33	1.25	80	6.05	2.82	92	6.58	4.28
rocking/wheel/high	chair	37	73	3.98	1.43	80	4.98	2.55	87	5.84	5.36
dew/comb/bee	honey	30	66	4.24	1.50	80	5.63	3.15	100	4.12	2.14
fountain/baking/pop	soda	34	71	4.25	1.23	78	6.01	2.69	92	5.50	3.30
preserve/ranger/tropical	forest	18	59	4.00	1.34	76	5.76	2.98	85	9.73	6.08
aid/rubber/wagon	band	22	56	4.21	1.50	75	5.41	2.15	69	6.51	4.62
flake/mobile/cone	snow	9	47	4.20	1.61	71	6.72	3.10	79	8.68	7.02
cracker/fly/fighter	fire	17	45	4.95	1.54	68	5.91	2.54	85	6.12	3.87
safety/cushion/point	pin	24	51	3.91	1.58	66	5.83	2.78	74	5.00	2.84
cane/daddy/plum	sugar	19	60	4.43	1.53	66	6.14	3.11	97	5.45	4.92
dream/break/light	day	24	56	4.36	1.49	64	5.35	2.56	56	7.91	6.72
fish/mine/rush	gold	17	46	4.27	1.09	63	6.48	3.32	74	9.07	6.83
political/surprise/line	party	7	26	5.06	1.29	61	7.84	3.43	90	8.79	5.20
measure/worm/video	tape	10	45	4.74	1.59	58	6.12	2.90	87	8.36	5.24
high/district/house	school/court	18	42	4.36	1.34	55	5.59	2.45	74	8.90	7.75
sense/courtesy/place	common	8	33	4.67	1.29	54	6.28	2.89	67	9.24	8.11
worm/shelf/end	book	17	49	4.31	1.38	53	5.88	2.90	85	6.76	6.25
piece/mind/dating	game	6	19	5.61	1.22	53	7.83	2.41	46	15.34	7.78
flower/friend/scout	girl	9	22	5.26	1.47	51	8.06	2.94	67	11.43	7.70
river/note/account	bank	2	29	5.64	0.99	50	7.98	2.81	79	10.53	5.88
print/berry/bird	blue	10	38	4.91	1.47	49	7.18	3.77	77	13.24	7.94
pie/luck/belly	pot	15	38	4.35	0.93	49	5.31	2.03	44	8.68	4.36
date/alley/fold	blind	13	40	4.51	1.22	47	6.99	3.33	85	7.06	5.42
opera/hand/dish	soap	16	33	5.26	1.41	47	6.54	3.11	62	7.92	6.45
cadet/capsule/ship	space	18	34	4.13	1.49	47	5.53	2.78	74	5.46	3.96
fur/rack/tail	coat	2	16	5.42	1.35	46	7.89	3.49	79	8.00	6.76
stick/maker/point	match	1	4	5.42	1.23	46	6.65	3.46	21	12.19	8.15
hound/pressure/shot	blood	4	32	4.51	1.43	42	6.48	3.94	72	6.98	5.32

APPENDIX (Continued)

		Maximum Time Allowed for Producing a Solution									
		2 sec $n = 89$	7 sec $n = 85$			15 sec $n = 76$			30 sec $n = 39$		
Remote Associate Items	Solutions	% of Participants Solving Item	% of Participants Solving Item	Mean Solution Time (sec)	*SD*	% of Participants Solving Item	Mean Solution Time (sec)	*SD*	% of Participants Solving Item	Mean Solution Time (sec)	*SD*
fox/man/peep	hole	16	41	4.23	1.32	42	5.70	2.61	64	7.06	4.80
sleeping/bean/trash	bag	27	68	4.02	1.59	41	5.94	3.11	82	6.80	6.36
dust/cereal/fish	bowl	11	24	4.43	1.78	41	6.39	3.29	49	9.53	6.64
light/birthday/stick	candle	8	36	5.14	1.65	41	7.97	3.02	46	9.74	6.83
food/forward/break	fast	4	24	4.75	1.58	41	7.54	3.24	82	7.73	5.77
shine/beam/struck	moon	3	22	4.55	1.80	41	6.08	2.62	62	6.17	4.93
peach/arm/tar	pit	15	39	3.86	1.27	41	5.00	2.39	67	10.01	7.97
water/mine/shaker	salt	12	28	4.93	1.43	41	7.45	2.85	85	7.85	3.37
palm/shoe/house	tree	12	25	4.84	1.72	41	7.79	3.19	51	13.90	7.90
basket/eight/snow	ball	7	25	5.27	1.14	39	9.57	3.57	72	10.87	7.18
wheel/hand/shopping	cart	16	31	5.08	1.36	39	7.96	3.33	49	10.65	6.20
right/cat/carbon	copy	6	25	4.84	1.78	39	7.45	3.14	46	11.88	7.43
home/sea/bed	sick	3	16	5.03	1.56	38	7.63	2.48	10†	5.83	2.77
nuclear/feud/album	family	3	16	4.70	1.49	37	8.29	3.22	85	9.48	5.47
sandwich/house/golf	club	4	16	5.31	1.29	36	7.01	2.96	82	9.10	4.95
cross/rain/tie	bow	3	18	5.54	1.24	34	8.56	3.25	46	13.75	8.39
sage/paint/hair	brush	8	28	5.30	1.35	34	7.04	2.72	69	9.88	6.87
french/car/shoe	horn	9	29	4.90	1.49	34	6.88	2.57	69	12.58	8.71
boot/summer/ground	camp	17	41	3.94	1.21	33	4.67	2.11	54	4.46	2.32
chamber/mask/natural	gas	7	26	3.93	1.13	33	5.86	2.25	44	5.27	4.90
mill/tooth/dust	saw	10	25	4.18	1.29	33	6.58	3.71	51	7.13	5.45
main/sweeper/light	street	12	32	4.70	1.35	33	5.73	2.82	64	7.70	5.65
pike/coat/signal	turn	4	16	4.61	1.71	33	6.80	3.58	64	12.55	9.68
office/mail/hat	box	2	14	6.03	0.83	32	8.26	3.74	21	17.23	7.60
fly/clip/wall	paper	9	34	5.09	1.53	32	7.29	3.21	49	11.02	7.49
age/mile/sand	stone	11	27	5.02	1.25	32	8.35	2.83	44	16.61	8.67
catcher/food/hot	dog	3	14	4.62	1.39	30	8.04	3.26	46	10.22	5.54
wagon/break/radio	station	13	19	5.36	1.20	30	7.88	3.31	51	14.57	8.77
tank/hill/secret	top	2	15	5.81	0.59	30	10.13	3.10	38	11.20	5.82
health/taker/less	care	2	12	5.04	2.08	29	7.76	3.11	44	10.58	7.26
lift/card/mask	face	7	21	5.17	1.25	29	7.55	3.31	33	12.79	7.72
dress/dial/flower	sun	4	15	4.45	1.62	29	5.79	2.74	51	7.78	5.72
force/line/mail	air	10	27	3.94	1.25	28	7.52	4.06	28	13.90	7.76
guy/rain/down	fall	3	12	5.03	1.73	28	9.42	3.52	41	13.30	8.12
eight/skate/stick	figure	4	16	4.66	1.22	28	5.78	2.65	59	5.55	4.18
down/question/check	mark	9	21	4.86	1.52	28	7.92	3.37	54	11.35	7.10
animal/back/rat	pack	7	26	5.06	1.17	28	8.86	3.79	49	10.72	7.08
officer/cash/larceny	petty	4	18	4.69	1.35	28	5.80	2.77	44	9.49	7.44
pine/crab/sauce	apple	6	16	4.57	1.24	26	7.23	3.11	33	14.97	8.41
house/thumb/pepper	green	7	20	4.45	1.43	26	7.71	3.24	49	12.59	7.60
carpet/alert/ink	red	4	32	4.66	1.60	26	6.40	2.83	59	11.02	8.14
master/toss/finger	ring	4	26	4.85	1.85	26	7.83	2.73	51	14.68	7.17
hammer/gear/hunter	head	1	14	4.67	1.45	25	8.35	3.40	56	8.13	5.18
knife/light/pal	pen	8	16	5.02	1.40	25	6.56	3.43	62	9.19	7.14
foul/ground/mate	play	2	6	4.81	1.26	25	8.12	2.87	46	9.33	6.85
change/circuit/cake	short	8	26	4.11	1.62	25	5.90	3.03	41	10.07	9.38
way/board/sleep	walk	11	25	5.15	1.25	25	7.85	3.50	64	11.45	8.44
blank/list/mate	check	7	19	5.10	1.47	24	7.43	2.65	51	6.12	2.57
tail/water/flood	gate	8	16	4.75	1.66	24	7.48	2.52	36	10.23	7.47
marshal/child/piano	grand	8	26	4.72	1.21	24	6.58	2.28	38	8.40	6.22
cover/arm/wear	under	2	19	4.74	1.49	24	7.53	3.44	36	13.71	5.90
rain/test/stomach	acid	1	12	5.85	0.92	22	8.65	3.56	31	13.64	7.70
time/blown/nelson	full	7	18	5.46	1.24	22	7.06	2.57	44	10.69	6.50
pile/market/room	stock	7	20	4.52	1.51	22	6.16	3.03	44	7.42	4.84
mouse/bear/sand	trap	3	28	5.15	1.20	22	7.17	3.46	72	7.63	6.27
cat/number/phone	call	1	14	5.77	1.14	21	9.45	2.82	54	11.74	7.00
keg/puff/room	powder	9	16	4.85	1.98	21	8.27	3.95	62	6.44	4.33
trip/house/goal	field	1	13	5.15	1.12	18	7.01	2.79	13	8.02	3.57
fork/dark/man	pitch	1	9	5.76	1.21	18	7.91	2.95	18	16.59	7.33
fence/card/master	post	1	12	4.98	1.44	18	6.33	2.66	13	18.69	11.21
test/runner/map	road	2	6	5.82	0.82	18	8.98	4.20	44	10.98	7.76
dive/light/rocket	sky	2	8	4.92	1.80	18	7.19	3.01	21	8.87	5.60

APPENDIX (Continued)

		Maximum Time Allowed for Producing a Solution									
		2 sec $n = 89$	7 sec $n = 85$			15 sec $n = 76$			30 sec $n = 39$		
Remote Associate Items	Solutions	% of Participants Solving Item	% of Participants Solving Item	Mean Solution Time (sec)	*SD*	% of Participants Solving Item	Mean Solution Time (sec)	*SD*	% of Participants Solving Item	Mean Solution Time (sec)	*SD*
man/glue/star	super	0	9	4.80	1.57	18	6.65	3.48	41	9.83	7.18
tooth/potato/heart	sweet	1	12	3.71	0.85	18	6.38	3.74	28	11.77	7.73
illness/bus/computer	terminal	1	5	5.98	0.77	18	7.42	1.74	18	11.43	5.82
type/ghost/screen	writer	1	18	5.20	1.20	18	8.02	2.58	54	9.37	7.08
mail/board/lung	black	0	5	5.28	0.94	17	7.47	3.69	18	14.67	9.22
teeth/arrest/start	false	6	12	5.34	1.36	17	6.87	3.95	44	11.46	7.67
iron/shovel/engine	steam	6	16	4.27	1.43	17	6.98	1.99	49	9.22	6.28
wet/law/business	suit	10	16	4.67	1.25	17	8.27	3.43	59	11.24	8.46
rope/truck/line	tow	4	16	4.67	1.51	17	7.56	2.96	21	14.58	6.94
off/military/first	base	1	12	4.81	1.68	16	8.13	3.88	31	11.36	8.72
spoon/cloth/card	table	1	6	4.63	1.60	16	8.84	3.22	26	13.80	10.55
cut/cream/war	cold	1	12	3.85	1.30	14	7.85	4.05	31	13.94	9.32
note/chain/master	key	0	6	5.89	0.57	14	8.08	4.39	26	12.68	5.30
shock/shave/taste	after	1	7	4.12	1.54	13	7.60	3.42	31	10.84	7.93
wise/work/tower	clock	3	11	4.85	1.41	13	9.04	3.92	13	13.32	7.85
grass/king/meat	crab	3	9	5.16	1.21	13	6.79	2.29	23	14.20	6.80
baby/spring/cap	shower	7	16	4.62	1.45	13	7.99	3.33	28	7.58	5.56
break/bean/cake	coffee	6	18	4.92	1.88	12	8.31	4.09	33	14.04	6.90
cry/front/ship	battle	2	9	4.70	1.59	11	8.20	2.87	18	13.69	9.78
hold/print/stool	foot	3	15	4.48	1.34	11	8.51	4.20	41	8.62	4.33
roll/bean/fish	jelly	0	11	4.39	1.51	11	4.03	1.42	26	13.24	6.16
horse/human/drag	race	8	32	5.03	1.37	11	7.39	2.01	56	12.14	6.67
oil/bar/tuna	salad	1	7	6.12	1.01	11	9.63	2.88	41	17.05	7.20
bottom/curve/hop	bell	2	1	4.16	–	9	6.25	2.08	46	7.73	6.80
tomato/bomb/picker	cherry	6	14	5.44	1.01	9	10.28	4.07	46	7.00	4.24
pea/shell/chest	nut	2	9	4.54	1.61	9	5.78	1.41	23	14.08	9.12
line/fruit/drunk	punch	1	4	5.06	0.27	9	6.91	2.20	10†	16.24	3.37
bump/egg/step	goose	4	4	6.02	0.83	8	7.68	4.57	‡	‡	‡
fight/control/machine	gun	0	9	5.93	0.94	8	8.70	3.09	28	13.92	6.28
home/arm/room	rest	0	5	5.11	2.09	8	9.90	2.32	21	13.48	7.10
child/scan/wash	brain	0	1	7.00	–	7	8.43	3.91	14†	12.18	4.68
nose/stone/bear	brown	1	2	6.83	0.24	7	9.36	2.79	26	16.11	9.12
end/line/lock	dead	1	5	4.97	1.40	7	10.06	3.18	‡	‡	‡
control/place/rate	birth	0	1	6.35	–	5	6.09	2.58	14†	10.25	13.00
lounge/hour/napkin	cocktail	0	5	5.05	1.44	5	12.55	1.86	10†	7.82	2.96
artist/hatch/route	escape	2	2	3.50	0.26	5	9.22	4.42	15†	9.42	7.83
pet/bottom/garden	rock	7	6	5.56	0.80	5	10.94	3.16	19†	8.95	6.82
mate/shoes/total	running	0	4	6.11	1.54	5	5.79	3.47	10†	23.47	5.17
self/attorney/spending	defense	1	4	4.00	2.01	4	8.42	4.83	10†	13.28	3.74
board/blade/back	switch	1	6	5.74	1.46	4	10.80	3.24	29†	16.14	9.45
land/hand/house	farm	0	1	5.61	–	3	8.20	0.54	0	–	–
hungry/order/belt	money	0	0	–	–	3	11.56	0.45	0	–	–
forward/flush/razor	straight	1	2	4.79	2.00	3	11.45	3.14	5	3.89	–
shadow/chart/drop	eye	0	1	5.34	–	1	0.56	–	15†	12.03	4.13
way/ground/weather	fair	0	5	5.53	1.39	1	3.11	–	10	17.04	5.48
cast/side/jump	broad	0	1	3.56	–	0	–	–	5	10.81	–
back/step/screen	door	0	2	5.47	0.53	0	–	–	33†	7.73	2.57
reading/service/stick	lip	1	1	6.11	–	0	–	–	10	9.57	8.00
over/plant/horse	power	0	1	5.45	–	0	–	–	10	18.30	5.26

*The problem was changed from cottage/swiss/cake to cottage/brick/cake. †Reflects the performance of only participants in the EEG experiment. ‡The problem was not used with a 30-sec time limit.

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