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FEATURE ARTICLE

Teasing Apart Actions and Objects:
A Picture Naming Study

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Teasing Apart Actions and Objects: A Picture Naming Study

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Abstract

The goal of the present study was to examine action and object naming under varying processing constraints, such as item difficulty and context, to observe how these different conditions affect naming performance. Normative data was collected from a group of thirty-eight healthy young adults as the first in a series of studies investigating the process of lexical access and its underlying neural substrates. Lead-in sentences used were either neutral (not predictive) or congruent (predictive of the particular lexical category, i.e. noun vs. verb). Results indicated that across subjects as well as items, objects and easy items elicited both significantly more accurate and faster responses than actions and difficult items. Congruent contexts facilitated processing compared to neutral contexts. In addition, these factors differentially affected objects and actions, with an advantage seen for object naming.

Introduction

Picture naming has long been used as a tool to gain insight into our lexical accessing abilities. More specifically, picture naming can help us gain access into the way we recognize a particular concept from an image, derive its specific meaning, and link that meaning to its appropriate label, thus naming the picture. Various different models have been proposed to account for our ability to perform such a task, each with its own set of processing stages. One such model is that suggested by Johnson et al. (1996), which includes a minimum of three universal stages: (1) analysis and recognition of the object or event being depicted, (2) retrieval of the word form(s) that express the object and selection of the preferred name, and (3) planning and execution of the selected name. Levelt's model of word production (Levelt, 1989; Levelt, Roelofs & Meyer, 1999), on the other hand, includes a fourth stage and assumes an added level of abstraction between sound and meaning. The four stages include: (1) individuation of a target concept, (2) selection of a word-specific lemma (the definitional lexical and grammatical content component of a lexical item), (3) activation of the word form (an abstract characterization of the sound pattern associated with a specific lemma), and (4) articulation of the motor program associated with that word form. Whichever model one chooses to accept, it is important to be aware of these stages as possible events in the cognitive processes subserving production tasks such as the one presented in this study.

Picture naming as a paradigm has spanned a range of research areas due to its usefulness with various populations. Pictures are useful when working with pre-literate (children) as well as illiterate populations, with language-disordered individuals (e.g., aphasic patients with word-finding difficulties), and in cross-linguistic tasks, due to their universality.

Most picture-naming studies, however, have focused solely on object (noun) naming. Original corpora for objects were introduced by pioneers such as

Snodgrass & Vanderwart (1980) and Sanfeliú & Fernandez (1996). More recent studies, however, have begun to address the distinction between objects and actions, with the intention of defining the potentially different brain organizations underlying nouns (objects) vs. verbs (actions).

Results from various developmental studies have revealed differences in the acquisition of the two lexical categories. Namely, the semantic structures underlying verbs have been found to be more complex and open-ended (Gentner, 1982), and at least in English, verbs seem to appear in a child's lexicon only after a considerable vocabulary expansion of approximately two-hundred words has taken place (Bates et al., 1988). In addition, a double-dissociation between noun and verb processing has been observed in brain-injured patients across several languages (Chen & Bates, 1998; Daniele et al., 1994; Zingeser & Berndt, 1990). While Wernicke's aphasics and some anomics display more severe problems producing nouns than verbs, non-fluent Broca's aphasics mainly display specific deficits in the production of verbs. Furthermore, studies using various imaging techniques such as ERP and PET, have suggested the presence of distinct brain structures underlying the processing of these different lexical categories (Perani et al., 1999; Molfese et al., 1996).

One issue that has also been investigated is the influence of contextual cues (both semantic and syntactic) on word processing. In a study by Liu (1996), noun and verb targets were presented with lexical class predicting contexts (lead-in sentences such as "I want to..." and "This is the..."). These sentences were found to affect word naming in both the visual and auditory modalities, either by inhibiting or facilitating the word's production.

Pictures are qualitatively different, however, in that the information they convey is purely conceptual and does not contain any word-form cues (at least in the present picture-naming task and similar studies). In a study by Federmeier and Bates (1997), subjects were presented with pictures of actions and objects paired with the same contextual cues used by Liu (1996). The lead-in sentences were either neutral (not predictive of either word class), noun-predicting or verb-predicting. In addition, a set number of trials contained switched cues, such that a noun-predicting cue was at times paired with a verb and a verb-predicting cue with a noun (creating an incongruent or conflicting context). These authors found that predictive contexts significantly facilitated the naming of both actions and objects (when compared to naming in the neutral condition) and at least for objects, conflicting contexts actually inhibited naming. The present study included lead-in sentences as well in order to further test the effects of context.

Finally, several investigators have attempted to match actions and objects on a number of parameters. Székely et al. (2001) have found that matching actions and objects on frequency, age of acquisition or picture complexity results in a mismatch for naming difficulty measures. Likewise, matching for difficulty results in a mismatch on other lexical and pictorial properties. One can confirm this by simply comparing response times for the same easy and hard objects vs. easy and hard actions collected previously in our lab: easy object response times ranged from 656 ms.- 822 ms. and easy action response times ranged from 792 ms.-1134 ms., barely overlapping. Likewise, difficult object RTs ranged from 1088 ms.-1635 ms., whereas difficult action RTs ranged from 1215 ms.-1777 ms. Therefore, matching either easy or hard across categories seems virtually impossible. Including difficulty as a constraint factor in this study aims to tease apart properties within each word category and not between categories, in order to analyze difficulty per se.

The present study

The task used in this study involved 280 2-D black-and-white drawings, 140 depicting objects and 140 depicting actions (both transitive and intransitive). These were acquired from a larger corpora of 520 objects and 275 actions used in previous studies under the CRL-IPNP (CRL International Picture-Naming Project, Bates et al., 2000). Lead-in sentences preceded each picture, and either predicted the lexical category of the particular word (congruent condition) or did not predict it at all (neutral lead-in). I did not include conflicting or incongruent lead-ins in my study, only neutral and facilitative (congruent). These were acquired from the Liu (1996) study mentioned above.

Method

Participants

Participants were thirty-eight UCSD undergraduate volunteers who received course credit for their participation. They were all right-handed, native speakers of English. None had had significant exposure to a language other than English before the age of 12, as assessed by a screening questionnaire issued before the task was administered. They were men and women ranging in age from 18 to 25.

Stimuli

This experiment used a 2x2x2 design, and was analyzed both across items and subjects. Across items, there were one within and two between-subjects factors. The within-subjects factor was context (congruent vs. neutral lead-in sentences) and the between-subjects factors were word category (action vs. object) and difficulty (hard vs. easy). Across subjects, all three of these were within-subjects factors. Both accuracy and reaction times served as dependent variables, and were only calculated for items that elicited the intended target name and were accurately detected by the computer.

Each subject was presented with a list of 280 pictures. Six different lists were used across subjects and each list was randomized from 2 master lists which included all possible word-context combinations. Each of the master lists consisted of 140 action and 140 object pictures. Within each word category there were 70 “easy” and 70 “hard” items, so that each list contained 70 easy actions, 70 hard actions, 70 easy objects and 70 hard objects.

Having arranged the original 520 object pictures and 275 action pictures in ascending order of total response time (erttot), “easy” items were 70 chosen from the beginning of the list (i.e., fastest erttot) and “hard” were 70 chosen from the end of the list (i.e., the slowest response times). In addition to fast or slow response times, pictures were chosen based on the accuracy with which subjects had responded to these in previous studies using the given stimuli.

The elex1 measure from the original corpora represents the percentage of subjects who elicited the target name for each particular picture. This measure tends to be lower for actions than for objects, perhaps due to a higher difficulty level inherent in verbs or to an inevitable higher level of visual complexity associated with pictures that depict actions. It has been argued that having to depict an act of motion may simply require more complex images within two-dimensional constraints (Federmeier & Bates, 1997). For this reason, pictures were also subjectively assessed for visual complexity, with a definite preference for less complex images. In addition, minimum cut-off elex1 scores for each category were different from each other. For objects, this number was 80% accuracy and for actions it was 60% accuracy. Therefore, all action pictures used had an elex1 of 0.60 or better and all object pictures had an elex1 of 0.80 or better. Furthermore, object picture response times (erttot) ranged from 656 ms.-822 ms. for the easy category and from 1088 ms.-1635 ms. for the difficult category. For actions, the easy items elicited responses ranging from 792 ms.-1134 ms. and the hard item responses ranged from 1215 ms.-1777 ms.

Lead-in sentences

Each picture was also preceded by a recorded lead-in sentence. Three types of lead-in sentences were used: congruent or predictive lead-ins for objects, congruent or predictive lead-ins for actions, and neutral or non-predictive sentences, which were matched with items from both lexical categories. For the first master list, the first 35 items were paired with congruent lead-in sentences, the next 35 with neutral, and so on. This way, half of all easy and half of all hard items for both categories were presented in a congruent context while the other half was presented in a neutral context. The second master list exhibited the same pattern, except the items paired with either condition were switched, so that throughout all 6 stimuli lists, each item was paired with a semantically-congruent lead-in sentence half of the time and with a semantically-neutral lead-in sentence the rest of the time. Table 1 lists the lead-in sentences used. There were 7 congruent action sentences, 7 congruent object sentences and 3 neutral sentences (acquired from Liu, 1996).

Table 1

Action lead-ins	Object lead-ins	Neutral lead-ins
It started to	Here is the	Now please say
He started to	He wants that	And now say
She started to	She wants that	Next please say
They started to	What about the	
I want to	Look at this	
They like to	They saw this	
When will you	I like this	

A greater variety of acceptable, non-repeating lead-ins was available for the congruent rather than the neutral context, and while using the same number for each condition may have been ideal, the larger number of congruent lead-ins was retained in order to provide greater variety in the stimuli presented to each subject, thus avoiding repetitiveness throughout the large number of trials.

Procedure

Each subject was given a set of headphones with an attached microphone with which they were able to hear the lead-in sentences and elicit their responses into the microphone. They were asked to name each picture as accurately and quickly as it appeared on the screen. Each picture automatically disappeared as soon as the subject's voice was detected. Subjects were told that some pictures would depict objects and others actions, and that these would be in random order. They were also told that some lead-in sentences would provide clues as to the lexical category depicted in each picture but that other lead-in sentences would not, making the answer potentially ambiguous. Subjects were asked to provide their best guess when not sure, and to use the infinitive form of the verb every time an action was presented (i.e. type, as opposed to typing). They were also asked to avoid any other type of extraneous sound that could be detected by the microphone and recorded as an actual answer, such as coughing, sneezing or utterances like "hmmm…" or "I don't know".

The task was experimenter controlled, meaning that the experimenter manually skipped from trial to trial. Subjects were allowed breaks if they so wished, but this was not requested by any of the subjects. They were told they would see 280 pictures, which should normally take about 30 minutes to complete. If they were not sure of a word, they were asked to remain silent. In such cases, the microphone would not detect a sound, an "X" would appear on the screen above the trial number and the experimenter could then move on to the next trial once the following number appeared on the screen in the same spot.

Results

Accuracy results are followed by response time results, both of which were analyzed over subjects as well as over items (F1 = analysis over subjects; F2 = analysis over items).

Accuracy

There were significant main effects of word category for both analyses ($F1(1,37) = 37.134$, $p<.0001$; $F2(1,276) = 26.338$, $p<.0001$), revealing that subjects were significantly more accurate naming objects than actions. Across the 280 items used in this study, mean accuracy scores ranged from 0.744 for actions to 0.829 for objects. Significant main effects were also found for difficulty ($F1(1,37) = 269.492$, $p<.0001$; $F2(1,276) = 128.093$, $p<.0001$), yielding more accurate responses for easy items than for hard items. Scores ranged from 0.693 for hard items to 0.881 for easy items. The third factor, context, also resulted in a significant main effect ($F1(1,37) = 18.353$, $p<.0001$; $F2(1,276) = 20.642$, $p<.0001$): subjects were significantly more accurate naming items when these were paired with congruent as opposed to neutral lead-in sentences. Scores ranged from 0.761 for neutral items to 0.812 for congruent items.

In addition, there was a significant 2-way interaction of category by difficulty over items as well as subjects ($F1(1,37) = 48.929$, $p<.0001$; $F2(1,276) = 7.579$, $p=.0063$). Post-hoc contrasts revealed that both actions and objects are significantly less accurate in the hard condition, yet actions take a significantly harder hit than objects do as difficulty increases. Figs. 1 and 2 illustrate these findings. There was also a significant 2-way interaction of category by context over subjects ($F1(1,37) = 4.369$, $p=.0435$). Post-hoc contrasts for these factors revealed that, while both actions and objects decreased in accuracy under the neutral condition, a lack of context impacted actions more strongly than objects. This finding is illustrated in Fig. 3.

Figure1: Accuracy: 2-Way Interaction (over items) of Category*Difficulty

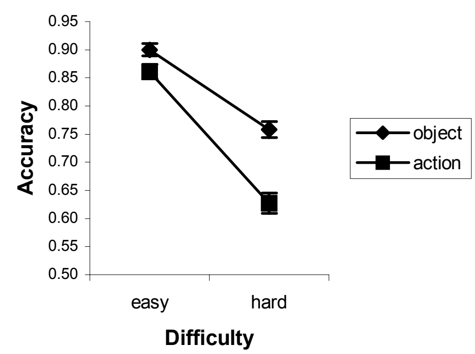
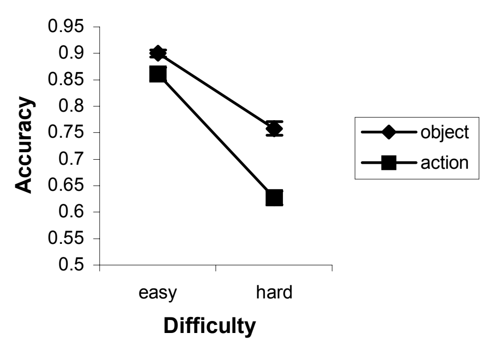
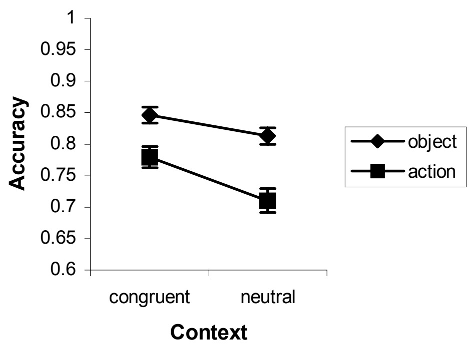


Figure2: Accuracy: 2-Way Interaction (over subjects) of Category*Difficulty



In summary, word category, difficulty and context significantly affected subjects' response accuracy when analyzed over items as well as subjects. In addition, both analyses revealed that while both actions and objects were less accurate in the hard condition, actions were more strongly affected by difficulty than objects were. Finally, across subjects, actions were more strongly impacted by a lack of context (the neutral condition) than were objects.

Figure3: Accuracy: 2-Way Interaction (over subjects) of Category*Context



It should be noted that some items were deemed incorrect due to machine failure to record a subject's voice, even if the answer given by the subject was the expected target word. Yet the number of these "uncodeable" responses was less than 5% of the total number of responses. Furthermore, many subjects elicited answers that would be considered acceptable synonyms of the target word; as mentioned above, however, only target answers were included in the analysis, therefore yielding slightly lower scores across items than what might be expected for healthy young adult subjects.

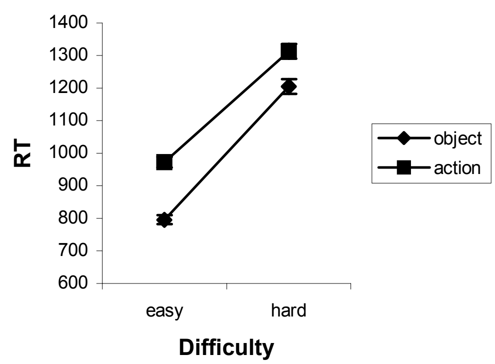
Response times

There was again a significant main effect of word category in both analyses (F1(1,37) = 192.245, p<.0001; F2(1,275) = 72.653, p<.0001): subjects were significantly faster at naming objects than actions. Across all items, mean response times ranged from 1,002.943 ms. for objects to 1,145.442 ms. for actions. There was also a significant main effect of difficulty (F1(1,37) = 589.294, p<.0001; F2(1,275) = 503.815, p<.0001), meaning that subjects were significantly faster at naming easy items than they were at naming difficult items. Mean response times ranged from 885.553 ms. for easy items to 1,263.677 ms. for hard items. Finally, there was no significant main effect of context in either analysis (F1(1,37) = 0.464, p=.5001; F2(1,275) = 1.905, p=.1686). Although results showed a trend in the expected direction (congruent items faster relative to neutral items), actual response times did not reach significance.

A 2-way interaction of category by difficulty reached significance in both analyses (F1(1,37) = 15.498, p=.004; F2(1,275) = 3.875, p=.0500). Post-hoc contrasts revealed that while both objects and actions are significantly slower in the hard condition, objects are more strongly impacted by this condition when compared to results in the easy condition. In other words, the decrease in performance (increase in response times) as difficulty increases is more drastic for objects than for actions. This finding is illustrated in Fig. 4.

Overall, there were significant main effects of word category and difficulty for response times, revealing that subjects responded faster to objects and to easy items than they did to actions and hard items. Results also showed that increasing difficulty affects objects more strongly than actions.

Figure4: RT: 2-Way Interaction (over subjects) Category*Difficulty



Conclusion

The purpose of this study was to explore whether and how picture-naming performance would be affected under three different sets of conditions: word category (action vs. object pictures), difficulty (easy vs. hard items), and context (items paired with congruent vs. neutral lead-in sentences). The present results pertain to a group of healthy young adults and provide preliminary norming data for a series of studies to be carried out in the near future. These studies will involve different populations (healthy subjects in different age groups and language-impaired individuals) as well as different paradigms (degraded conditions, imaging design, etc.). The larger purpose of these studies is to further investigate the neural substrates underlying language processing, and specifically the processing distinction of actions versus objects (i.e., verbs versus nouns).

Our data revealed that subjects were able to respond to objects significantly faster and more accurately when compared to actions, both across all 280 items and 30 subjects. In addition, they were faster and more accurate when naming easy items as opposed to hard items, again across items as well as subjects. They were significantly more accurate when naming items that were presented in congruent contexts compared to those presented with neutral contexts (across items and subjects), yet their response times were not significantly faster. In all cases, however, the trend is in favor of the congruently presented items, and acquiring a larger subject pool may result in a different outcome.

One possible explanation for this lack of significance may be that context helps subjects recognize and name pictures accurately, yet not necessarily quickly. In other words, accuracy remains at the expense of speed. It should be noted that response times for congruent vs. neutral contexts displayed a very large range, and hence a very large standard error. This seems to suggest that subjects were literally “all over the place”, very inconsistent in the speed with which they answered and therefore probably also diverse in their chosen picture-naming strategies. It may be that simply increasing the subject pool could potentially yield significant context effects on response times. It is also important to note that analyses were carried out only on the target responses, leaving many synonymous answers out of the equation.

In addition, for accuracy across items and subjects, actions were more strongly impacted by difficulty than objects. In other words, the hard condition made actions comparatively more difficult than objects, and hence yielded less accurate responses. A possible explanation for this is that objects may simply be easier overall, and even the hard items are simply “not that hard”. Across subjects, actions were also more strongly impacted by context: the neutral condition made actions significantly less accurate than objects. Again, it may be that the inherent easy nature of objects and/or their picture representations may cause them to remain easy, and hence yield more accurate responses, across all context conditions, both facilitative and neutral. One possible conclusion from this is that the disadvantage seen for action naming may not be directly attributable to difficulty or context per se, but rather to an inherent difference in the nature of this word class category, how we process and/or store it.

Finally, for response times across subjects, objects were more strongly impacted by difficulty than actions. Alternatively, one could propose that when both objects and actions are easy, actions are still somewhat harder, comparatively, and thus the change that occurs in performance as difficulty increases is not as drastic for the actions as it is for the objects. Either way, as revealed more than once by these results, actions and objects do in fact behave differently.

In conclusion, results strongly suggest that normal adult processing of verbs vs. nouns (actions vs. objects) in a picture-naming design requires the recruitment of different processing systems. The question remains unanswered as to whether these different systems involve partially-overlapping or distinct neural structures, or even different cognitive networks.

The results obtained in this study will be useful when testing different populations, such as children, individuals with aphasia, and healthy adults across different languages. Furthermore, a subset of these stimuli will be chosen to implement the task in an imaging design, using fMRI; results from these tests will hopefully bring us a step closer to understanding the neural underpinnings of nouns and verbs as well as lexical processing in general.

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APPENDIX

***Object pictures**: RT-total refers to mean reaction times for previous studies conducted at CRL; RT-target refers to reaction times for dominant responses only; Ln frequency is the log natural frequency for each word's dominant response; VisComplexity is each picture's objective visual complexity based on its picture file size in jpg format

No.	Picture Name	RT-total	RT-target	Ln frequency	VisComplexity
1	ACCORDION	1216	1179	0.69	21540
2	ACORN	1273	1242	1.1	9198
3	AIRPLANE	800	778	1.95	16810
4	ANT	1240	1171	2.56	13915
5	APPLE	810	810	3.43	8241
6	ARROW	788	785	2.77	5990
7	ARTICHOKE	1463	1397	1.1	15203
8	ASHTRAY	1369	1250	2.3	12932
9	ASPARAGUS	1429	1388	1.1	9654
10	AX	1119	1085	2.3	7849
11	BABY	751	729	5.56	18598
12	BABYBOTTLE	804	775	4.76	8529
13	BALLOON	702	702	1.95	8015
14	BANANA	808	808	2.2	8767
15	BANDAID	757	743	0	13392
16	BED	706	706	5.14	13761
17	BELL	703	703	3.33	11109
18	BELT	812	812	3.3	18762
19	BICYCLE	751	731	1.79	24322
20	BLIMP	1368	1359	4.58	9051
21	BOOK	656	656	6.08	8619
22	BREAD	774	773	4.32	10161
23	BROOM	821	821	2.2	11261
24	BUTTERFLY	720	720	2.4	24645
25	CAKE	789	789	3.56	16237
26	CAMERA	725	725	3.61	16408
27	CANNON	1159	1159	1.95	17678
28	CAR	751	751	5.87	9255
29	CARROT	806	806	2.2	13201
30	CAT	767	766	4.22	9894
31	CHAIR	732	732	4.92	11238
32	CHIMNEY	1169	1169	2.4	9730
33	CLOCK	776	772	3.69	25639
34	COMB	717	717	1.79	28324
35	CORK	1347	1354	1.79	18503
36	COW	1115	1079	3.71	17300
37	CRIB	1090	1127	0.69	13719
38	DEER	1258	1182	2.56	15056
39	DOG	702	702	4.75	12012
40	DOOR	719	719	5.96	12638
41	DRUM	779	766	2.83	39085
42	EAR	681	681	4.49	9033
43	ENVELOPE	803	794	3.22	11394
44	FAUCET	1168	1130	1.1	17509
45	FENCE	817	819	3.43	17349
46	FISHINGROD	1231	1213	0	5685
47	FORK	723	723	2.77	8818
48	FROG	751	751	2.3	14773

49	FUNNEL	1260	1243	1.1	6468
50	GENIE	1217	1214	0.69	18559
51	GIRAFFE	783	783	1.1	18422
52	GLASSES	766	758	3.5	11525
53	HAMMER	724	724	2.48	9533
54	HANDCUFFS	1139	1113	1.1	21347
55	HANGER	794	777	1.1	7003
56	HAT	692	684	4.23	8732
57	HIGHCHAIR	1234	1205	0	19638
58	HINGE	1388	1349	1.61	6973
59	HOOF	1126	1088	2.2	13837
60	HORSE	809	809	4.89	18397
61	HOUSE	755	745	6.41	18069
62	IRONINGBOARD	1110	1105	0	12848
63	JACK	1635	1512	1.95	11170
64	KITE	796	796	1.79	17880
65	LAWNMOWER	1182	1166	0	18238
66	LIGHTBULB	752	737	0	10034
67	LION	812	812	3.26	32267
68	LIZARD	1229	1155	1.61	12070
69	LOBSTER	1361	1289	1.39	20034
70	MAGNET	1202	1189	1.39	23234
71	MICROPHONE	1532	1473	2.2	9962
72	MICROSCOPE	1203	1212	2.2	20349
73	MOON	804	804	4.09	3730
74	MUSHROOM	746	746	2.64	8337
75	NEEDLE	1514	1449	2.83	8377
76	ONION	1115	1100	2.83	11645
77	ORANGE	1129	1098	3.04	10314
78	OSTRICH	1419	1337	1.39	13009
79	PACKAGE	1088	1102	3.04	29767
80	PANTS	779	757	2.83	16138
81	PAPERCLIP	1327	1262	0	21555
82	PEANUT	780	780	1.79	10266
83	PENCIL	702	702	3	7899
84	PENCILSHARPENER	1608	1617	0	19617
85	PIANO	798	798	3.33	19570
86	PLUG	1262	1241	2.3	11385
87	PORCUPINE	1321	1291	0.69	20053
88	PURSE	780	772	2.4	21948
89	RABBIT	742	746	3	11295
90	RAZOR	1099	1089	2.3	14404
91	RING	785	785	1.39	7652
92	ROBOT	822	793	2.08	9502
93	ROPE	810	810	3.76	34568
94	RULER	779	779	2.94	10785
95	SAFE	1253	1243	2.08	10940
96	SANDWICH	775	775	0	13607
97	SAXOPHONE	1103	1061	0.69	8795
98	SCARF	1111	1116	2.56	24187
99	SCORPION	1318	1252	1.1	13037
100	SCREWDRIVER	1179	1179	1.39	9051
101	SEAHORSE	1157	1132	0	9744
102	SEAL	1221	1115	2.71	12172
103	SHELL	1129	1101	3.85	18590
104	SHOE	737	737	4.38	14105
105	SKELETON	817	817	2.56	10724

106	SLED	1198	1188	0.69	16722
107	SLINGSHOT	1308	1265	0.69	25531
108	SMOKE	1212	1221	3.89	10642
109	SNAKE	775	775	3.18	23761
110	SOCK	712	712	2.94	8316
111	SPATULA	1444	1472	0	7762
112	SQUIRREL	1225	1234	1.95	21975
113	STATUE	1234	1214	3.18	7359
114	STETHOSCOPE	1281	1209	0.69	13841
115	STROLLER	1316	1346	0.69	22353
116	SUBMARINE	1144	1145	2.89	12481
117	SUN	762	762	5.03	18102
118	TANK	1181	1155	3.69	11180
119	TELEPHONE	761	752	4.66	19758
120	TELEVISION	799	786	0	18950
121	TENT	744	744	3.81	16963
122	THERMOS	1287	1289	1.1	5251
123	TIRE	805	804	2.48	14920
124	TOOTHBRUSH	811	811	1.1	8597
125	TOP	1226	1083	5.15	10581
126	TREE	796	796	5.26	26074
127	TURKEY	1159	1160	1.79	15338
128	TURTLE	734	734	1.61	14768
129	TWEEZERS	1322	1328	1.1	7308
130	TYPEWRITER	778	778	2.48	28850
131	UMBRELLA	738	738	2.71	15140
132	UNICYCLE	1173	1179	0	20238
133	VASE	1168	1171	2.08	20221
134	WAITER	1161	1156	3.14	27418
135	WHEELBARROW	1226	1207	0.69	20045
136	WHISTLE	790	790	2.3	10521
137	WINDMILL	1252	1226	2.3	12430
138	WORM	1106	1110	2.89	20764
139	WRENCH	1346	1331	1.39	7594
140	YOYO	1155	1141	0	8066

***Action pictures**: RT-total refers to mean reaction times for previous studies conducted at CRL; RT-target refers to reaction times for dominant responses only; Ln frequency is the log natural frequency for each word's dominant response; VisComplexity is each picture's objective visual complexity based on its picture file size in jpg format

No.	Picture Name	RT-total	RT-target	Ln frequency	VisComplexity
1	BARK	949	949	2.4	18031
2	BEG	1348	1292	3.43	17686
3	BITE	1015	993	3.33	24562
4	BLOW	974	974	4.44	19790
5	BOIL	1272	1209	3.78	30327
6	BOUNCE	917	880	2.83	18068
7	BOWL	891	856	2.64	16487
8	BOX	967	963	0.69	16757
9	BREAK	1484	1399	5.44	21546
10	BRUSH	903	888	3.22	23911
11	BURY	1644	1563	3.93	32313
12	BUY	1413	1338	5.86	27841
13	CARRY	1253	1180	5.74	17053
14	CLIMB	1001	989	4.53	37429
15	COMB	861	867	2.3	16924
16	CONDUCT	1426	1373	3.66	13067
17	COUGH	1334	1255	2.56	33349
18	COUNT	1220	1187	4.16	16391
19	CRAWL	1045	1045	3.26	16855
20	CRY	962	934	4.8	22897
21	CURL	1346	1326	2.77	27471
22	CURTSEY	1306	1203	0.69	14133
23	CUT	1065	1065	5.25	18411
24	DANCE	993	979	4.2	30516
25	DELIVER	1452	1408	3.85	21286
26	DIP	1317	1294	2.89	20402
27	DIVE	938	938	2.64	16005
28	DRAG	1353	1315	3.89	28354
29	DRILL	1370	1315	2.56	14929
30	DRINK	888	848	4.87	25613
31	DRIP	980	947	2.4	15971
32	DRIVE	999	989	5.39	35400
33	DROWN	1067	1001	3.26	20210
34	DUST	1215	1209	2.2	13403
35	EAT	1118	1105	5.67	21812
36	ERASE	1319	1244	1.61	23620
37	ERUPT	1409	1404	1.95	27002
38	EXPLODE	1586	1547	3.14	23934
39	FALL	1134	1159	5.69	26229
40	FEED	1241	1208	4.9	22683
41	FIGHT	1235	1199	4.96	27377
42	FILL	1777	1716	4.93	27175
43	FISH	1080	1080	3.47	12729
44	FLOAT	1413	1390	3.53	26049
45	FLY	914	914	4.57	13178
46	FOLD	1356	1275	3.66	24426
47	FOLLOW	1318	1321	5.69	19976
48	FRIGHTEN	1322	1246	2.08	24409

49	GIVE	1330	1343	7.15	27760
50	GLUE	1364	1375	1.39	20359
51	GOLF	1471	1438	1.39	53094
52	GREET	1216	1174	4.88	34427
53	HATCH	1237	1142	1.79	19137
54	HIDE	1430	1408	4.62	25967
55	HITCHHIKE	1340	1360	0.69	26145
56	HUG	995	936	2.48	16095
57	HUNT	1254	1282	3.4	45398
58	IRON	977	977	1.79	13323
59	JUGGLE	961	967	1.1	14974
60	JUMP	1353	1318	4.22	15496
61	KICK	866	853	3.76	17222
62	KISS	958	958	4.09	31961
63	KNEEL	1331	1252	3.18	14002
64	LAUGH	977	956	5.14	39099
65	LICK	1120	1100	2.48	18076
66	LIGHT	1298	1304	4.01	20907
67	LISTEN	1245	1263	5.18	37439
68	LOOK	1494	1439	7.21	19979
69	MAIL	1246	1134	1.61	25541
70	MAKE	1569	1419	7.75	20999
71	MARRY	1376	1301	4.84	23413
72	MASSAGE	1130	1141	1.61	21386
73	MILK	1404	1360	2.4	28992
74	MOP	1332	1258	1.95	20337
75	OIL	1498	1421	1.61	11309
76	PAINT	994	994	4.29	22022
77	PARACHUTE	1399	1288	0	20365
78	PET	935	934	1.39	17815
79	PLAY	1119	1109	6	26095
80	PLUG	1048	1046	2.08	11886
81	POINT	1102	1063	4.89	16800
82	POLISH	1233	1118	3.09	19609
83	POP	1261	1121	3	15804
84	POUR	890	852	4.38	26916
85	PRAY	1224	1216	3.37	45299
86	PULL	1255	1223	5.23	30784
87	PUSH	871	871	4.84	22838
88	RAKE	990	981	1.95	15121
89	REACH	1300	1261	5.55	18105
90	READ	993	993	5.92	30065
91	REPAIR	1383	1321	3.71	24690
92	RIDE	1001	1006	4.06	18320
93	ROW	947	913	0.69	31568
94	RUN	912	918	6.09	17276
95	SAIL	992	988	3.04	18904
96	SALUTE	1028	1028	1.39	15575
97	SCOOP	1117	1114	2.08	24485
98	SCULPT	1371	1325	3.04	26513
99	SELL	1628	1544	4.98	36299
100	SEW	1417	1393	2.48	23884
101	SHARPEN	1526	1540	2.3	19312
102	SHAVE	909	909	2.71	30336
103	SHOOT	1032	1012	4.32	19808
104	SHOWER	974	947	1.95	28383

105	SING	928	925	4.37	23644
106	SINK	1489	1471	3.93	13410
107	SIT	984	964	6.22	18449
108	SKI	1050	1053	1.95	17193
109	SLEEP	991	991	4.87	33733
110	SLIDE	913	886	3.58	32449
111	SLIP	1238	1231	4.13	27692
112	SMILE	1119	1107	5.09	40153
113	SMOKE	921	921	3.81	17842
114	SNOW	1266	1221	1.61	44104
115	SPILL	1733	1703	2.94	23590
116	SPLASH	1417	1284	2.4	35117
117	SPRAY	1480	1312	2.4	23144
118	SPREAD	1351	1367	4.49	25846
119	SQUEEZE	1133	1128	3.37	17216
120	STACK	1324	1204	2.48	11764
121	STIR	1386	1278	3.74	18270
122	SURF	946	946	0	20492
123	SWAT	1420	1342	0.69	34760
124	SWEAT	1239	1201	2.89	16947
125	SWEEP	958	956	3.95	17562
126	SWIM	852	852	3.87	16766
127	SWING	874	874	4.04	18530
128	THROW	1091	1055	5.08	24589
129	TICKLE	1258	1172	1.61	18027
130	TIE	1093	1099	4.13	23682
131	TYPE	792	792	2.89	19194
132	VACUUM	996	993	0.69	30285
133	WALK	929	929	5.74	14385
134	WATCH	1118	1081	5.53	25732
135	WAVE	1224	1207	3.83	15853
136	WEIGH	1116	1113	3.43	22346
137	WHISPER	1127	1088	3.78	31922
138	WINK	1024	989	2.2	20114
139	YAWN	996	950	2.2	13506
140	YELL	1266	1249	3.14	20192