The Organization and Processing of Verbs and Nouns in the Mental Lexicon

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Abstract

The organizational as well as the processing differences between grammatical classes of words (e.g., verbs & nouns) have recently become a topic of interest among psycholinguists, researchers into language acquisition, and aphasiologists. Previous studies have shown that verbs, as a class, are more complex compared to nouns. Although this is the case, whether the difference between nouns and verbs lies at an organizational or processing level has not been thoroughly investigated. In this context, the objective of the current study was to probe into this issue by employing a semantic association judgment paradigm in a group of 25 normal subjects. The dependent variable (reaction time - RT) of nouns and verbs showed faster RT for the semantically associated pairs compared to the unassociated pairs, replicating previous similar results using nouns. Although, the verb pairs too showed such a tendency, the overall RT required for verbs was more than that for nouns. In addition, the analysis of the error data further revealed the complex interaction of the semantic attribute in nouns and verbs. Based on these findings, we argue that both nouns and verbs have similar organizational principle within the mental lexicon, yet with definite processing differences between the two, as indicated by the RT differences and error analysis.

Key words: Grammatical class, Transitivity, Complexity, Mental lexicon, Semantic feature density

The study of word categories in language processing has been a prominent topic in psycholinguistic research, since categories like nouns and verbs provide a window to the cognitive bases of grammatical class distinctions (Kauschke & Stenneken, 2008). A major line of evidence for the differential lexical organization of verbs from nouns has primarily come from the grammatical-class-specific impairments resulting from brain damage. For example, as early as in 1961, Fillenbaum, Jones, and Wepman reported verb production impairments in Broca's aphasia followed by an overwhelming number of case studies reporting either selective noun or verb retrieval deficits (Caramazza & Hillis, 1991; Shapiro, Shelton, & Caramazza, 2000; Laiacona & Caramazza, 2004). Though there are conflicting evidences on the anatomical locus of verb retrieval skills in the brain (see Cappa & Perani, 2003, for a discussion), in general, it is evident that either nouns or verbs could be differentially impaired following brain damage, reflecting the possible differences either in the organization and/or processing of these two grammatical classes of words.

Another source of evidence for the noun-verb difference comes from developmental studies. For instance, the vocabulary of very young children includes mainly nouns, while verbs are present in a very limited number (Gentner, 1982; McNamara, 1972; Nelson, 1973). The possible interpretation for this advantage for nouns compared to verbs lies in the greater conceptual complexity of verbs compared to nouns. The lesser complexity of nouns leads to the earlier acquisition of the names for nouns than for verbs (Gentner, 1982; McNamara, 1972). The categories for nouns are more natural than those for verbs; they often refer to the perceptual properties that tend to cohere and form natural conceptual categories. Thus, the name of an object would be learned by mapping a linguistic label to a preexisting conceptual category (Gentner, 1981; Gentner & Boroditsky, 2001). Verbs, instead, express mostly relational meanings, and therefore their meanings are more dependent on the context, and are more easily subject to changes, according to the nouns they relate.

The differential organization of nouns and verbs poses an interesting question on the

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organizational architecture of the mental lexicon. In normal subjects, there has been a wealth of data on this assumption, primarily derived from reaction time studies using object names. Over and again, it is stated in the literature that those concepts that share similar features are closely located in the mental lexicon. Findings from priming studies have been considered as strong evidence for this assumption. In semantic priming, the latency to name an item significantly reduces when it is preceded by a semantically related, but not an unrelated item. This observed phenomenon has been explained based on the *spreading activation theory* (Collins & Loftus, 1975; Dell, 1986). For example, when naming the picture of a dog, the subject has to recognize the picture and select the appropriate semantic concept. At this point, it is noteworthy to assume that the concept of an item (for e.g., *dog*) is stored as a set of features such as has a *tail*, *pet*, *animal*, *faithful* etc. These features spread their activation to the corresponding lexical node '*dog*' in the lexical layer. However, the individual features of this feature bundle are not only possessed by the concept *dog*, but also by others concepts, say, for e.g., *cat*. Therefore, we can presume that while naming the picture of a *dog*, the features that are common to the other concepts activate their corresponding lexical node partially. Under normal circumstances, the speaker selects the lexical node with highest level of activation (*dog*). The partially activated lexical node (for e.g., *cat*), therefore does not get selected to the output. The selected lexical node (*dog*) in turn, spreads its activation to the phonological layer in order to select the phonemes that constitute the word DOG. These selected phonemes are then fed to the speech articulatory unit for the production (Caramazza, 2000; Krishnan & Tiwari, 2008). As mentioned above, such facilitatory effects of the semantically associated words have majorly come from studies using nouns as stimuli.

Although using nouns are certainly relevant to studies of lexical memory, it only represents part of adults' lexical knowledge, and theories and tools developed to investigate semantic organization must generalize beyond the noun class (Vigliocco, Vinson, Damian, & Levelt, 2002).

Nouns are arguably easier because they tend to be more concrete, or more easily imaginable than verbs (Chiarello, Shears, & Lund, 1999), and it is known that concrete words have a processing advantage over abstract words in different tasks (de Groot, Dannenburg, & van Hell, 1994). This advantage has been explained in many ways. One explanation, based on the dual coding theory (Paivio, 1971, 1986) is that concrete words can be represented both in an imaginable as well as in a verbal-propositional manner, whereas abstract words are represented only in the latter manner. That is, the concrete words are dually coded in the memory, unlike the abstract words. According to the second interpretation, the concrete words are at an advantageous position owing to the interrelations these words can make among the concrete concepts. Such interrelations among concrete concepts are due to the increased availability of relevant meaning relations. However, when such relations are made experimentally available by a sentence context, even abstract words showed equal processing as that of the nouns (Schwanenflugel, Harnishfeger, & Stowe, 1988). The concrete nature of nouns is also evident from various other studies (e.g., Bleasdale, 1987) as well as from various experimental paradigms such as eye movement tracking (Juhasz & Reyner, 2003), electrophysiological correlates (Kounios & Holocomb, 1994), and from brain activation (e.g., Binder, Westbury, McKiernan, Possing, & Medler, 2005). Therefore, from such evidences, it is apparent that the extrapolation of the findings from studies using nouns to the verbs may not be valid as there are definite differences between these two grammatical classes.

In the literature, however, a few studies have investigated into the nature of verb processing. For example, Roelofs (1992) studied the semantic interference effect (SIE) in verb naming. The SIE is usually elicited with a picture-word interference paradigm. In this paradigm, the subjects are required to name pictures with the distracter words embedded on them. In Roelofs' (1992) study, the reaction times of naming verb pictures (e.g., *eating*) were greater when the distracter word was a semantically related verb (*drinking*). This finding was in accordance with similar observations from studies using nouns. From this finding, Roelofs argued that the selection principles behind the nouns and verbs were essentially the same. Similar findings were also reported by Collina and Tabossi (2003).

Tabossi and Collina (2002) studied fourteen classes of verbs of intuitive and semantic sets using a picture word interference paradigm. These authors used an intuitive criterion for verbs as they believed that the verbs may be organized in the mental lexicon based on an abstract intuition of the category items (e.g., *run*, *walk*, and *jump* – as quoted by the authors). In this study, the distracters were part of the response set and each word was paired with two distracter verbs: one semantically related to the target and the other, unrelated. The results obtained, however failed to show the semantic interference effects either in the semantic or in the intuitive sets. The reason for the

failure of this study to replicate Roelofs' (1993) study was attributed to the difference in the transitivity nature of the verbs used in the study. In Roelofs (1993) study, most of the verbs used were intransitive, whereas majority of the verbs in Tabossi and Collina's (2002) experiments were transitive in nature.

In 1998, Schriefers, Teruel, and Meinshausen addressed the semantic interference effect in verbs in the sentential context. In addition to this, these authors also addressed the extent to which the semantic interference effect arises for both transitive and intransitive verbs. Their results revealed that the transitivity attribute of the verb affected the magnitude of the semantic interference effect (SIE). With respect to the sentential context, the SIE for transitive verbs was observed only when they occupied the initial position in the utterance, whereas no SIE was seen for intransitive verbs irrespective of their position in the sentence. Thus, the apparently simple explanation of Roelofs (1993) was complicated by Schriefers et al. (1998) study. In yet another study by Schnur, Costa, and Caramazza (submitted, cited from Tabossi & Collina, 2002) the semantic interference effect in verb production was investigated in three experiments. Although these authors observed the SIE, when the transitive and intransitive verbs were analyzed separately, the SIE was inconsistent.

It is apparent from the available studies in the past that the investigations addressing the nature of verb processing in the mental lexicon are apparently less. In addition, the available studies are insufficient to explain the organizational as well as the processing differences between nouns and verbs. Moreover, the semantic interference effect has failed to replicate the results across the studies, and this failure could partly be attributed to the transitivity nature of the verbs used across the studies. Finally, owing to the inherent nature of the verbs, being less concrete and more complex, a mere extrapolation of the findings from nouns may not provide reliable insights about the organization as well as processing of verbs in the mental lexicon. Further, no studies have attempted to investigate whether the difference between nouns and verbs lies at the organizational and/or at the processing level between them.

Aim of the study

In the context of such lacunae in our understanding about the organizational and/or processing difference between nouns and verbs, the present study aimed at investigating into this issue by employing a different paradigm – the semantic association judgment. In this paradigm, the participants were required to judge the presence or absence of semantic association between the words of the stimulus pairs. This paradigm has been effectively used in previous studies (e.g., Krishnan & Tiwari, 2008).

Objectives of the study

Specifically, the objective of the study was to compare the semantic association judgment times (here, the reaction time – RT) of semantically associated and unassociated nouns with that of verbs.

Working hypotheses

The working hypotheses of the current study were:

- A common trend across the nouns and verbs, both in the semantically associated and unassociated conditions may be indicative of a comparable organization of these two grammatical classes in the mental lexicon.
- If a considerable difference in the RT between nouns and verbs is observed, it may be indicative of the difference in processing demand between these two grammatical classes of words.

Method

Stimuli

For the purpose of the current study, a pool of verb pairs was generated by asking a group of five subjects to list out all the possible verbs in English. This pool was further examined to categorize them based on the concreteness (imageability), and transitivity attributes. From this filtered pool, we generated 14 semantically associated and 13 semantically unassociated, concrete, and transitive verb pairs. The nouns stimuli were selected from a previous pool (Krishnan & Tiwari, 2008) of semantically associated and unassociated nouns pairs. Twenty seven noun pairs (14 associated & 13 unassociated) were selected for the current study. From the total of 54 pairs, four pairs (one each from the four conditions) were used as trial items. In addition, both the noun as well as verb pairs were selected carefully such that all the items were concrete and, therefore, highly imaginable. *With respect to the verbs, only transitive verbs were selected for the current study.* Therefore, the material consisted of 50 critical items (excluding the trial items) belonging to four different conditions as follows: semantically associated nouns (n = 13) (e.g., *cat-dog*), semantically unassociated nouns (n = 12) (e.g., *stone-spoon*), semantically associated verbs (n = 13) (e.g., *eat-drink*), and semantically unassociated verbs (n =

12) (e.g., *beg-slip*) (See Appendix A for the stimulus pairs).

Participants

Twenty-five graduate students (mean age = 21 years, SD = 2) from Manipal University volunteered to participate in the current study, with English as their medium of instruction starting at the age of 4-5 years. All subjects were right-handed and had normal or corrected-to-normal vision.

Procedure

The subjects were made to sit in a dimly lit, soundproof room and verbal instructions were given about the task. This was followed by the presentation of training items and the subjects were made familiar with the task and the response. The stimulus presentation through the computer was controlled by DMDX reaction time software (Forster & Forster, 2003). We used the procedure employed by Krishnan and Tiwari (2008) to obtain the reaction times. However, in the present study, the stimuli were randomized and grouped into two blocks of 25 each. At the end of the first block, a rest period (one minute) was given and for each subject, and the testing was completed in a single session.

Results

Response latency

For the statistical analysis of the response latencies, the RTs of incorrect responses were eliminated. The data were analyzed using SPSS 16 software for windows. The mean RT for semantically associated noun pairs was 757.08 ms (SD = 153.2), and for the semantically unassociated noun pairs, it was 900.73 ms (SD = 237.47). Similarly, the mean RT for the semantically associated and unassociated verbs were 812.82 (SD = 192.9) and 935.83 ms (SD = 256.01), respectively. On an average, the subjects took lesser time to respond to noun pairs compared to verbs. The results also showed that the subjects responded faster to the semantically associated conditions compared to semantically unassociated conditions (Figure 1).

In order to find the interaction between the types of grammatical classes (noun & verb) versus the semantic condition (associated & unassociated), the data were submitted to Two-way Analysis of Variance (ANOVA). The results of the analysis showed a significant main effect for the semantic condition (F (1, 96) = 9.73, $p < 0.05$). However, there was no significant main effect observed for the word type (nouns vs. verbs) (F (1, 96) = 1.13, $p > 0.05$). Although, the comparison between the two variables (word type vs. semantic association) revealed a meager interaction between the two (see Figure 1), it did not reach the significance level (F (1, 96) = 0.058, $p > 0.05$).

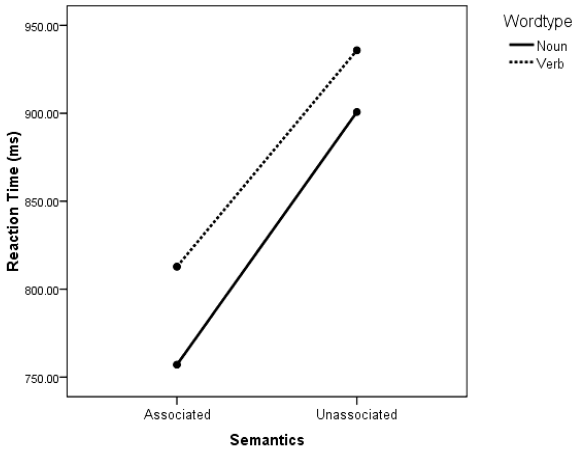

Figure 1: Mean reaction times as function of semantics and the word type.

In order to find out the difference between the associated nouns versus verbs as well as the unassociated nouns versus verbs, paired sample t-tests were performed using SPSS 16. The results revealed significant difference between nouns and verbs in the associated condition (t (24) = -2.63, $p < 0.05$), but not in the unassociated condition (t (24) = -1.314, $p > 0.05$).

Errors

The total number of responses inclusive of both nouns and verbs in the semantically associated and unassociated conditions were 1250 (25 subjects x 50 items). The distribution of errors across the four conditions was as follows: semantically associated nouns - 15/325 (4.6%; Mean = 0.6; SD = 0.64), semantically unassociated nouns - 39/300 (13%; Mean = 1.56; SD = 1.38), semantically associated verbs - 43/325 (13.26%; Mean = 1.72; SD = 0.93), and semantically unassociated verbs - 31/300 (10.33%; Mean = 1.24; SD = 0.97). We analyzed the variance (Two-way ANOVA) of the errors with respect to their semantic attribute (associated vs. unassociated) and word type (noun vs. verb). There were no significant main effects either for the semantic attribute (F (1, 96) = 1.38; $p > 0.05$) or for the word type (F (1, 96) = 3.84; $p > 0.05$). However, the interaction between these two variables was quite significant (F (1, 96) = 12.47; $p < 0.05$) (Figure 2).

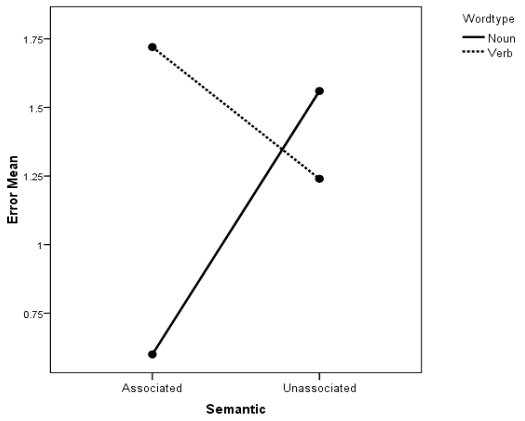

Figure 2: Mean errors as a function of semantics and grammatical classes

In order to find out the difference in mean error rates between the associated nouns versus verbs as well as the unassociated nouns versus verbs, paired sample *t*-tests were performed using SPSS 16. The results revealed significant difference between nouns and verbs in the associated condition (t (24) = -4.96, $p < 0.05$), but not in the unassociated condition (t (24) = -1.138, $p > 0.05$).

Discussion

The goal of the present study was to investigate into the organizational as well as processing difference between nouns and verbs in the mental lexicon. For this task, we employed a semantic association judgment (similar to Krishnan & Tiwari, 2008) in a group of 25 normal subjects.

Response Latency

As evident from our results, the response latency was shortest in the case of semantically associated pairs compared to the unassociated pairs. In the domain of nouns, the current results replicated the previous findings reported by Krishnan and Tiwari (2008). Similarly, the semantically associated verbs too showed advantage over the unassociated verbs. In general, both nouns and verbs were judged faster in the semantically associated condition compared to the unassociated condition. We had hypothesized that a common trend in both nouns and verbs in the semantically associated and unassociated conditions would be indicative of the similarity of organization between these two grammatical classes in the mental lexicon. The current observations were congruent with this hypothesis. Therefore, we argue that both nouns and verbs have similar organizational pattern in the mental lexicon. Roelofs (1993) has also reported similar findings, although she used a different paradigm in her investigation (i.e., semantic interference effect).

Addressing our second hypothesis, that is, a significant difference in RT between the nouns and verbs would be indicative of the differences in the processing demand between these two types of words, has also been supported by the current study. From the results (see Figure 1), it is apparent that the verbs were slower compared to nouns irrespective of the semantic condition. Although various researchers have reported processing difference between nouns and verbs (e.g., Bird, Franklin, & Howard, 2000), by employing a different paradigm, the current study provided further support for the increased processing difficulty of verbs compared to nouns.

Combining the above two major observations on the organization as well as the processing of nouns and verbs, there emerges the picture of the mental lexicon where both nouns and verbs have similar organizational principles with increased processing demand (as evidenced by increased RT) for verbs compared to nouns. Although this was the case, there were some additional and vital observations from the current study.

An interesting observation from the current study was that when the two grammatical classes of stimuli were collapsed (nouns & verbs), the semantic condition showed a significant main effect. However, when the two semantic conditions (associated & unassociated) were collapsed, the grammatical word class did not show any significant main effect with respect to the reaction time (F (1, 96) = 1.13, $p > 0.05$). Further, the interaction between the nouns and verbs, although present, was meager and it did not reach the significant level (but, see the error data, below). These findings reveal that with respect to the organization of the mental lexicon, the semantic association among the members of the lexicon is vital than their grammatical classes. That is, irrespective of the grammatical class, the semantically associated pairs were judged faster compared to the unassociated pairs. However, such a finding was not observed when both semantically associated and unassociated word pairs were combined and compared between nouns and verbs. Therefore, this interpretation shows that the processing difference between nouns and verbs arises at the semantic level. The earlier observation that nouns are processed faster compared to verbs, may therefore be interpreted as the influence of the semantic attribute. Hence, the apparent processing difference (as indicated by the RT differences) between nouns and verbs could be attributed to the semantic attributes. In this context, the claim that the reduced semantic

features contributing the increased reaction time difference between nouns and verbs (Bird et al., 2000) gains further support from the present study.

Furthermore, the comparison between the semantically associated nouns and its verb counterparts showed an apparent difference between the two (nouns were judged faster compared to verbs (t (24) = -2.63, p < 0.05).However, in the unassociated condition, the paired comparison did not reveal such a difference between nouns and verbs (t (24) = -1.314, p > 0.05). Such a difference only in the semantically associated condition, favoring the nouns compared to the verbs is in support with the arguments of Bird et al. (2000). These authors reported that verbs have fewer semantic features compared to nouns. According to the spreading activation theory (Collins & Loftus, 1975; Dell, 1986), fewer semantic features (which are shared by the stimulus pairs) apparently delay the semantic association judgment (see Krishnan & Tiwari, 2008, for an explanation). The absence of a significant difference in RT in the semantically unassociated nouns and verbs may be explained based on the same principle. That is, the absence of adequate overlapping (or shared) semantic features between nouns and verbs in the semantically unassociated condition might have resulted in insignificant difference between the two word types.

Error analysis

The error analysis too revealed some interesting findings between nouns and verbs. Although there was no significant main effect for the word type as well as the semantic condition, the interaction between these two variables was significant (F (1, 96) = 12.47; p < 0.05). That is, when the nouns showed fewer errors, the verbs showed more in the associated condition. This pattern was reversed in the semantically unassociated condition, where the verbs showed fewer errors compared to nouns (See Figure 2). This finding appears paradoxical and a little difficult to explain with the available information on the organizational structure of the mental lexicon. Yet, we attempt an explanation for this as follows. From the Figure 2, it is apparent that, in general, the subjects showed more errors in the semantically associated verbs as well as in the unassociated verbs and nouns. We attribute these findings to the 'semantic feature density'.

By the term 'semantic feature density', we refer to the number of semantic features that are available to a given semantic concept. The denser the features are, the more concrete the semantic item is. In this regards, based on the previous evidences, it may be argued that the verbs have relatively lesser number of semantic features (e.g. Bird et al., 2000). We further argue that, the processing time (RT) and the accuracy (error rate) are influenced by the semantic feature density, perhaps, in two contrasting ways. First, increased number of *overlapping* or *shared* semantic features increases the processing speed (i.e., smaller RTs) as well as the accuracy (i.e., lesser errors). This is typically noticed in the case of semantically associated nouns. However in the case of semantically associated verbs, the increased number of errors could be attributed to the lesser number (compared to the nouns) of semantic features, although they were *overlapping* or *shared*). In the unassociated condition, the error rates showed some vital findings. That is, verbs exhibited fewer errors compared to nouns *(although, the error rates did not significantly differ from each other).* We argue that the explanation for this seemingly paradoxical finding is again the semantic feature density. That is, the nouns are expected to have more number of semantic features compared to verbs. In the semantically unassociated condition, the mere possession of dense semantic features (which are *non-overlapping* or *unshared*) would tax the mental lexicon, resulting in more errors. The lesser number of errors in the case of unassociated verbs (compared to their noun counterparts) may be attributed to the generally lesser number of (unshared) semantic features, and consequently, reduced processing demand in the mental lexicon. Interestingly, our results further indicated that such taxing affects principally the accuracy rather than the processing time, as the RT in the unassociated nouns was lesser than that of the unassociated verbs.

In essence, it may be argued that the number of overlapping semantic features increases the efficiency of the mental lexicon, resulting in quicker and more accurate judgments (e.g. semantically associated nouns), whereas lesser overlapping (or shared) semantic features increases the judgment time (compared to their noun counterparts) as well as error rate (e.g. semantically associated verbs). Similarly, the increased number of non-overlapping features would compromise the accuracy of the processing, rather than its speed (e.g., semantically unassociated nouns)

Finally, the stimuli used in the current study were carefully selected so that all the nouns and verbs used were concrete in nature. In addition, all the verb pairs were transitive in nature. Hence, the finding of the current study is applicable to concrete nouns and (transitive) verbs. Future studies may compare the organization as well as processing difference between abstract nouns and

verbs and both transitive and intransitive verbs by employing different paradigms for experiment.

Conclusions

In summary, the findings of the present study revealed several vital observations with respect to the organization as well as the processing of nouns and verbs in the mental lexicon. A similar trend between processing of nouns and verbs (as revealed by the RTs) supports a resemblance in their organizational structure in the mental lexicon. Yet, the processing was more demanding for verbs compared to nouns, supporting our second hypothesis. In addition, the error analysis data revealed the influence of the semantic feature density (shared or unshared features) and its differential effects on nouns and verbs.

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Appendix - A

Semantically Associated Nouns	**Semantically Unassociated Nouns**	**Semantically Associated Verbs**	**Semantically Unassociated Verbs**
Bread – Butter	Soap – Phone	Pick – Drop	Hit – wash
Pencil – Eraser	Stone – Lion	Read – Write	Smoke – grab
Ring – Finger	Room – Kite	Throw – Catch	Beg – Slip
Apple – Mango	Chair – Spoon	Punish – Cry	Tie – Slip
Bank – Money	Pipe – Shirt	Eat – Drink	Bathe – Draw
Fish – Water	Boat – Ball	Write – Draw	Shave – Push
Bag – Book	Moon – Leaf	Drop – Break	Chew – Chase
Door – Lock	Thread – Stove	Sweep – Mop	Clap – Fly
Pen – Ink	Iron – Shoe	Bring – take	Cough – Crawl
Bed – Night	Key – Nose	Cook – Eat	Swim – Speak
Window – Curtain	Tree – Switch	Draw – paint	Dip – Hit
Table – Bench	Knife – Feather	Wash – Wipe	Jump – Salute
Road – Vehicle		Cut – paste	