# The picture-word interference paradigm: conceptual effects in the production of verbs

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In recent years, experimental research on language production has started to make increasing use of the so-called picture-word interference paradigm to explore lexical retrieval processes. While providing useful information on the production of nouns, the paradigm has not led, so far, to comparable results with respect to the production of verbs. The paper presents an experiment and provides a discussion aiming at clarifying some of the variables that affect verb production and render semantic interference effects difficult to observe.

## *1. Interference effects and the production of nouns*

Interference paradigms have long been popular among psychologists studying cognitive phenomena. The technique is simple: participants are presented with a stimulus made up of two different components. Their task is to respond to one component of the stimulus, ignoring the other. For example, they could be presented with a word such as *blue* written in red ink, and requested to name the ink colour as quickly as possible (Stroop 1935).

When the two components of the stimulus are a picture and a word, the task is typically one of picture naming: participants are instructed to ignore the distractor word and to name the picture, producing a target word. Usually, experimental conditions are manipulated by the researcher who varies the relationship between distractor and target words or the time interval between the presentations of picture and distractor (SOA: Stimulus Onset Asynchrony).

Over a decade ago, in an influential study conducted in Dutch, Schriefers et al. (1990) employed this paradigm to study the production of nouns. They found that naming a picture (e.g., a dog) takes longer when the distractor is semantically related (e.g., *cat*) than when it is unrelated (e.g., *roof*) to the target (e.g., *dog*). This effect is observed when the distractor is presented shortly before or at the same time as the picture (SOA = -150/0 ms), but disappears when it is presented after the picture (SOA = + 150 ms). In contrast, when target and distractor are phonologically related (e.g., *dog/fog*) respon-

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ses are faster than when they are not (e.g., *dog/roof*), provided that the distractor is presented after the target.

Similar results were subsequently replicated in Dutch as well as in other languages (Miozzo & Caramazza 1999; Roelofs 1992). Levelt and co-workers explained the findings based on their model of language production, in which the lexicon is viewed as a three layer net (Levelt et al. 1999). The first stratum of the net contains interconnected conceptual nodes and the labeled links between them express the nature of the semantic relationships. Some conceptual nodes – the lexical concepts – have a bidirectional link with their corresponding lemma nodes at the successive stratum, where words' syntactic properties are specified (the lemma stratum). Each lemma, in turn, has monodirectional links to nodes belonging to the next layer of the network, containing words' phonological information (lexeme stratum). Once in the phonological/articulatory domain, the selected lemma must be translated into the appropriate articulatory gestures for execution.

In this model, word retrieval is represented as a spreading activation process. Whenever a lexical concept becomes activated, it spreads activation to all the connected concept nodes. Moreover, it activates its lemma. Among the lemmas receiving activation from the conceptual nodes, the lemma that has the highest level of activation gets selected. Once selected, it then sends activation to the corresponding nodes at the lexeme level (Roelofs 1992).

Within this framework, semantic effects are assumed to occur in picture word-interference experiments under the constraint that all distractors are also names of pictures. Furthermore, while a picture directly activates its corresponding concept and then its lemma, a word has direct access to the lemma and only through this to the corresponding lexical concept. Given these assumptions, semantic interference effects arise when the distractor and the target concepts are connected: due to these connections, activation from the distractor and target concepts will enhance the level of activation of the distractor lemma which will be higher than the level of activation of a lemma whose concept has no connection with the target concept. Therefore, the distractor lemma will be a stronger competitor for the target lemma when their concepts are related, and it will take longer before the level of activation of the target will exceed that of the related distractor, leading to a longer selection time.

As for phonological facilitation, it occurs only when the distractor word is presented after the target lemma has been selected. At this point, if the distractor is phonologically related to the target, the

activation it sends to the lexeme level reaches some of the nodes activated by the target lemma, enhancing their activation and thus facilitating the selection of the target's phonological representation.

Studies conducted with the picture-word interference paradigm have extended the empirical basis traditionally available in support of the notion that the production of a word occurs in two fairly distinct stages, one involving the retrieval of the word's semantic and syntactic information and the other involving the retrieval of the corresponding lexical-phonological information (Bock 1986; Caramazza 1997; Dell 1986; Levelt 1989). It was well-known that in word substitution errors occurring during normal speech the pronounced word often shares with the intended word a relation that is only semantic or only phonological (e.g., *dog-cat*; *dog-fog*), suggesting the independence of the two types of information (Fay & Cutler 1977; Garrett 1988). Consistently with speech errors data, neuropsychological research has indicated that while some aphasic patients show difficulties at the semantic level, resulting, for instance, in producing semantic paraphasias, others produce frequent phonological substitutions or random rearrangements in words' phonemes, showing impairments at the phonological level (Garrett 1982; Ellis 1985; Kohn 1985). The experimental findings obtained with the picture-word interference paradigm have provided new and independent evidence on the temporal difference between semantic and phonological effects such that while semantic effects occur in the early phases of word production, phonological effects appear only later in the process (Roefols, 1998; Schriefers et al. 1990).

In fact, interesting issues concerning the production of nouns have been addressed and clarified in picture-word interference studies. For example, Schriefers (1993) asked his participants to name a picture producing a noun phrase (e.g., 'de groene stoel'-'the green chair'). The study was in Dutch, a language in which determiners and adjectives are marked for grammatical gender. The results showed faster responses when the grammatical gender of the distractor and target nouns were the same rather than different. Subsequent work made it clear that the congruency effect, initially interpreted as a purely syntactic phenomenon, may occur late in the production process, when determiners' phonological forms must be retrieved (Miozzo & Caramazza 1999).

Recent studies have also shed light on the role played by the response set in determining semantic interference effects. As already mentioned, according to Levelt and colleagues, a crucial condition in order to obtain these effects in a picture-word interference study is

that distractor and target words all belong to a set of words – the response set – that participants are given prior to the experiment, so that they can pre-activate and select them from among all the words they know (Levelt et al. 1999; Roelofs 1992). In contrast with this claim, however, Caramazza and colleagues have shown that semantic effects can be obtained even when distractor words are not part of the response set, and whether the nature of the effects is one of interference or facilitation depends on the relationship between target and distractor: if they are co-hyponyms (e.g., *dog-cat*), they interfere with each other, but if the target is a hypernym (e.g., *animal)*, the distractor (e.g., *cat)* facilitates the response (Caramazza & Costa 2000; Costa et al. in press).

*2. Interference effects and the production of verbs*

As fruitful as it may be in the study of noun production, the picture-word interference paradigm, at least so far, has not proven very productive with verbs. In a work in which distractors were part of the response set, Roelofs (1993) asked his Dutch participants to name the picture of an action, producing a target verb in the inifinitive form (e.g., *drinken* - 'to drink'). Contemporarily with the picture, a verb distractor was also presented. The distractor was semantically related (e.g., *eten* - 'to eat') or unrelated (e.g. *niezen* - 'to sneeze') to the target. As in noun studies, participants were slower in the related than unrelated condition, showing semantic interference effects.

Since Roelofs' work (1993), production processes have become increasingly popular and verbs have attracted a considerable amount of interest in language research (e.g., Berndt et al. 1997; Breedin & Martin, 1996; Breedin et al. 1998; Pickering and Branigan 1998; Levin & Rappaport Hovav 1996). Yet, only two picture-word interference studies exploring verb production have appeared so far, and neither of them provides a clear replication of Roelof's findings (Schriefers, Teruel, & Meinshausen, 1998; Tabossi & Collina, 2001). Schriefers et al. (1998) obtained semantic interference effects, albeit restricted to transitive verbs, in a study that looked at sentence rather than word production, whereas Tabossi & Collina (2001) found semantic effects in the assignment of aspectual auxiliary during the production of Italian verbs.

More recently, we conducted a study whose main goal was to replicate Roelofs' findings and to assess the relevance of the response set in the production of verbs. The results indicated a semantic inter-

ference effect. Participants were slower in naming a picture of a verb in presence of a semantically related distractor than in presence of an unrelated one (Collina & Tabossi, submitted).

This study replicates in Italian the results obtained by Roelofs (1993), corroborating the view that like noun production, verb production may be sensitive to effects of semantic interference. Furthermore, in analogy with what Caramazza & Costa (2000) have shown for nouns, our data suggest that the effects can be found regardless of whether or not distractor verbs are part of the response set, thus strengthening the evidence that calls for a re-consideration of the selection mechanism proposed by Levelt and colleagues in their model of lexical access (Levelt et al. 1999).

However, the materials we used in that study were Italian translations of Roelof's verbs and in both studies semantic relatedness between distractor and target verbs was decided on purely intuitive grounds. Hence, it is still not clear whether Roelof's and our own results would hold with entirely different sets of verbs, possibly selected on a principled way.

Unfortunately, our knowledge of how semantic information is mentally organized is not as good for verbs as it is for nouns. Even though there may be occasional uncertainties, usually intuition, empirical data, and theoretical models all suggest that in our mental organization a canary and a hawk, for example, are members of the category of birds, which in turn are a type of animals, whereas a fork and a spoon are types of cutlery, whose superordinate category is that of utensils (Rosch 1975).

We do have intuitions on the meanings of verbs; we know, for example, that the meanings of *run*, *walk* and *jump* 'go together', but have no strong relation with the meanings of *think* and *imagine*, which are 'close' to each other. But we soon run into troubles. Let us assume, for example, that *run*, *walk* and *jump* are all verbs of movement, what other members would the category include? Would *travel* or *go* belong to the same category? And what would their hypernym be? Current theories reflect somewhat these difficulties and various suggestions have been put forward in recent years (Jackendoff 1983; Levin & Pinker 1991). In order to test how well these theories capture the way in which verb meanings are mentally organized we ran the experiment described below.

## *3. The experimental investigation*

One interesting linguistic hypothesis assumes that the syntactic behaviour of a verb can be predicted on the basis of its meaning (Chomsky 1986; Hale & Keyser 1987). On this assumption, Levin (1993) proposed to organize a large number of English verbs in classes whose members while sharing meaning components such as motion, contact, change of state, causation, also exhibit similar syntactic behaviours.

Levin's syntactic analyses are restricted to English verbs. Moreover, she makes no claims on the psychological relevance of her classification. However, the hypothesis is rather influential among psycholinguists (Fisher et al. 1991; Pinker 1989), and many of the meaning components identified in her work are common to various cognitive theories (Jackendoff 1983; Levin & Pinker 1991; Miller & Johnson-Laird 1976). Accordingly, we decided to rely on Levin's classification to select in a principled way verbs and to use them in a new picture-word interference experiment in Italian.

### *3.1. Methods*

#### *3.1.1. Participants*

Twenty-one Italian native speakers from the University of Trieste took part in the experiment.

#### *3.1.2. Materials*

Fourteen classes of verbs were chosen, and from each class (e.g., verbs of learning), we selected two pairs of verbs such that while in one pair the relation between the two verbs was intuitively apparent (e.g., *studiare* - 'to study' */imparare* - 'to learn'), in the other pair it was not (e.g., *pensare* - 'to think' */leggere* - 'to read'). These pairs were used to create two sets of materials: the intuitive set and the semantic set. In this study distractors were part of the response set; hence, for each word, a black and white $13 \times 13$ picture was created and paired with two distractor verbs: one semantically related to the target and one unrelated. Before the experiment proper, pictures were presented to a panel of ten participants who had to name the action depicted. Only the pictures named with the intended verb were used in the experiment.

*3.1.3. Procedure*

Participants were presented with a picture along with a distractor verb in the infinitive form. Pictures were presented on the centre of the screen and the distractor word appeared above or below the picture.

Each trial had the following structure: picture and distractor were presented contemporarily on the screen (SOA = 0) for 1500 ms and then erased. After 2500 ms the next trial began. Participant's task was to name the picture as fast as possible producing the infinitive form of the verb. Onset naming latencies were measured from the onset of the picture to the beginning of the response by means of the voice key.

*3.2. Results*

The following types of responses were scored as errors and were excluded from the analyses: (a) the production of verbs that differed from those designated by the experimenter; (b) verbal disfluencies (e.g. stuttering); (c) recording failures. The percentage of errors was 16.6%.

There were two independent variables: set of materials (intuitive vs. principled) and relatedness (related vs. unrelated).

Responses were submitted to two analyses: one by subjects and one by items. In both analyses the set of materials was a between factor and the relatedness was a within factor.

The difference between the mean response latencies in the related and unrelated conditions was reliable neither in the intuitive set (933 ms, SD 206 ms vs. 953 ms, SD 312 ms), nor in the semantic set (943 ms, SD 212 ms vs. 930 ms, SD 203 ms).

In no case we found any evidence of an interference effect ($F1(1,20) = 1.20$, $MSe = 1361$, $p = 0.28$; $F2(1,55) = 0.083$, $MSe = 4112$, $p = 0.77$). No sources or interaction were reliable.

Semantic interference effects failed to be observed either in the linguistically principled or in the intuitive set. The classes of verbs we chose to use for the principled set were among the least uncontrovertial in the linguistic and psycholinguistic literature (Fellbaum 1990; Miller & Fellbaum 1991). It may still be argued, however, that these classes are not psychologically real independently of the theories that propose them. But, in addition, our data fail to replicate Roelofs (1993) and Collina & Tabossi (submitted) providing no support to the notion that verb distractors that have an intuitive semantic relation

with their target interfere with their production. No doubts, negative results call for great interpretative caution. Yet the lack of any semantic effect in the intuitive set was an unexpected result.

Why did we fail to replicate Roelofs' and Collina & Tabossi's results? How do the verbs we used in this study differ from theirs?

### *4. Transitive and intransitive verbs*

It has recently been observed that semantic interference effects are more likely to be found with intransitive than transitive verbs. In fact, in Roelofs (1993) and Collina & Tabossi (submitted) the most part of the verbs used were intransitive, whereas the majority of the verbs in the experiment we have just described were transitive.

The possible relevance of this difference found some empirical ground in a series of five experiments where Schnur, Costa & Caramazza (submitted) observed that the transitivity value of a verb modulates the probability of getting semantic interference effect.

Tabossi & Collina (in preparation) directly compared the ability of transitive and intransitive verbs to give rise to semantic interference effects. What they found was a clear-cut interaction: naming latencies were reliably slower in the related than the unrelated condition when the verbs were intransitive. However, when the verbs were transitive no reliable effect was observed. This suggests that the transitivity of the verbs in Tabossi & Collina (in preparation) may in fact be responsible for the failure to detect semantic interference effect in that study. But why? Undoubtedly, there are semantic differences between intransitive and transitive verbs, the most obvious of which, perhaps, is that intransitive verbs are used to say something about entities, whereas transitive verbs are used to express relations among entities (Chierchia & McConnell-Ginet 1990). However, it is difficult to see how these differences could lead to a mental organization of the two types of verbs such that, while related intransitive verbs compete with each other in order to be selected during production, transitive verbs do not. Perhaps, a more promising way to explain the difference is one that considers the role of the context in word interpretation.

It is well-known that words may receive different interpretations depending upon the sentential contexts in which they occur. Anderson & Ortony (1975), for example, showed that *basket* is a better memory cue than *bottle* for a sentence like *The container held the apples*, whereas the reverse is true for a sentence like *The container*

*held the cola*. Context-dependent encoding, however, is not restricted to nouns. In fact, the sentence *The housewife cooked the chips* suggests that the housewife fried the chips. Hence, *fried* is a better recall cue for the sentence than *cooked*. But *fried* is not a better cue than *cooked* for *The housewife cooked the peas*. This sentence suggests that the housewife boiled the peas, and hence *boiled* is a better recall cue for it than *cooked* (Garnham 1979).

In this paradigm, pictures used to prompt the production of an intransitive target verb typically represent an individual performing an action (e.g. to laugh). However, a picture used to prompt a transitive verb requires, in addition, the representation of the object that is being acted upon and the selection of this object may determine the type of event actually represented. For instance, if the picture for *to write* depicts a person writing an essay, the event represented would be one of learning, whereas if the person is writing a letter, the event would be of a different type, namely one of communication. Thus a distractor verb (e.g., *to study*) which may be related to the target verb in one of its realizations (e.g., writing an essay), may not be in another (e.g., writing a letter), preventing semantic interference effects from being observed.

The entities involved in the action expressed by a verb play, in general, a crucial role in determining its interpretation, but the nature of transitive verbs seems to render their interpretation more dependent on context than the interpretation of intransitive verbs (Schnur et al., submitted). We assessed the difference by looking at the number of different uses listed for transitive and intransitive verbs. Our search, that used a recent Italian dictionary (Sabatini-Coletti 1997) and was restricted to frequent words only (using the option 'Dizionario di base'), revealed that the number of uses that a noun or a verb may receive is on average 3.82, in a range that goes from 1 to 26. Verbs, in general, have more distinct uses than nouns (4.60 vs. 3.04). However, among verbs, transitives have the largest number of uses (M = 5.37) compared not only to intransitives (M = 4.27), but also to modals (M = 4.88) and reflexives (M = 3.50). A one-way independent ANOVA which directly compared transitive and intransitive verbs showed a reliable difference in the number of contexts in which they appear ($F(1, 1807) = 41.9$; MSe = 3.76; $p = 0.000$). As rough as it is, the dictionary count gives a simple indication of the fact that transitive verbs are used to refer to a larger variety of events than intransitive verbs.

It is possible that this difference has an effect in the context of the picture-word interference paradigm. Some support to this

hypothesis comes from a recent study in which we explored the possibility to obtain interference effects with transitive verbs. Indeed, we found that the production of a target is slowed down by a distractor even though this is not semantically related [1], provided that the two verbs are related in the event represented in the picture. *To load*, for example, interfered in the production of *to shoot*, when the picture showed a shooting event.

People have intuitions on the semantics of verbs. We know, for example, that *to shoot* is close to *to fire* and far from *to load*. Likewise, we know that the meaning of a verb like *to write* is 'close' to the meanings of verbs like *to read* or *to study*, and far from the meaning of a verb like *to send*, which is close to the meaning of *to receive*. However, our findings seem to suggest that verb production in picture- word interference studies is sensitive not so much to semantic relation, as to the conceptual organization of complex events like TO BUY A NEW DRESS, TO COMMUNICATE BY MAIL, TO MAKE MUSIC TO USE WEAPONS. We know that in an epistolary exchange, for instance, we may write letters, read them, post, send, stamp, and receive them.

Work on knowledge representation has shown that events are mentally structured and are organized in basic, superordinate and subordinate levels just like objects' (Barsalou 1985; Barsalou et al. 1998; Morris & Murphy 1990). However, notions such as goal and time, which play no major role in the mental organization of objects, are central in the organization of events (Barsalou & Sewell 1985). A complex event such as TO BUY A NEW DRESS, for example, would include actions like TO SELECT A DRESS and TO PAY, which would be stored along with the specification that the latter action must occur after the former.

Probably, conceptual effects are particularly evident with transitive verbs for the joint effects of two factors. First, the relational nature of these verbs makes their interpretation very dependent on the specification of their arguments, in particular their themes (Schnur et al., submitted). Second, this characteristic becomes apparent in picture-word studies in which the use of a visual stimulus makes it impossible to avoid the pictorial realization of verb's arguments. However, there is no reason to believe that the conceptual phenomena are restricted to the production of transitive verbs or to verbs only. To the contrary, the effects we observed suggest the need for a careful scrutiny of the nature of the effects we observed in picture-word interference studies.

## *5. Concluding remarks*

In language production research, the picture-word interference paradigm is currently used to study word production, including the processes of word selection. In this framework, semantic interference effects have typically been interpreted as evidence of competition for selection of two lemmas whose meaning is related.

Levelt and colleagues argue for the correctness of this interpretation. In particular, Schriefers (1990) found that the effect of interference disappears when the naming task is changed into a non verbal task such as categorizing the pictures as new or old by pressing a button.

Unfortunately, our discussion seems to indicate that the linguistic process of verb selection may be affected by extralinguistic phenomena such as speakers' conceptual organization of complex events. If the hypothesis is correct, it has two main consequences. On the one hand it casts doubts on the adequacy of the picture- word interference paradigm in the study of the linguistic processes involved in verb production. On the other hand, however, it highlights the fact that our semantic knowledge is probably so tightly interwound with conceptual knowledge that studying one ignoring the other maybe actually prove to be impossible.

In current psycholinguistics, it is usually agreed that the meaning of a word is the same of the concept (Bock & Levelt 1984; Levelt et al. 1999). The meaning of the word apple is the same of the concept APPLE. Consider, now, a verb like *escort*. According to Levelt and colleagues, the meaning of *escort* is represented by all the links the concept ESCORT (X, Y) has with other concepts, like its hypernym ACCOMPANY (X, Y). Semantic relations such as class inclusion reflect people's linguistic intuitions whereby if, for instance, *Mary escorts Peter* is true, *Mary accompanies Peter* must also be true.

However, in addition to these relations, discussed by Levelt and colleagues, ESCORT (X, Y) may have other types of conceptual relations. In a domain organizing our knowledge of balls, for example, escorting is an act of courtesy in the context of a dancing situation, whereas in the domain of anti-crime initiatives in Sicily, it is a dangerous activity to protect judges' threatened lives. All these types of information, concerning the lexical knowledge of meaning as well as the world knowledge, are likely to be normally available to people when they speak or listen to discourse. Almost 30 years ago, Miller & Johnson-Laird produced an in-depth analysis of the kind of conceptual organization that is necessary to explain our linguistic beha-

viour. Since their seminal work, much progress has been made. Research on concepts has developed into an independent field (Ross & Spalding 1994), and current computational tools no longer include the decision tables employed by Miller and Johnson-Laird. However, their theory is probably the most developed conceptual theory of meaning to date. It provides an analysis of core concepts and operators that we use to organize our experience into semantic fields. Concepts are part of different semantic fields and within each field the relations they have with one another depend upon the field's conceptual core, i.e. the abstract conceptualization of the field.

According to Miller & Johnson-Laird (1976), our verb knowledge is captured in two ways: lexical concepts of events are organized in fields that reflect our knowledge of the relations among those concepts. In addition, each of these concepts participates in other fields that organize longer chunks of experience.

In our view, the picture-word interference is sensitive to both types of knowledge.

Perhaps, researchers have underestimated the complex relationship between the two, and this may account for some of the difficulties and the inconsistencies faced so far in the use of the paradigm at least in the study of verbs.

Most of these problems, however, may probably be overcome by a more careful consideration of the factors that intervene in naming a depicted event. In this way the picture-word interference paradigm might become a valuable tool in the study of how verb knowledge is mentally organized and retrieved during speech.

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*Footnotes*

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1 A panel of twenty participants judged on a scale from 1 to 7 the semantic relation between the verbs (MEAN = 4.79; SD = 0.98).

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