

# Speed of Processing Effects on Spoken Idiom Comprehension

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## Abstract

We report two experiments which investigated the time course of spoken idiom comprehension. We also assessed whether differences in individual speed of processing specifically affected idiom meaning activation. Using a cross-modal lexical decision paradigm, we found activation of ambiguous idioms meaning at offset for idioms identified early in the string (early identification idioms) and at offset (late identification idioms) in fast and slow participants. The two groups instead differed in the amount of time required for activating the idiomatic meaning.

## Individual differences and speed of processing

In recent years, a renewed interest emerged on how individual differences modulate spoken and written language comprehension (e.g., Just & Carpenter, 1992; Gernsbacher & Faust, 1991; McNamara & McDaniel, 2004; Hannon & Daneman, 2001; Faust et al., 1999). A specific aspect that has attracted a consistent empirical interest is individual speed of processing (henceforth SOP). This factor in fact predicts high level cognitive performances and plays an important role in language comprehension in aged and non-aged participants. A long tradition of studies exists investigating the speed with which an individual performs mental operations and several models have been proposed to explain the determinants and effects of SOP. In a nutshell, a growing consensus exists that SOP might be a stable feature that differentiates individuals and groups: individuals would possess a specific global speed of processing that remains constant across an extensive range of tasks of different nature and complexity (e.g., choice RT, line-length discrimination, letter classification, mental rotation, visual search, word judgment) (e.g., Hale & Jansen, 1994; Vernon & Jensen, 1984; Myerson et al., 2003; Faust et al., 1999; Salthouse, 1994). For each individual, it would be possible to define a speed parameter represented by the slope of the best fitting linear function of his/her mean response latencies (Faust et al., 1999).

Recently, Hanon and Daneman (2001) showed that the proportion of variance in reading comprehension performances of university students dramatically increased when an autonomous speed of response component was

added to the four components underlying reading comprehension (i.e., text memory, text inferences, knowledge access, knowledge integration). However, the extent to which a specific and independent role for SOP can be isolated in language comprehension is still controversial. SOP effects might in fact reflect the role of components and resources characterizing the human information processing system (e.g., reading skills, general knowledge level, working memory structure, long term memory retrieval, verbal and non verbal intelligence) (for reviews, see Faust et al., 1999; Myerson et al., 2003).

## Speed of processing and sentence comprehension

Most of the evidence on SOP concerns aged participants (for a review, see McCabe & Hartman, 2003). In the present study we instead investigated the effect of SOP on language comprehension in undergraduates.

Language-related SOP differences in non-aged speakers have been investigated especially at a word level, a battlefield for alternative models of reading and dyslexia (for reviews, see Seidenberg & McClelland, 1989; Coltheart et al., 2001; Kello & Plaut, 2003). Less attention has been instead devoted to the role of SOP differences in modulating sentence comprehension in non-aged language unimpaired participants. For instance, Breznitz and Berman (2003) manipulated the reading rate of Hebrew and English non-aged speakers systematically accelerating or decelerating the silent reading rate of paragraphs that were followed by comprehension questions. Surprisingly, when participants were asked to read faster than at their own self-paced rate, less decoding errors occurred and the comprehension improved. On the contrary, deceleration improved the reading accuracy but impaired comprehension. McNamara and McDaniel (2004) investigated the effect of domain knowledge on the resolution of lexical ambiguity in participants with different reading skills and SOP. Participants read sentences ending with an ambiguous homograph and were asked to judge the relatedness of a visual target word that had a contextually irrelevant meaning. A wider relevance effect was found in less skilled readers that also were slower in responding to the target

word (Experiment 1). The irrelevant meaning of the target interfered less for skilled readers with high general knowledge than for both skilled and less skilled participants with low general knowledge (Experiment 3).

### **Idiomatic expressions: how are they represented and understood?**

Idiomatic expressions are phrasal units whose meaning generally cannot be derived from the meaning of the constituent parts. Few studies investigated the role of individual differences in idiomatic meaning comprehension in language-unimpaired adults (e.g., Johnson, 1991; Nippold & Martin, 1989; Nippold, Moran & Schwarz, 2001). These results showed that idiom understanding is associated with measures of intelligence, academic achievement in reading and listening comprehension, and with general non-verbal measures of mental capacity. None of these studies directly addressed the role of individual SOP in on-line spoken idiom comprehension.

Idioms are very widespread in language, but the processes underlying their on-line comprehension are still controversial. For “Lexical look-up” models (Bobrow & Bell, 1973; Swinney & Cutler, 1979; Gibbs, 1980), idioms are multiword lexical units accessed as such from the mental lexicon. Their meaning is apprehended by direct memory retrieval and not elaborated via linguistic processing. The fast nature of idiomatic meaning retrieval, often faster than corresponding literal sentences, is explained postulating an “horse race” between a full compositional analysis of the string, that requires longer reaction times, and the faster retrieval of its global figurative meaning. This class of models differs in terms of representational assumptions: for Bobrow and Bell (1973), idioms are stored in a separate idiom list in the mental lexicon whereas for Swinney and Cutler (1979) they are represented as non-compositional units together with the other items. For “Non-Lexical” models (Cacciari & Tabossi, 1988; Tabossi & Zardon, 1993, 1995; Titone & Connine, 1994; Tabossi, Fanari & Wolf, in press), idioms are represented as configurations of lexical items, with no duplication of lexical information and no separate representation for idioms. The Configuration Hypothesis (Cacciari & Tabossi 1988) belongs to this second class and posits that idiom meanings are associated with configurations formed by the same words activated during the comprehension of literal sentences. The idiomatic string is processed word-by-word, as any other piece of language (Peterson et al., 2001), until enough information accumulates to render the string identifiable as a memorized figurative string. Only at this moment is the idiomatic meaning retrieved. Usually, the recognition of the idiomatic nature of the string depends on a specific part of the idiom that can be located early in the string (early identification idioms), or later on (late identification idioms), for instance at offset. Hence, the point in which the string is identified as idiomatic should determine how early is activated the idiomatic meaning. However, the evidence on idiom meaning activation especially for late identification idioms is still inconclusive with some studies showing that activation requires time occurring only after idiom offset (Cacciari & Tabossi, 1988; Tabossi & Zardon, 1993, 1995)

and others finding it already at idiom offset (Titone & Connine, 1994; Tabossi et al., in press).

### **The present study**

We investigated the comprehension of idioms with an early vs. late point of identification (early identification vs. late identification idioms) with a cross-modal lexical decision paradigm. An idiom-related visual word was presented before the idiom verb (control position) or at idiom offset (Tabossi & Zardon, 1993). A facilitation for the target at offset with respect to the control position indicates whether is the idiom meaning activated. Most of the evidence collected so far concerns non ambiguous idioms. This study instead used strings having both a literal and an idiomatic interpretation (ambiguous idioms, e.g., “break the ice”) embedded in contexts either biasing the literal or the idiomatic meaning of the string. Ambiguous idioms are well suited for testing alternative predictions on both idiomatic meaning retrieval processes and sentential ambiguity effects. Specifically, we aimed at testing: a. whether the dominant meaning of an idiom (in our case, the figurative one) is activated irrespective from contextual information or only when contextually appropriate (as in Colombo, 1995, 1998), b. the interaction between meaning dominance and idiom identification.

As recently argued by Hannon and Daneman (2001), the presence of individual differences obscured by group data can be one of the causes of inconsistent findings in the literature. Therefore, this study tested the extent to which individual SOP differences modulated ambiguous idioms comprehension in language unimpaired undergraduates. This factor might account for some of the incongruencies found in the literature insofar as none of the existing on-line studies tested, to our knowledge, the effect of SOP. Evidence exists that non-aged participants with faster SOP (henceforth, fast participants) process sentential information provided more actively than those with slower SOP (henceforth, slow participants) (e.g., McNamara, 1997; Long, Oppy & Seely, 1994; Long, Seely & Oppy, 1999). Hence, we expect fast and slow participants to differ in spoken idiom comprehension as well.

### **Experiment 1**

We divided our participants into fast and slow using the distribution of the individual mean speed of response in the cross-modal lexical decision task (see below). It is reasonable to assume that both fast and slow participants would recognize early identification idioms before offset. Hence, a facilitation for the visual target with respect to control condition should be observed for early identification idioms indicating an idiomatic meaning activation at offset. If meaning dominance effects extend to idioms, we might expect to find activation in both literal and idiomatic contexts. The picture is less clear for late identification idioms for which the existing findings are contrasting. If their idiomatic meaning indeed requires time to be identified and emerge (as in Cacciari & Tabossi, 1988; Tabossi & Zardon, 1993, 1995), then no activation should be observed at the string offset especially in literal contexts. The activation of late identification idiom meaning might in fact require an idiomatic context that increases the expectation

toward a figurative interpretation of the string (as in Tabossi & Cacciari, 1988; Colombo, 1993, 1998). However, Titone and Connine (1994) and Tabossi et al. (in press), found that the meaning of late identification non-ambiguous idioms was already available at offset in neutral contexts. If these findings extend to ambiguous idioms, then we might find activation of late identification idiom irrespective from the contextual bias. If indeed fast participants outperform slow participants in processing sentential information (as in McNamara, 1997; Long et al, 1994, 1999), then differential idiomatic meaning activation patterns should emerge for late identification idioms.

## Method

**Participants.** One-hundred forty-one undergraduates of the University of Modena participated in the norming phase and eighty different undergraduates in Experiment 1. All were Italian native speakers.

**Materials.** In the norming phase we assessed: a. the familiarity and knowledge of the idiomatic meaning; b. the idiom Identification point; c. the dominant vs. subordinate nature of the idiomatic vs. literal meaning. We selected 24 familiar idiom strings with a dominant figurative meaning, 12 were identifiable as idioms before offset (i.e., early identification) and 12 were not (i.e., late identification). The visual target words were uniquely associated with the idiomatic meaning of the string and were balanced for number of characters and syllables, age of acquisition, written frequency, bigram frequency and lexical decision times in isolation. For each idiom string, two sentences of similar length and structure were constructed (mean number of words 15.4) that biased toward the literal or the idiomatic interpretation. In addition, 72 filler sentences without any idiom were prepared together with 48 legal non-words and 24 words to serve as targets. Four experimental lists were created each containing 72 fillers, 12 early identification and 12 late identification idioms, half embedded in an idiomatic context and half in a literal one. Half of the targets in each context condition appeared before the idiom string and half at offset. Participants were randomly assigned to one of the four lists.

**Procedure.** The sentences were digitally recorded by a male speaker. A cue, inaudible to the participants, was placed in the sound files to specify the position of the target and caused the program to display it on the screen. In the experimental sentences the target appeared either at idiom offset (experimental condition) or at the offset of the word preceding the idiom (control condition) when no activation of the idiomatic meaning was expected. The target appeared in the center of the screen in black characters on a white background and remained on the screen until participant response; if no response was given in 4000 ms., the target disappeared and the next trial followed. An interval of 900 ms. followed the participant response before the subsequent sentence begun. A recognition test on the sentences heard during the experiment was performed at the end of the experiment to check that the participants actually listened for comprehension. Participants were tested individually in a sound-attenuated room. Their task was to judge whether the visual target word corresponded to an Italian word or to a

non-word by pressing the appropriately labeled response keys.

## Results and Discussion

35 participants whose mean lexical decision times were below the 45° percentile were considered as fast participants and 35 participants whose times exceeded the 55° percentile as slow. The statistical analyses were conducted on the  $\log_{10}$  transformation of the raw lexical decision times. Table 1 reports untransformed means. In order to reduce variability, data points  $\pm 2$  SDs from the mean response time of each participant were excluded from the analyses (1.9%).

Table 1: Mean lexical decision times for early identification and late identification idioms, literal and idiomatic contexts, P1/P2 (i.e., control/experimental target positions), and fast (F) and slow (S) participants.

Early identification		Late identification	
Literal Context	Idiomatic Context	Literal Context	Idiomatic Context
P1/P2	P1/P2	P1/P2	P1/P2
F 858/829	849/839	850/849	847/836
S 1381/1370	1400/1378	1418/1378	1416/1363

Fast and slow participants were equally accurate, as shown by the same low mean percentage of errors (1.9% vs. 1.2%, respectively;  $t < 1$ ). Overall, the idiomatic meaning was already activated at offset [Target:  $F_p(1,68)=28.81$ ,  $p < .001$ ;  $F_i(1,22)=120.04$ ,  $p < .001$ ], a result consistent with Titone and Connine (1994) and Tabossi et al. (in press) but not with Cacciari and Tabossi (1988). An effect of the idiom identification point emerged with the targets associated with early identification idioms responded to more rapidly than for late identification ones [Identification:  $F_p(1,68)=7.73$ ,  $p = .007$ ;  $F_i(1,22)=4.06$ ,  $p = .05$ ]. In literal contexts, the targets associated with early identification idioms were responded to faster than for late identification idioms suggesting that their meaning required more time to be retrieved [Context X Identification:  $F_p(1,68)=4.1$ ,  $p < .05$ ]. No difference was observed in idiomatic contexts.

The time course of the meaning activation of early identification idiom was faster than that of late identification idioms. This might reflect an earlier availability of the idiomatic meaning of early identification idioms that speeded up the decision on the target at offset. Due to our experimental paradigm, we did not know whether any difference exists in the amount of activation that early identification vs. late identification idioms received during the string processing. That some difference might exist is indirectly suggested by Tabossi et al. (in press) who found that late identification idioms produced reliable priming effect only at the string offset but not earlier on, as instead happened for early identification idioms.

As to the SOP, fast and slow participants differed in general [ $F_p(1,68)=136.92$ ,  $p < .001$ ;  $F_i(1,22)=1543.52$ ,  $p < .001$ ] and in the specific processing of both early identification and late identification idioms: whereas slow participants were faster with early identification than with

late identification idioms, no difference emerged for fast participants [SOP X Identification:  $F_p(1,68)=4.17$ ,  $p=.04$ ;  $F_i(1,22)=5.53$ ,  $p=.03$ ]. Both fast and slow participants were faster when the targets were presented at offset than at control position [SOP X Target:  $F_p(1,68)=3.78$ ,  $p=.05$ ]. The idiomatic meaning of early identification idioms was activated by both fast and slow participants. Despite what we expected, slow participants showed a full-fledged activation of the idiomatic meaning of late identification idioms, whereas for fast participants the result only approached significance ( $p=.07$ ) [SOP X Target X Identification:  $F_p(1,68)=5.33$ ,  $p=.02$ ]. Why? One possibility has to do with the slow response pace of slow participants: early identification and late identification idioms in fact differ in the amount of perceptual input required for the recognition of their idiomatic nature, with the first recognized as idioms well before their offset (early identification point), and the second only when the last word has occurred (late identification point). The response pace of slow participants was so slow (see the 544 ms delay with respect to fast ones) that the difference between early and late identification idioms presumably was annulled: when slow participants responded to the target associated with a late identification idiom, enough perceptual input had already arrived to transform a late identification idiom into an early identification one. Thereby Experiment 2 was designed in which a response deadline was introduced.

## Experiment 2

Experiment 2 was divided into two sessions: in Session 1 only early identification idioms were used with the same experimental procedure of Experiment 1. This was motivated by the need of clear cut time measures to be used to divide participants into fast vs. slow (see below). In Session 2 only late identification idioms were employed and a response deadline introduced (see below). The presence of a response deadline should clarify the extent to which slow participants indeed activated the idiomatic meaning of late identification idioms, or whether they simply annulled the difference between early vs. late identification due to their slowed response rate. Breznitz and Berman (2003) recently documented a beneficial effect on sentence comprehension of a reading rate acceleration for slow readers, normal readers and dyslexic. Hence, we might expect a general speeding up of idiomatic meaning activation.

### Method

**Participants.** Eighty-five undergraduates of the University of Modena participated in Experiment 2. They were native speakers of Italian and had not participate in any phase of Experiment 1.

**Materials and Procedure.** The experimental materials were those used in Experiment 1 but presented in two sessions divided by a short rest. In Session 1 only early identification idioms (plus appropriate fillers) were used with the same procedure of Experiment 1. In Session 2 only late identification idioms (plus fillers) were employed and a response deadline introduced whose length (1007 ms) resulted from summing up the mean decision time of fast participants in Experiment 1 plus 1.5 SD. The same cross-modal lexical decision paradigm of Session 1 was

employed. At the beginning of the experiment, participants were advised that it was composed by two sessions and that in the second a response deadline was used. The instructions were repeated at the beginning of each session. In Session 2, a warning message appeared on the screen when the deadline was over. Each new trial begun 900 ms after the response (or the deadline end). The distribution of the response times obtained in Session 1 was used to divide the participants into fast vs. slow in both sessions.

### Results and Discussion

Based on the results of Session 1, we split the participants into fast and slow ones (with 37 participants per group) with the same procedure of Experiment 1. We present the results of the two sessions separately (Table 2). Session 1: A high accuracy level was again observed with no fast vs. slow difference (2.2% vs. 1.3% of errors respectively,  $t<1$ ). The idiomatic meaning of early identification idioms was already activated at offset, as in Experiment 1 [Target:  $F_p(1,72)=114.23$ ,  $p<.001$ ;  $F_i(1,11)=124.63$ ,  $p<.001$ ], by both fast and slow participants [SOP X Target:  $F_p(1,72)=10.02$ ,  $p=.002$ ;  $F_i(1,11)=25.64$ ,  $p<.001$ ]. The mean decision times of fast vs. slow participants again significantly differed [ $F_p(1,72)=166.75$ ,  $p<.001$ ;  $F_i(1,11)=403.79$ ,  $p<.001$ ].

Table 2: Mean decision times in literal and idiomatic contexts, for P1/P2 (i.e., control vs. experimental positions), fast (F) and slow (S) participants in Session 1 (early identification idioms) and Session 2 (late identification idioms and response deadline).

	Session 1		Session 2	
	Literal Context	Idiomatic Context	Literal Context	Idiomatic Context
	P1/P2	P1/P2	P1/P2	P1/P2
F	877/719	847/729	671/628	683/594
S	1416/1080	1467/1020	749/661	754/664

Session 2: The idiomatic meaning of late identification idioms was already activated at offset, as in Experiment 1 [Target:  $F_p(1,72)=80.306$ ,  $p<.001$ ;  $F_i(1,11)=82.170$ ,  $p<.001$ ] in both types of context [Context X Target:  $F_p(1,72)=2.87$ ,  $p=.094$ ;  $F_i(1,11)=5.65$ ,  $p=.03$ ]. Despite the deadline, fast and slow participants overall significantly differed [105 ms,  $F_p(1,72)=19.77$ ,  $p<.001$ ;  $F_i(1,11)=51.4$ ,  $p<.001$ ], although to a lesser extent (105 ms) than in Session 1 (452 ms) and in Experiment 1 (544 ms). No specific effect of SOP emerged.

However, if the time pressure speeded up the lexical decision on idiom-related targets fostering idiomatic meaning activation, it also had an accuracy cost as shown by the higher mean error rate of Session 2 (Session 2: 5%; Session 1: 1.8%), with more errors in literal than in idiomatic contexts [ $F_p(1,72)=3.9$ ,  $p=.05$ ;  $F_i(1,11)=4.14$ ,  $p=.06$ ]. Slow participants were as much accurate as fast ones (5.4% vs. 4.7%, respectively). Unsurprisingly, slow participants gave more post-deadline responses than fast ones [3.7% vs. 2.9%, respectively;  $F_p(1,72)=3.59$ ,  $p=.06$ ]. More post-deadline responses were provided by both slow and fast participants when the targets were presented at control position than at idiom offset [ $F_p(1,72)=17.03$ ,

$p < .0001$ ;  $F_1(1,11) = 17.74$ ,  $p = .001$ ], and more so in idiomatic than in literal contexts [Context X Target:  $F_p(1,72) = 5.07$ ,  $p = .03$ ].

Under time pressure, a recruitment of attentional and processing resources speeded up the response times of both fast and slow participants. The response deadline accelerated slow participants more than fast ones, as suggested by the 583 ms mean between-session time difference for slow participants (i.e., a decrease of 46.8%) as compared with the 149 ms difference for fast participants (i.e., 19%).

### Conclusion

The idiomatic meaning of ambiguous spoken idioms was activated at offset for both early and late identification idioms, as in Titone and Connine (1994) and Tabossi et al. (in press) but not in Cacciari and Tabossi (1988) and Colombo (1993, 1998). Then the effects of context of the present study are certainly less clear-cut than those reported in Tabossi and Cacciari (1988) and Colombo (1993, 1998). This can at least in part be due to a meaning dominance effect analogous to that reported in studies on semantic ambiguities: we in fact selected idiom strings with a dominant figurative meaning.

How to reconcile these different findings? We can discard an idiom familiarity effect since the expressions employed in these studies were all familiar. More sound candidates for explaining these discrepancies lie in methodological differences. Titone and Connine, Cacciari and Tabossi, Tabossi et al. used a cross-modal lexical decision paradigm and Colombo a self-paced reading times paradigm. Then, the cross-modal studies employed different control conditions: here we compared the lexical decision time for a same target word presented either before the idiom, where no facilitation at all is expected, or at the idiom offset. Such a modality can be more sensitive toward smaller amount of activation than when an idiom-related target is compared with an idiom-unrelated word, as in Cacciari and Tabossi, for instance. Idioms also vary in the extent to which the strings also have a literal meaning: when an idiom string has two possible interpretations they rarely are equally frequent with the dominance of the idiomatic meaning affecting meaning activation (Poppel & McRae, 1988). A word should then be said on the notion of identification point (or predictability) that has been differently operationalized. Furthermore the decision on an idiom identification point relies on off-line, paper-and-pencil measures whose predictive effect on on-line measures should be further assessed.

Last, and not at all least, we took individual differences into serious account. Did SOP differences modulate spoken idiom comprehension? Although further investigations are needed (and are in progress), we observed a clear-cut SOP effect. Specifically, in Experiment 1, slow participants were more sensitive to the difference between early identification and late identification idioms than fast ones, and processed the first faster than the second. Spoken idiom identification occurs word-by-word and is successfully achieved when enough information is build up to render an idiom recognizable: only then can its meaning be retrieved. Slow participants needed more perceptual input than fast participants to identify a string as idiomatic and activate its

meaning. In contrast, fast participants processed sentential information more actively, consistently with the literature.

The response deadline introduced in Experiment 2 affected both groups of participants with a more striking effect on slow ones. With a deadline, the magnitude of the facilitation for the idiomatic target was in fact quite similar for fast and slow participants (66 ms vs. 89 ms, respectively). That imposing a response deadline speeded up mental processing and changed the allocation of time and processing resources among different task components had already been documented in the literature on judgment and decision-making (for a review, see Svenson & Maule, 1993) and on reading comprehension (Breznitz & Berman, 2003). According to Breznitz and Bearman (2003), who extensively investigated this “acceleration phenomenon”, reading acceleration extends attention span, reduces distractibility, helps to overcome some capacity limitations of short term memory and of working memory and increases word retrieval from the mental lexicon. Identifying the factors underlying the differences between fast and slow participants is the major problem we are currently investigating in a set of experiments designed to assess the specific role of sensorimotor speed components, cognitive speed components and personality-based components in accounting for SOP differences in spoken idiom comprehension.

Overall, the results of this study are more compatible with Non-Lexical models of idiom comprehension than with Lexical-look up ones. In fact we concurred with other studies in showing that idioms do not behave as long words, since their meaning activation requires time and can start only after the string is identified as idiomatic. The SOP effects we found on idiomatic meaning activation are best accommodated by Non-Lexical models that posit that the idiomatic sentence is fully processed up to recognition of its figurative nature (and syntactically, even later on). Only then can the idiomatic meaning be retrieved. In contrast, Lexical-look up models assume direct retrieval of an idiom meaning, a cognition operation that might prove less sensitive toward SOP differences being less demanding even for slow participants. In sum, idiom comprehension cannot be reduced to mere meaning retrieval from the mental lexicon.

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