Chapter 7

Understanding acronyms: The time course of accessibility

_Morton Ann Gernsbacher_

1. Introduction

Literally, acronyms are the abbreviations comprising the first letters of two or more words (e.g., _CD_ is the acronym for _compact disc_). However, on a more conceptual level, acronyms are often highly associated with objects or ideas that are not explicitly contained in the components of the acronym itself (e.g., _CD_ is commonly associated with _music_). Which meaning is more accessible? The literal (component) meaning (e.g., _disc_) or the conceptual (associate) meaning (e.g., _music_)? Does the accessibility of either or both of those two meanings, literal-component meaning and the conceptual-associate, change over time? What happens when acronyms are processed as letter strings rather than lexical units? Is the accessibility of their literal-components or conceptual-associate attenuated? This chapter describes a series of six laboratory experiments conducted to answer these questions.

2. Understanding acronyms: The time course of accessibility

We know little about how people access the meanings of acronyms. The majority of previous psycholinguistic research on acronyms has focused on how people recognize individual letters within acronyms and what that tells us about how people recognize letters when they are reading actual words. For example, Staller and Lappin (1981) report that amid a briefly presented array of six letters, familiar acronyms, such as _DVD_, pop out as readily as do words, such as _DID_. Noice and Hock (1987) report that acronyms are privileged by the word superiority effect: It is easier to recognize an individual letter in a briefly presented word – or acronym – than it is to recognize the same letter in an unfamiliar string of letters (e.g., _DYD_; see also Laszlo and Federmeier 2007a). Furthermore, repeated acronyms, like repeated words, are easier to identify than repeated unfamiliar letter strings (Carr et al. 1979), and repeated acronyms, like repeated words, trigger a characteristic reduction in the N400 event-related brain potential (Laszlo and Federmeier 2007b).
Thus, prior psycholinguistic research has primarily investigated the identification and processing of the individual letters composing acronyms. Participants in these experiments have not been required to read acronyms in order to comprehend them (cf. Laszlo and Federmeier 2008). Indeed, most of these word-like effects also hold for pronounceable nonwords (so called pseudowords), such as \textit{DED}, suggesting that these word-like effects derive from familiarity with the orthography (for acronyms) or with the phonology (for pronounceable pseudowords).

This shortcoming in the existing research becomes interesting as we notice the dichotomous nature of acronyms. Literally, acronyms are the abbreviations comprising the first letters of two or more words (e.g., \textit{CD} is the acronym for \textit{compact disc}). However, on a more conceptual level, acronyms are often associated with objects or ideas that are not explicitly contained in the components of the acronym itself (e.g., \textit{CD} is commonly associated with \textit{music}). For this reason, understanding acronyms can be considered a case of understanding figurative language. Just as puns, metaphors, and idioms are identified by both a literal meaning and a figurative, or conceptual, meaning, so too are acronyms.

For acronyms, several unanswered questions remain: Which meaning is more accessible? The literal (component) meaning (e.g., the \textit{disc}-meaning of \textit{CD}) or the conceptual (associate) meaning (e.g., the \textit{music}-related connotation of \textit{CD})? Does the accessibility of the literal-component meaning or the conceptual-associate meaning change over time? When acronyms are processed as letter strings rather than lexical units, is the accessibility of their literal-components or conceptual-associate attenuated? This chapter describes a series of six laboratory experiments conducted to answer these questions.

3. Basic Experimental Task

To investigate whether the literal components or the conceptual associates of acronyms are more accessible, a standard priming-for-lexical-decision task was used. Participants viewed an acronym presented on a computer screen for an amount of time determined by the acronym’s length (16.67 ms multiplied by the number of characters in the acronym plus a constant 350 ms; e.g., a two-letter acronym appeared for 383 ms, a three-letter acronym appeared for 400 ms, and a four-letter acronym appeared for 417 ms). In priming-for-lexical-decision-task nomenclature, the acronym served as the prime. After the acronym-prime disappeared from the screen, a blank period intervened prior to the presentation of the target. The blank interval, otherwise known as the inter-stimulus interval, was manipulated across...
three different experiments. Following the inter-stimulus interval, the target appeared. The target was a letter string to which participants performed a lexical decision task: As accurately and rapidly as they could, participants decided whether the letter string formed a word. Figure 7.1 graphically displays this sequence of events that occurred on each trial.

The priming-for-lexical-decision task is frequently used in cognitive psychology to index how quickly people can access the meanings of words. For example, in a classic experiment, Meyer and Schvaneveldt (1971) presented participants with letter strings, and the participants’ task was to decide rapidly and accurately whether each letter string formed a word (hence, the name “lexical decision”). Meyer and Schvaneveldt reported that participants can more rapidly decide that a letter string like *nurse* is a word when it is preceded by a related word, for example, *doctor*, as opposed to an unrelated word, such as *butter*. This classic finding, replicated numerous times, suggests that the speed with which participants responding to target words is affected by the primes that immediately precede them.

In the current experiments, the prime stimuli were familiar acronyms and the target words were either a literal component of the acronym prime or conceptual associate of the acronym prime. For example, for the acronym prime, *CD*, the literal-component target word was *compact*. The other target word was a conceptual associate of the acronym prime. For example, for the acronym prime, *CD*, the conceptual-associate target word was *music*.

The acronyms were identified by first compiling a list of approximately 140 acronyms and second by asking participants in a norming study to write out what each acronym stood for. The 24 familiar acronyms that served as prime acronyms in the current experiments were those for which 83% or
more of the participants in the norming study successfully wrote out what the acronym stood for. For each of the 24 familiar acronym primes, two target words were chosen: One target word was a literal component of the acronym prime, and the other target word was a conceptual associate of the acronym prime.

Because it might be possible that the two sets of target words chosen to serve as literal-component target words and conceptual-associate target words varied in how difficult they were to recognize, each target word also served as its own control target word in two other conditions of the experiment, as shown in Table 7.1. When a target word served as its own control, it was completely unrelated to its preceding acronym prime. For example, the conceptual-associate target word *music* was preceded in one condition by its associated acronym prime, *CD*. In this case, it served to test the experimental-conceptual relation. To assess a control condition for this target word, the same target word, *music*, was preceded by an unrelated acronym prime; for example, *DC*. Similarly, the literal-component target word *compact* was tested as both an experimental-literal target, preceded by the acronym prime, *CD*, and as a control-literal target, preceded by the unrelated acronym prime, *DC*. As demonstrated by this example, when a literal-component target word (e.g., *compact*) was put into a control condition, its initial letter (e.g., *c*) was a part of the preceding acronym (e.g., *DC*); however, the control target word was not a component of the acronym (e.g., *compact* is not a component of *DC*).

<table>
<thead>
<tr>
<th>Prime</th>
<th>Target</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>music</td>
<td>Experimental-Conceptual</td>
</tr>
<tr>
<td>CD</td>
<td>compact</td>
<td>Experimental-Literal</td>
</tr>
<tr>
<td>DC</td>
<td>music</td>
<td>Control-Conceptual</td>
</tr>
<tr>
<td>DC</td>
<td>compact</td>
<td>Control-Literal</td>
</tr>
<tr>
<td>DC</td>
<td>Washington</td>
<td>Experimental-Conceptual</td>
</tr>
<tr>
<td>DC</td>
<td>District</td>
<td>Experimental-Literal</td>
</tr>
<tr>
<td>CD</td>
<td>Washington</td>
<td>Control-Conceptual</td>
</tr>
<tr>
<td>CD</td>
<td>District</td>
<td>Control-Literal</td>
</tr>
</tbody>
</table>

Thus, each experiment comprised four conditions. Each of the 24 acronym primes was followed by a literal-component target word or a conceptual-associate target word, and each literal-component or conceptual-associate words was tested as an experimental and as a control target word. Four material sets were constructed for each experiment, and each participant was exposed to only one material set. Therefore, each participant was exposed
only once to each acronym, and, similarly, each participant was exposed only once to each target word.

Consistent with a typical lexical-decision design, trials were also included in which the target string of letters did not form a word. These catch-trial target letter strings were pronounceable pseudowords like reveme and discantful and were preceded by a different set of acronyms than the experimental or control target letter strings. The filler catch-trial target letter strings were designed to resemble the experimental and control target word trials as much as possible. Thus, to mimic the Literal-component target word condition, the target letter strings in half of the catch trials were paired with acronym primes that shared a common letter (e.g., RN - retrate or IRS - rilmely).

To summarize, each experiment comprised four conditions. Each acronym-prime was followed by either a literal-component target word or a conceptual-associate target word. Additionally, each literal-component target word and each conceptual-associate target word was tested in both the experimental and the control condition.

The predictions for each experiment were very straightforward. If reading an acronym prime (e.g., CD) causes its conceptual associates to become accessible, then participants should respond significantly faster to conceptual-associate target words (e.g., music) when they are preceded by their experimental acronym primes (e.g., CD) than when they are preceded by their control acronym primes (e.g., DC). Similarly, if reading an acronym prime causes its literal components to become accessible, then participants should respond significantly faster to literal-component target words (e.g., compact) when they are preceded by their experimental acronym primes (e.g., CD) than when they are preceded by their control acronym primes (e.g., DC).

Figure 7.2 displays the 80 participants’ correct reaction times to the lexical decision target words when the inter-stimulus interval was extensive (i.e., 2500 ms). Analyses of variance (ANOVAs) on participants’ correct reaction times indicated that both conceptual-associate targets (e.g., music) and literal-component (e.g., compact) targets were responded to more rapidly when preceded by their experimental acronym (e.g., CD) primes than when preceded by their control acronym (e.g., DC) primes [F1(1,79) = 16.40, p<.001; F2(1,23) = 5.61, p<.03 for conceptual-associate targets; F1(1,79) = 10.27, p<.002; F2(1,23) = 5.04, p<.04 for literal-component targets]. Thus, when the acronym primes were given substantial processing time, both the conceptual-associates’ meanings and the literal-components’ meanings were accessible. To our knowledge, this is the first investigation of how acronyms are understood, and this investigation suggests that after
adequate processing time, both the literal components and the conceptual associates of acronyms are equally accessible.

4. Time Course of Accessibility

Language is not a static commodity, and access to meaning is not static during language comprehension. What is accessible more than two seconds after processing an acronym is not necessarily what is accessible much earlier. Therefore, in a second experiment, the inter-stimulus interval was dramatically reduced. Participants in this second experiment also read acronym primes and responded to letter string targets in a lexical decision task; however, whereas the letter string targets in the first experiment were separated from the acronym primes by a 2500 ms interval (i.e., the lexical decision targets appeared after a 2500 ms inter-stimulus interval), the target letter strings in the second experiment were separated from the acronym primes by a much shorter, 250 ms, inter-stimulus interval.

Figure 7.3 displays the 96 participants’ correct reaction times to the lexical decision target words when the inter-stimulus interval was 250 ms. Just as with the much longer 2500 ms inter-stimulus interval, with a much shorter 250 ms inter-stimulus interval, both conceptual-associate targets (e.g., music) and literal-component (e.g., compact) targets were responded to more rapidly when preceded by their experimental acronym (e.g., CD) primes than when preceded by their control acronym (e.g., DC) primes.
Figure 7.3. Mean correct reaction times to lexical decision target words when the inter-stimulus interval was 250 ms (Experiment 2).

\[F_1(1,95) = 5.63, p<.02; F_2(1,23) = 4.22, p<.06\text{ for conceptual-associate targets}; F_1(1,95) = 3.45, p<.07; F_2(1,23)<2.0\text{ for literal-component targets}.\]

However, statistically speaking, the priming effect observed on the literal-component targets was only marginally significant when participants were considered a random effect and failed to reach significance when target words were considered a random effect; therefore, a replication of the experiment was conducted.

Figure 7.4 displays the 92 participants’ correct reaction times to the lexical decision targets for this replication experiment. Again, both conceptual-associate targets (e.g., music) and literal-component (e.g., compact) targets were responded to more rapidly when preceded by their experimental acronym (e.g., CD) primes than when preceded by their control acronym (e.g., DC) primes \[F_1(1,91)=14.01, p<.02; F_2(1,23)=5.97, p<.05\text{ for conceptual-associate targets}; F_1(1,91)=3.37, p<.06; F_2(1,23)<2\text{ for literal-component targets}.\] And again the priming advantage for the literal-component targets was only marginally significant when participants were considered a random effect and failed to reach significance when target words were considered a random effect; however, the fact that the data from this experiment replicated that of the previous experiment, it is safe to assume that in both cases, with an inter-stimulus interval of 250 ms, both the conceptual-associates’ meanings and the literal-components’ meanings are salient aspects of understanding acronyms.
What about after very brief periods of processing? Are both the conceptual-associates and the literal-components of acronyms accessible immediately after an acronym is read? A third experiment explored that question by further reducing the inter-stimulus interval to 50 ms, and Figure 7.5 displays the 104 participants’ correct reaction times to the lexical decision targets.
when the inter-stimulus interval was the very brief 50 ms. In contrast to the results obtained when the inter-stimulus interval was the much longer 2500 ms or even the briefer 250 ms, when the inter-stimulus interval was the very brief 50 ms, only the literal-component (e.g., *compact*) targets were responded to more rapidly when preceded by their experimental acronym (e.g., *CD*) primes than when preceded by their control acronym (e.g., *DC*) primes \( F(1,103)=13.28, p<.001 \) for literal-component targets; \( F(1,103)<2 \) for conceptual-associate targets].

![Figure 7.6](image.png)

*Figure 7.6.* Time course of accessibility of conceptual-associates’ meanings and literal-components’ meanings (from Experiments 1, 2, 3, with Experiment 2’s replication, as indicated by the unfilled circle and square).

Putting these three experiments together, as illustrated in Figure 7.6, illustrates the time course of the literal components and the conceptual associates of familiar acronyms. Both are equally accessible more than two seconds after an acronym is processed (i.e., at the 2500 ms inter-stimulus interval). Both are also equally accessible only a quarter of a second after an acronym is processed (i.e., at the 250 ms inter-stimulus interval). However, immediately after an acronym is processed (i.e., at a very brief 50 ms inter-stimulus interval), only the literal meaning is accessible. According to Gio-
Understanding Acronyms

ra’s Graded Salience Hypothesis (1997, 2003), “more salient meanings,” that is, meanings “foremost on our minds,” should be accessed more rapidly than less salient meanings. Thus, at early stages of processing acronyms, the literal-components are most salient, but within only a short period, both literal-components and conceptual-associates are accessible in parallel, a state that remains for over two seconds.

5. Attenuating the Salience

Presumably the accessibility of both the conceptual associates and the literal components of acronyms is driven by acronyms being treated as familiar, lexical units. If so, we should be able to diminish the accessibility of both the conceptual associates and the literal components by treating the acronyms not as familiar lexical units but rather as simple strings of letters. Rather than reading the acronym primes, what if participants are told to focus on the letters within the acronym primes? To answer this question, in a fifth experiment participants performed a letter-detection task on the acronyms prior to performing the lexical-decision task on the target words.

In a typical letter-detection task, participants are given a particular letter to search for in a target. Participants respond “yes” if the specified letter appears in the target and “no” if it does not. Thus, in this experiment, the acronyms served as targets for the letter-detection task. However, because the experimental question was whether by focusing the participants’ attention on the letters of the acronym, as opposed to the acronym as a whole, the salience of the acronyms’ conceptual-associates and literal-components could be attenuated, in this experiment the acronyms also served as implicit primes for their subsequent lexical-decision targets, as they had served in the previous four experiments.

More specifically, prior to the presentation of each acronym, first a small warning box appeared, then a letter cue appeared. When the acronym appeared, participants indicated as rapidly and accurately whether the cued letter was contained in the acronym. And, then, as before, a letter string appeared to which participants performed a lexical decision task. Figure 7 graphically displays this sequence of events that occurred on each trial. To provide the heartiest test of the ability to diminish salience, an inter-stimulus interval (between the acronym and the lexical-decision target) of 2500 ms was used. This extensive inter-stimulus interval provided the most stringent test of the potential to diminish the salient meanings of the acronyms.
Figure 7.7. Sequence of events for each trial in Experiment 4.

Figure 7.8 displays the 144 participants’ correct reaction times to the lexical decision target words when the inter-stimulus interval was extensive, 2500 ms, and the participants performed a letter-detection task on each acronym prime. Neither the conceptual-associate targets (e.g., music) nor the literal-component (e.g., compact) targets were responded to more rapidly when preceded by their experimental acronym (e.g., CD) primes than when preceded by their control acronym (e.g., DC) primes [$F_1$ and $F_2<2$ for conceptual-associate targets; $F_1$ and $F_2<1$ for literal-component targets]. Thus, when the acronym primes were treated as letter strings, by virtue of the letter-detection task, neither the conceptual-associates’ meanings nor the literal-components’ meanings were salient. To ensure that these results were reliable, the experiment was repeated with another set of 112 participants, and the results remained the same: Neither the conceptual-associate targets (e.g., music) nor the literal-component (e.g., compact) targets were responded to more rapidly when preceded by their experimental acronym (e.g., CD) primes than when preceded by their control acronym (e.g., DC) primes [$F_1$ and $F_2<2$ for conceptual-associate targets; $F_1$ and $F_2<1$ for literal-component targets].

Thus, the salience of acronyms can be attenuated when the acronyms are processed as letter strings rather than lexical units. In contrast, when acronyms are processed as lexical units, they lead to priming of their literal components at very short processing lags and to priming of both their conceptual associates and their literal components at longer processing lags.
Together, these data suggest that the literal components of acronyms are their more salient meanings, but that their conceptual associates can be accessed, in time and when the acronyms are processed as lexical units.

6. Notes

Author’s Acknowledgment: Martha Fuiten assisted in conducting several of the experiments reported in this chapter.

7. References

Giora, Rachel

Laszlo, Sarah, and Kara D. Federmeier
2007b Better the DVL you know: Acronyms reveal the contribution of familiarity to single-word reading. Psychological Science, 18, 122–126.
2008 Minding the PS, queues, and PXQs: Uniformity of semantic processing across multiple stimulus types. Psychophysiology, 45, 458–466.
Meyer, David E., and Roger W. Schvaneveldt

Noice, Helga, and Howard. S. Hock

Staller, Joshua. D. and Joseph S. Lappin