

What do we read aloud and how fast?

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Abstract

We don't read Word. By. Word, but instead we do read (and speak) accent phrases by accent phrases, i.e., by sequences of words containing only one (non-emphatic) stressed syllable. Only when we don't recognize globally a string of written text or when we learn another language, more precisely when we learn to read in a language we are learning, that we proceed or may proceed syllable by syllable, to progressively reach reading word by word sequences, and finally accent phrase by accent phrase to attain reading fluency aloud or silently.

Keywords: accent phrases, silent reading, theta brain oscillations, delta brain oscillations

What do we read?

We don't read Word. By. Word. and even less Syl. La. Ble. by Syl. La. Ble, but instead we do read (and speak) accent phrases by accent phrases, i.e., by sequences of words containing only one (non-emphatic) stressed syllable. Only when we don't recognize globally a string of written text or when learn to read in a language we are learning, that we proceed or may proceed syllable by syllable, to progressively reach reading word by word sequences, and finally accent phrase by accent phrase to attain reading fluency aloud or silently. In lexically stressed languages such as English or Italian, accent phrases, speaking and reading units, contain a single content word together with its associated grammatical words (pronoun, conjunction, prepositions...).

Reading French

In French however, accent phrases can contain more than one lexical item and are limited only by the maximum time it takes to pronounce them orally, 1250-1350 ms, or silently, a minimum time of 250 ms (Martin Ph. 2014). Accent phrases are also constrained by the minimum gap existing between two consecutive stressed syllables, about 250 ms. Accent phrases appear as groups of words already stored in the reader and speaker memory, with their lexical and depending grammatical words, ready to be used without any syntactic assembly effort from the speaker/reader. This is also supported by the fact that hesitations and reformulations are done with complete accent phrases in spontaneous speech, and not partially completed (Blanche-Benveniste, 2003).

Some facts about reading

Eye movements

Reading, either aloud or silently, involve eye saccades, which operate in a limited character span of some 5 to 10 characters before the focal point, and some 10 to 15 characters after the focal point, and take 70 to 80 ms (Gagl and al., 2022). These 15 to 25 characters encompass some 5 to 8 syllables, assuming an average of 3 characters per syllable.

Therefore, the eye saccades span encompasses the average number of syllables per accent phrase, varying from 1 to 8. Each eye saccade going to the next focal point is actually aiming to the next accent phrase, and not an isolated word inside the accent phrase.

Fast reading

While reading continuously, each saccade decodes an orthographic accent phrase (AP), from the AP reader lexicon entry. This conversion is synchronized by delta brain oscillations, operating in a 250 ms - 1350 ms duration range (Martin Ph., 2014).

For silent speech, there is no articulatory constrain that would slow down the reading process. Still, the recovering of the AP lexicon entry as synchronized by delta cannot go faster than 250 ms, i.e., 4 AP's per second.

This explains also the fact that we cannot have two successive stressed syllables closer than some 250 ms. Closer stressed syllables cannot be found in natural speech. When instantiated by a speech editor, the first syllable ceased then to be perceived as stressed while keeping the same acoustical characteristics.

Slow reading

If the reader is operating at a slower pace, for instance focusing on the text word by word, each word becomes an AP, and is instantiated orally or silently as an accent phrase with a stressed syllable. Going even slower, reading syllable by syllable or even character by character, each read unit actually becomes an accent phrase. Syllabic perception becomes then synchronized by delta brain oscillations.

Reading long words

Long orthographic words give an example of regulation by delta brain waves. In reading aloud, long words such as *paraskevidekatriaphobia* cannot be pronounced fast enough as one single AP. They require extra stressed syllables, usually located at some internal morphological boundary known or assumed by the reader. This applies as well to silent reading.

Speech short time memory

Breath groups in respiration cycles occur every 2-3 seconds. The expiration phase while phonation is realized should match with the listener short-time speech memory, also in the 2-3 second range (Martin R., 2014), in order to attain a successful dialog. The inspiration phase then occurs, with a minimum duration of 250 ms, giving the listener the opportunity to process the linguistic information perceived in the last 2 – 3 seconds.

Cognitive master processes

Speaking and reading aloud or silently are constrained along the time scale by the following processes:

- Theta brain oscillation: 4 Hz – 10 Hz, i.e., 100 ms - 250 ms period.
- Delta brain oscillation: 0.8 Hz – 4 Hz, i.e., 250 ms - 1250 ms period.
- Short-time speech memory (running speech): max 2000-3000 ms.
- Expiration phase in respiratory cycle: maximum about 3000 ms.

Speech synchronized processes

The expiration phase duration appears to be the master clock in the speech production system, conditioned by the short-time speech memory of the listener(s) (speaker included). Speech units are synchronized by theta and delta brain oscillations, giving a proper account for their respective range of duration:

- Syllabic duration: min 100 ms (Ghitza 2011), synced by theta oscillations.
- Consecutive stressed syllables minimal interval (stress clash): min about 250 ms (Martin, 2014) synced by delta oscillations.
- Accent phrase duration in silent reading: min about 250 ms (Martin 2014, Dunning 2010), synced by delta oscillations (Gagl, Martin, Rimmele 2022), whereas saccades in eye movement: take only 70-80 ms (Gagl et al., Rayner, Reichle et al., 2022).
- Accent phrase duration in oral reading: min 250 ms max 1350 ms (Gilbert, Boucher 2007, Martin 2014, Rimmele et al., 2021), synced by delta oscillations.
- Intonation Phrase and intermediate intonation phrase duration (CPS ended): 2000-3000 ms (Gilbert, Boucher 2007), constrained by short-term speech memory (Martin et al. 2014).
- Breath group -> Short-time speech memory (Martin et al.), IP and ip duration, also in silent reading.

Figure 1 gives an example of embedded timing of theta, delta oscillations, accent phrases and syllables.

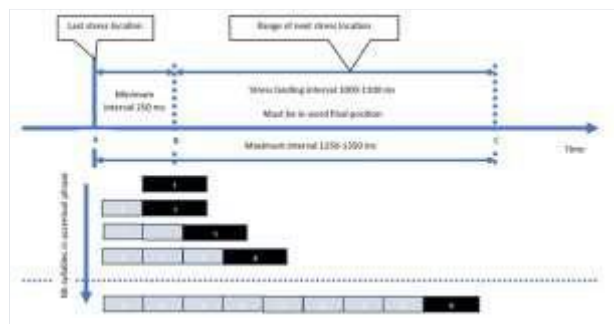


Figure 1. Reading aloud at 8 syllables / second.

References

- Blanche-Benveniste C. 2003. La naissance des syntagmes dans les hésitations et répétitions du parler, in Araoui J.L. ed. *Le sens et la mesure. Hommages à Benoît de Cornulier*, Honoré Champion, Paris, 40-55.
- Ciuffo, M., Myers, J., Ingrassia, M. et al. 2017. How fast can we read in the mind? Developmental trajectories of silent reading fluency. *Read Writ* 30, 1667–1686 (2017). <https://doi.org/10.1007/s11145-017-9744-2>.
- Dunning, B. 2010. Speed Reading, Skeptoid Podcast. Skeptoid Media, Inc., 26 Oct 2010. Web. 12 Dec 2013. <http://skeptoid.com/episodes/4229>
- Friederici A. D., Wartenburger I. 2010. Language and brain, *Cognitive Science*, vol. 10, 150-159, 2010.
- Gagl B, Gregorova K, Golch J, et al. 2022. Eye movements during text reading align with the rate of speech production. *Nat Hum Behav.* 2022; 6(3):429-442. doi:10.1038/s41562-021-01215-4
- Gilbert, A, Boucher, V. 2007. What do listeners attend to in hearing prosodic structures ? Investigating the human speech-parser using short-term recall, *Proc. Interspeech 2007*, 430-433.
- Ghitza O. 2011. Linking speech perception and neurophysiology: speech decoding guided by cascaded oscillators locked to the input rhythm, *Frontiers in Psychol.* 2011; 2: 130.
- Martin Ph. 2014. Spontaneous speech corpus data validates prosodic constraints, *Proc. 6th conference on speech prosody*, Campbell, Gibbon, and Hirst (eds.), 525-529.
- Martin R., Yan H., Schnur T. 2014. Working memory and planning during sentence production, *Acta Psychologica*, 152C,120-132.
- Nowak, P. 2012. Speed reading tips: 5 ways to minimize subvocalization, <http://www.irisreading.com/speedreading/speed-reading-tips-5-ways-to-minimize-subvocalization/>
- Reichle E. D., Pollatsek A. et al. 1998. Toward a model of eye movement control in reading », *Psychological Review*, vol. 105, n° 1, 125-157, 1998.
- Rimmele J., Poeppel D., Ghitza O. 2021. Acoustically Driven Cortical δ Oscillations Underpin Prosodic Chunking. *eNeuro.* 2021; 8(4).