COMPOUNDING MATTERS: THE P1 AS AN INDEX OF SEMANTIC ACCESS TO COMPOUND WORDS

Charles P. Davis, Gary Libben, and Sidney J. Segalowitz
Brock University, St. Catharines, Ontario, Canada

BACKGROUND

- **PREMISE** Word retrieval from lexical and semantic memory involves a series of cascaded processes.
- **UNKNOWN** Timing, degree of overlap, and nature of these processes.
- **RECENT WORK** shows that lexical-semantic variables (e.g., lexicality—whether the item is a word or not, word frequency) modulate event-related potential (ERP) components as early as the P100 (~100 ms).[4]
- **A COMPLICATION:** Early ERP components (P100, N170) can be the product of multiple underlying generators.[1]
- **COMPOUND WORDS,** with two constituents—both real independent words—permit assessing the timing of access to lexical/semantic stores.
- **CURRENT STUDY**: We examined the timing of the P100 ERP component to lexical semantic access as a function of morphological composition.[1,5]

STIMULI

Transparent–transparent (TT)	Opaque–transparent (OT)
e.g., bedroom schoolboy sailboat (avg: 8.2 letters)	e.g., strawberry chopstick nickname (avg: 8.4 letters)

Transparent–opaque (TO)	Opaque–opaque (OO)
e.g., staircase jailbird heatwave (avg: 8.3 letters)	e.g., deadline stalemate fleabag (avg: 7.3 letters)

TASK

- Lexical decisions on 80 real and 80 novel English compounds, each presented 6 times.
- Target stimuli: 40 real words varying on semantic transparency (overlap between word meaning and constituent meaning).
- Because the "head" (carrying the word's semantic properties) typically is to the right in English, an OT word is "more transparent" than a TO word.
- Non-words: novel English compounds, which could plausibly be words (e.g., sodacorn, watchpanic)

METHODS

PARTICIPANTS

- 22 undergraduate students (15 women, M_{age} = 20.5 y, 3 left-handed).

DATA COLLECTION & PROCESSING

- EEG acquired with EGI 128-channel sensor-nets.
- Preprocessing performed with EEGLab toolbox functions, with SHARCNET plugin for artifact removal and periods of non-stationarity

ERP ANALYSIS

- ERPs segmented by word (averaged over participants) to analyze effects of word frequency. Each ERP had 132 averaged trials per word.
- Average amplitudes were extracted from 20 ms windows with 10 ms overlaps.

BEHAVIORAL RESULTS

- TT and OT words were responded to with greater accuracy and identified faster than TO and OO words – words with an opaque right constituent (where the head *should* be) are processed differently from words with a transparent head.

	TT	OT	TO	OO
RT	607.60	607.40	636.65	630.85
ACC	.85	.89	.77	.73

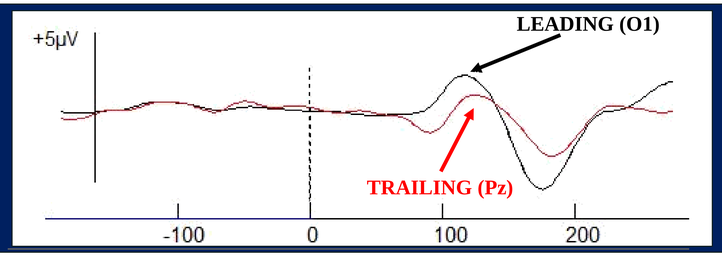
ERP RESULTS

PEAK ANALYSES

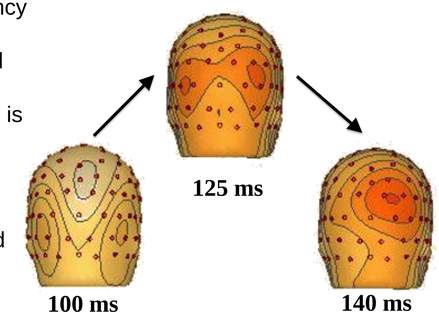
- Regression analyses predicted ERP amplitudes from whole-word frequency (WF) and 1st and 2nd constituent transparency (C1 and C2).
- WF and C2 each accounted for unique variance in P100 amplitude (R^2 = .361)
- C2, but not WF, uniquely predicted differences in P200 (R^2 = .238), P300 (R^2 = .211), and N400 (R^2 = .205) amplitudes.
- Conclusion: the expected head facilitates early semantic access.
- All significant values are for left-sided sites (P7, PO7). Right-sided differences only significant at N400, localized at sites P1, P2, and Pz

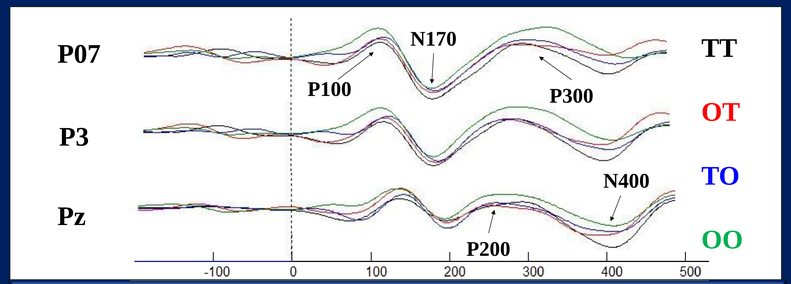
P100 "SPREAD" ANALYSIS

- The P100 was scored at the earliest occurring peak ("leading") and the latest occurring peak ("trailing"), following work by Klimesch and colleagues on "traveling alpha waves".[5]
- Only P100 latency scored for earliest peak was significant: Whole-word frequency predicted differences (R^2 = .116, r = -.340, p = .032): more frequently occurring words have earlier leading P100 peaks.
- P100 spread and trailing latency did not relate to word type or whole word frequency.



- Above figure illustrates a latency difference between the early lateral-occipital peak (O1) and the later medial-parietal peak (Pz). The waveform displayed is **averaged across all words**.
- Right figure shows topographical maps demonstrating the time-lapsed change in the balance of underlying generators of the P100.





CONCLUSIONS

TIMING OF LEXICAL/SEMANTIC ACCESS

- Semantic effects are apparent as early as the P100 component, though the mechanism by which this is possible remains unknown.
- The effect of word frequency on the P100 can be accounted for by visual similarity.

MORPHOLOGICAL DECOMPOSITION

- The opacity/transparency of the 2nd constituent drove the significant findings, suggesting that the expected head is critical in the processing of multimorphemic words. The findings are supportive of multi-route models of compound processing,[2] i.e., of the maximization of opportunity principle (that all possible lexical activations are accessed).[3]

THE P100 ERP COMPONENT

- Word frequency affects the timing of the early lateral P100, but not the later medial P100.
- The P100 can be dissociated into two underlying components, concordant with independent component analysis (ICA) research.[1]

NEXT STEPS:

- ICA for underlying components of the P100 as a function of semantics.
- Balancing word frequency for better experimental control.

REFERENCES

1. Desjardins, J. A., & Segalowitz, S. J. (2013). Deconstructing the early visual electrocortical responses to face and house stimuli. *Journal of Vision 13*(5), 1–18.
2. Kuperman, V., Schreuder, R., Bertram, R., and Baayen. R. H. (2009). Reading polymorphemic Dutch compounds: Toward a multiple route model of lexical processing.
3. Libben, G. (2010). Compound words, semantic transparency, and morphological transcendence. *Linguistische Berichte Sonderheft, 17*, 212–232.
4. Segalowitz, S. & Zheng, X. (2009). An ERP study of category priming: Evidence of early lexical semantic access. *Biological Psychology, 80*, 122–129.
5. Zauner, A., Gruber, W., Himmelstoβ, N. A., Lechinger, K., & Klimesch, W. (2014). Lexical access and evoked traveling alpha waves. *NeuroImage, 91*, 252–261.

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