Event-related potential responses reveal simultaneous processing across multiple levels of representation in spoken word recognition

3pSC14.

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Introduction

Major debate about whether different sources of information are encapsulated from each other, and whether information is processed sequentially (Trueswell et al., 1995)

Sequential processing predicts late effects for higher-level information; ***parallel*** processing predicts simultaneous effects

Question:

> Do listeners finish processing lower-level information (e.g., encoding acoustic differences) before beginning higher-level processing (e.g., determining the meaning of a word or its grammatical status)?

Recent work suggests lexical processing begins by 140-200 ms (Baart & Samuel, 2015; Toscano et al., sub.)

Certain ERP components may reflect these processes (N400; P600), but there is debate over what these components index (Kutas & Federmeier, 2011; Tanner & Van Hell, 2014)

Alternative approach is to use component-independent design to examine time-course (Thorpe et al., 1996)

Method

Word-final CVC minimal pair stimuli presented over EARTONE ER-3A insert earphones at MCL

Cross-spliced to control for acoustic differences and balanced for word frequency and phonotactic probability

24 stimuli (12 pairs) across three conditions (lexical, syntactic, semantic) presented 30 times each in random order for a total of 720 trials

Word	Non-word
*tu**b***	*tu**p***
*ra**p***	*ra**b***

Noun	Verb
*ga**p***	*ga**b***
*ri**b***	*ri**p***

2AFC phonological judgment task

EEG responses recorded with a Brain Vision actiCHamp system with 32 electrodes (FP1, Fz, F3, F7, FT9, FC5, FC1, C3, T7, A1, CP5, CP1, Pz, P3, P7, O1, Oz, O2, P4, P8, A2, CP6, CP2, Cz, C4, T8, FT10, FC6, FC2, F4, F8, FP2), at 500 Hz, with a high-pass filter at 0.01 Hz. Referenced online to A1 and re-referenced offline to average mastoid

Results

Stimulus Norming

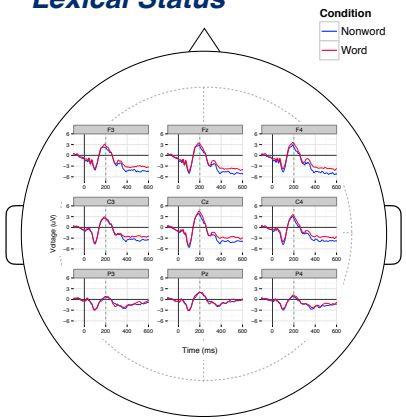
Sets of minimal pair stimuli presented to identify pairs that served as clear exemplars of the relevant category (N=18)

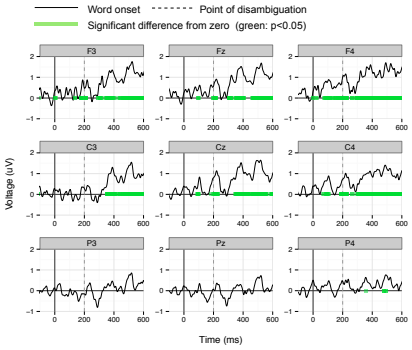
Pair	Prop. Word (Word/NW)	Phonotactic prob. (Word/NW)
tip/tib	1.00, 0.06	0.0049, 0.0023
bib/bip	1.00, 0.11	0.0023, 0.0049
top/tob	1.00, 0.28	0.0025, 0.0019
tub/tup	0.94, 0.11	0.0019, 0.0021
TOTAL	0.99, 0.14	0.0029, 0.0028

Pair	Prop. Noun (Noun/Verb)	Log KF Freq. (Noun/Verb)	Phonotactic prob. (Noun/Verb)
hat/had	1.00, 0.11	1.75, 3.71	0.0059, 0.0024
lid/lit	0.89, 0.11	1.28, 1.23	0.0032, 0.0059
fate/fade	0.83, 0.06	1.52, 0.30	0.0030, 0.0023
rod/rot	0.94, 0.00	1.26, 0.90	0.0025, 0.0027
TOTAL	0.92, 0.07	1.45, 1.54	0.0037, 0.0033

Pair	Prop. Animate (Animate/Non)	Log KF Freq. (Animate/Non)	Phonotactic prob. (Animate/Non)
cub/cup	0.89, 0.00	0.00, 1.65	0.0019, 0.0021
pup/pub	0.94, 0.00	0.30, 0.00	0.0021, 0.0019
mutt/mud	0.78, 0.00	0.00, 1.50	0.0025, 0.0007
kid/kit	0.94, 0.06	1.79, 0.30	0.0032, 0.0059
TOTAL	0.89, 0.015	0.52, 0.86	0.0024, 0.0027

Lexical Status





N = 19 subjects in all conditions (within-subject)

No N1 differences (i.e., cross-splicing procedure was successful)

Difference waves calculated (*Word-Nonword*)

Multiple t-test approach used to determine onset of significant effect (15 consecutive t-tests; 30 ms of data) (Thorpe et al., 1996)

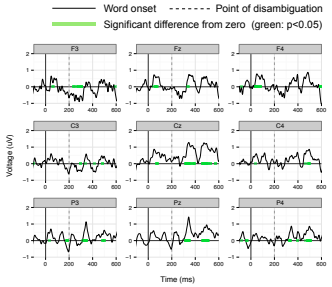
Lexicality effect observed at several scalp locations, particularly frontal & central channels; earliest effect at **90 ms** post-disambiguation (@ F4)

Syntactic Class

N = 19

Difference waves calculated (*Verb-Noun*)

Smaller effects, but similar time-course to lexicality



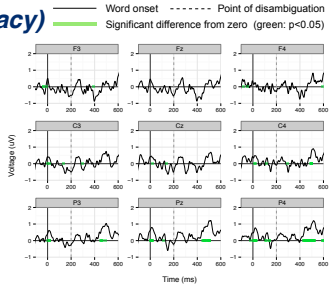
Earliest syntactic effect observed at **116 ms** (@ Pz)

Semantics (Animacy)

N = 19

Difference waves calculated (*Non-animate-Animate*)

Smaller effects; later time-course than lexicality and syntactic conditions



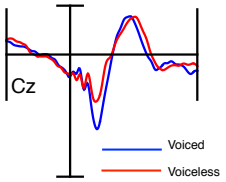
Earliest semantic effect observed at **266 ms** (@CP6)

Phonetic Effects

Pilot experiment: N=15 subjects

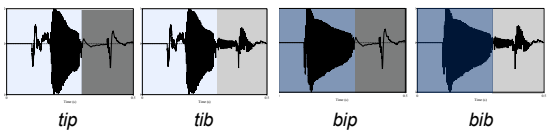
Word-initial minimal pair stimuli (e.g., lexical status pair babe/pabe) cross-spliced to control for acoustic differences

Larger N1 for short VOTs—consistent with previous data



Cross-splicing Procedure

Onset and coda of each stimulus cross-spliced to control for acoustic differences; e.g., lexical stimuli:



Discussion

Cross-splicing technique successfully controlled for acoustic differences in order to isolate lexical status, syntactic class, and semantic effects

Time-course of processing reveals extremely rapid lexical activation; similar to other recent work suggesting early effects (60 ms, Baart & Samuel, 2015; 144 ms, Toscano et al., in prep)

Time-course of each effect overlaps with others, and also with phonetic processing (approx. first 200 ms after onset of acoustic difference), suggesting parallel activation of phonetic and lexical representations

Lexicality effect may correspond to leading edge of N400 onset (Kutas & Federmeier, 2011), though component-independent design allows us to examine time-course independently of specific ERP components

Early syntactic class effect fits with recent work arguing against traditional N400/P600 distinction (Tanner & Van Hell, 2014)

Overall, results suggest multiple types of linguistic representations are active simultaneously during spoken word recognition, consistent with parallel processing models

References & Acknowledgments

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