Reading, Language, and Application

(Bonus Material for Lecture: Memory, Thinking, and Language – Gedächtnis, Denken, und Sprache)

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Core Reading (Bonus Lecture)

- McCandliss, B. D., Cohen, L., & Dehaene, S. (2003). The visual word form area: expertise for reading in the fusiform gyrus. *Trends in Cognitive Sciences,* 7(7), 293-299.

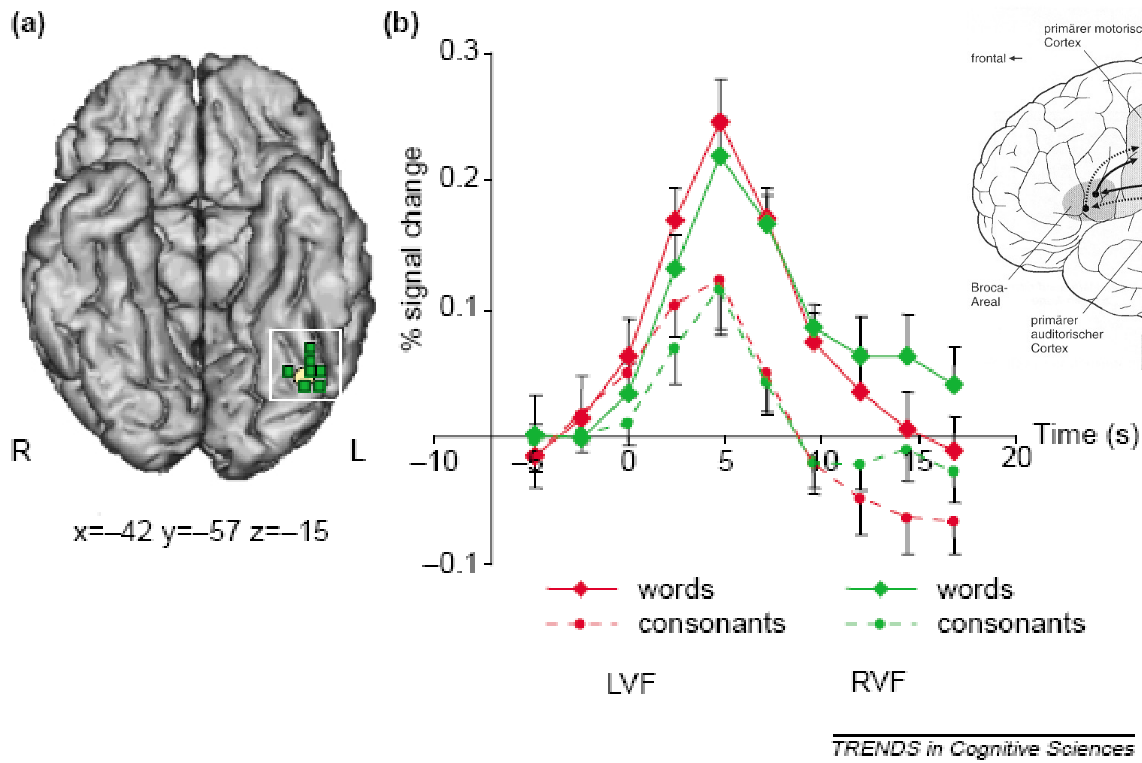
- Price, C. J., & Devlin, J. T. (2003). The myth of the visual word form area. *NeuroImage, 19(3)*, 473-481.

- Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P. K. S., & Suma, K. (2015, Jul). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological Science, 26*(7), 1071-1083. https://doi.org/10.1177/0956797615581493

Opinion TRENDS in Cognitive Sciences Vol.7 No.7 July 2003 293

The visual word form area: expertise for reading in the fusiform gyrus

Bruce D. McCandliss[1], Laurent Cohen[2,3] and Stanislas Dehaene[3]



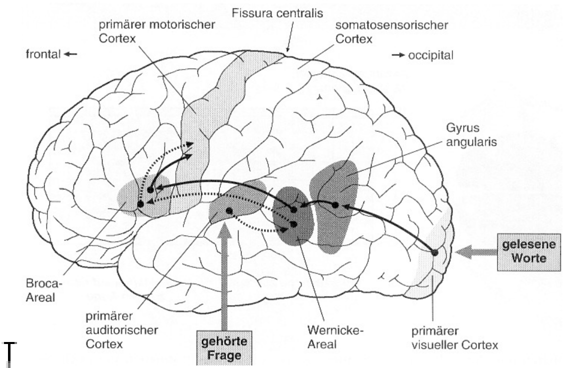


Fig. 1. (a) Peak of the Visual Word Form Area (VWFA) identified in individual subjects (green squares) and in group analyses (yellow circle) projected onto the inferior surface of a normalized brain. L indicates left hemisphere, R right. (b) Percentage change in BOLD signal for words and consonant strings versus checkerboards in the left and right hemifields at the peak of the group VWFA, averaged across subjects (bars represent the intersubject standard error).

The VWFA (visual word form area)

- Soon after children learned to decode letters within words, they develop expertise to integrate groups of letters into words
- This expertise is becoming increasingly effortless and efficient
- McCandliss et al. (2003) postulate a relationship between this expertise and a brain area in the „Gyrus fusiformis of the left hemisphere“
- Reading and writing, as cultural techniques, are only existing since about 5000-6000 years. How can a separate module specialized on reading have developed in the human brain?
- McCandliss et al. assume that the VWFA had precursors in systems that mediate visual object recognition in the ventral temporal lobe. In that sense, perceptual experience with written words may have been a catalyser towards an increasing specialisation of these existing systems

Perceptual Expertise in Reading

- Despite enormous variations in size, *writing systems*, **Font types** or retinal positions, the visual system is able to extract relevant information from a written word within less than 250 ms
- Reading speed (at least in words with 3-6 letters length) is remarkably independent from word length, which suggests parallel processing of the letters (Nazir et al., 1998)
- The so-called **word superiority effect** illustrates that a target letter within a meaningful word is processed more efficiently than the same letter within a meaningless letter string (Reicher, 1969)
- These perceptual effects persist across a number of nonessential changes in the stimulus (e.g. in font or size). This suggests that readers extract abstractive and invariant information about the structure of visual words (i.e. visual word forms) and integrate these into a “perceptual object” that is essential for normal reading (Rayner & Pollatsek, 1989)

VWFA

- Note: Areas in the Gyrus fusiformis can be activated by visual objects, faces, or words, but the precise localization and hemispheric asymmetry of activation can differ depending on object class

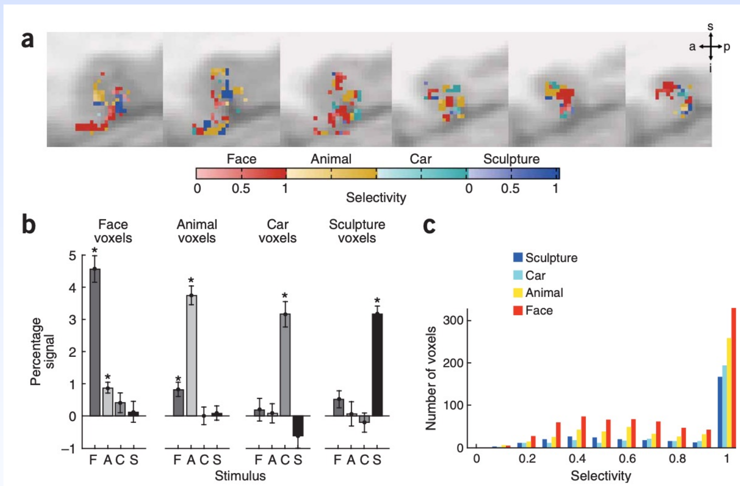
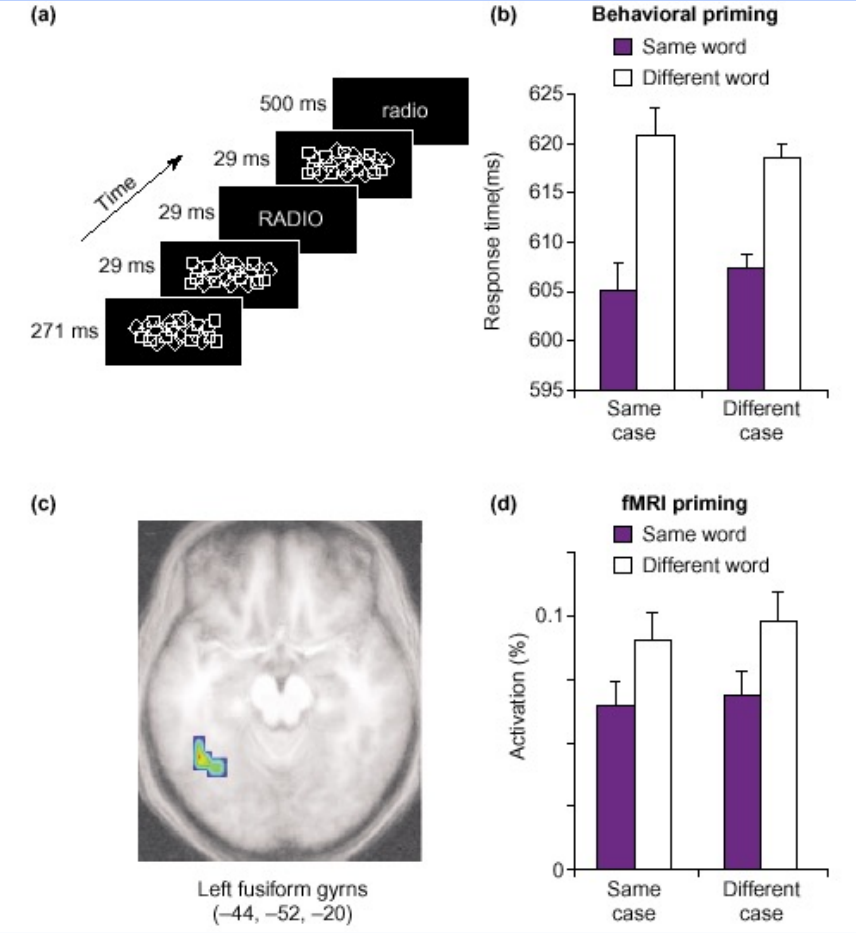


Figure 4 HR-fMRI (1 mm × 1 mm × 1 mm) of the FFA. (**a**) FFA selectivity map (subject 3). Data are shown for a magnified region in the vicinity of the FFA, on six consecutive 1-mm in-plane slices. Color bar, preferred category and selectivity level. The leftmost slice is the most lateral. (**b**) Response amplitudes of voxel populations within the FFA to different stimuli. Data are averaged across five subjects. Baseline is scrambled condition. Error bars indicate s.e.m. across subjects. $*P < 0.05$ (higher response as compared to scrambled; *t*-test across subjects). (**c**) Histogram of the selectivity index of high-resolution FFA voxels across five subjects.

Source: Grill-Spector, Sayres, & Ress (2006). High-resolution imaging reveals highly selective nonface clusters in the fusiform face area. *Nature Neuroscience, 9(9)*, 1177-1185.

VWFA (left hemisphere)



Source: DeHaene et al, 2001. *Nature Neuroscience*

Fig. 2. Evidence for subliminal activation of a case-invariant representation of words in the left fusiform gyrus. (a) A subliminal priming paradigm allowed the presentation of a short masked prime followed by a word target. Subjects were engaged in a semantic classification task on target words and were not unaware of the presence of primes. (b) The behavioral results indicated a reduction of response time when the same word was repeated as prime and as target, irrespective of case change. (c) The cerebral bases of this repetition priming were identified by searching the whole brain for regions of reduced activation on repeated-word trials. This revealed the visual word form area in the left fusiform gyrus. (d) The activation profile of this area, relative to control trials with masks only, parallels response times in showing reduced activation on repeated trials irrespective of case change. This suggests that this area holds a case-invariant neural code for visual words and that this code can be activated automatically without awareness.

VWFA and Dyslexia

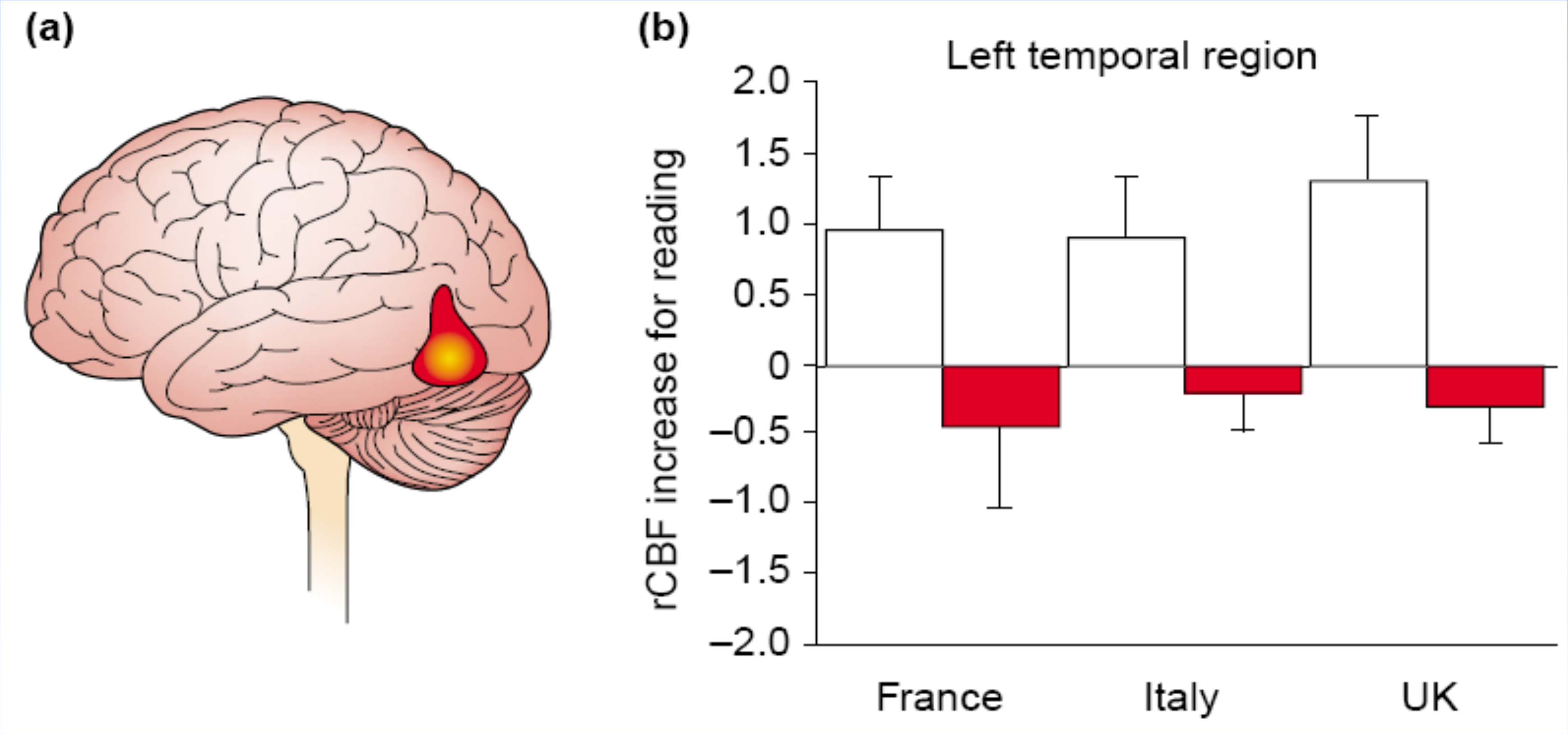


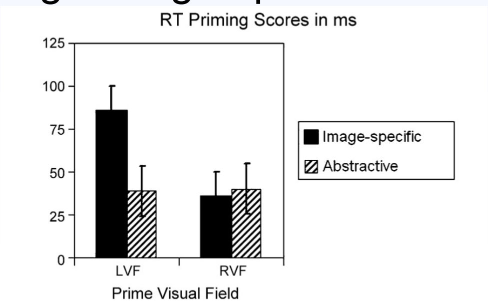
Fig. I. (a) Area consistently more active for normal readers versus dyslexic adults during reading tasks, with a peak difference located near the VWFA (x = −52, y = −60, z = −14). Activations displayed for this analysis are restricted to areas that consistently demonstrated group differences between normal and dyslexic adults under conditions that included both explicit and implicit reading tasks, and subject populations reading French, Italian, and English. (b) Bar graphs illustrate the PET measures of increased relative cerebral blood flow in this region for each language. Error bars indicate 1 standard error. Normal adult readers showed an increase in rCBF (white bars), whereas dyslexic readers (red bars) consistently failed to show this response. Redrawn with permission from Ref. [44]. © 2001 American Association for the Advancement of Science.

Source: McCandliss, B. D., Cohen, L., & Dehaene, S. (2003). The visual word form area: expertise for reading in the fusiform gyrus. *Trends in Cognitive Sciences*, 7(7), 293-299.

Interim Summary

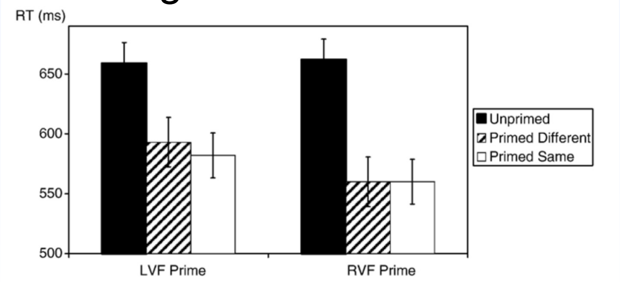
- Areas in the *Gyrus fusiformis* are specialized for the recognition of complex visual stimuli (faces, object, words).
- It remains possible that the relevant processes differ at the dimension of "holistic vs. feature-based processing" (Farah, 1991), and the relevant representations which are relevant for recognition may be more or less "pictorial vs. abstractive", depending on stimulus category
- Hemispheric asymmetries in the fusiform gyrus take the form of a right hemispheric specialization for faces (more holistic, more pictorial) vs. a left hemispheric specialization for words (more feature based, more abstractive representations)

Face Priming: Image-specific in LVF/RH

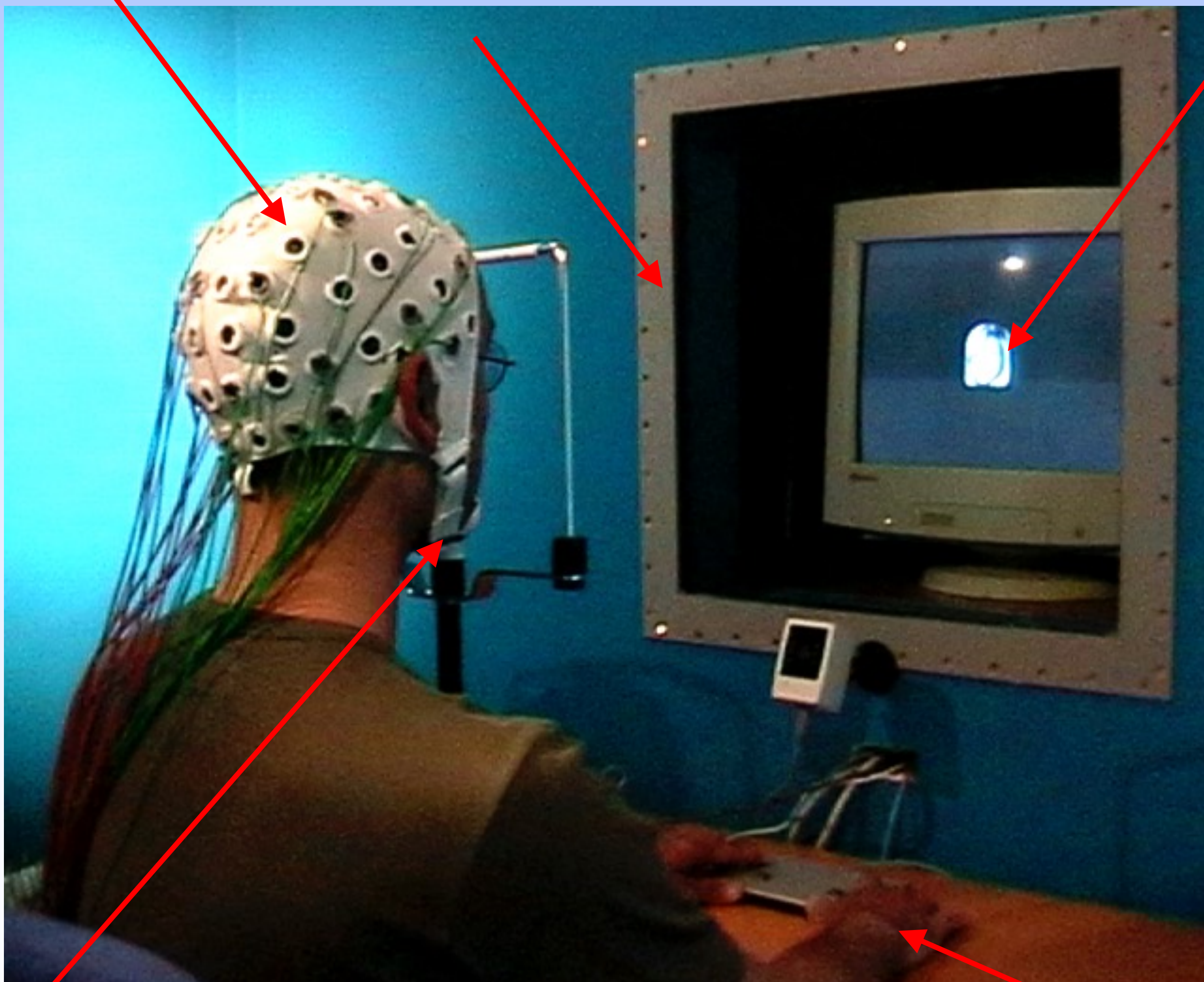


Source: Cooper et al, 2007. *Neuropsychologia*

Word Priming: Abstractive in both hemispheres



Source: Schweinberger et al, 2006. *Brain Research*


Head cap with inserted Ag/AgCl electrodes
Electromagnetically shielded recording chamber
Visual stimulus presentation
Fixed chin rest
Keypress response pad

Models of Face, Voice and Person Perception

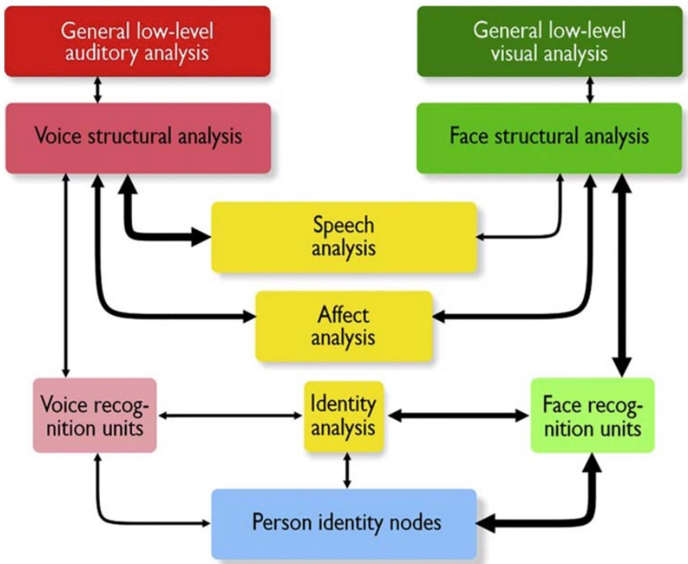


Figure 1. Revised Functional Model of Face and Voice Perception. The model shows components that involve relatively unimodal responses to voices in reddish highlighting, and components that involve relatively unimodal responses to faces in green highlighting. Relatively low-level analyses are indicated by more intense colours. Components in yellow highlighting involve multimodal perceptual integration for speech, affect, and identity, with the size of boxes and the weight of arrows indicating the relative importance of perceptual integration for speech, affect, and identity. A component that involves postperceptual representations at the level of episodic or semantic processing is highlighted in blue. Line thicknesses are used to indicate the relative weighting of different functional connections at higher processing levels.

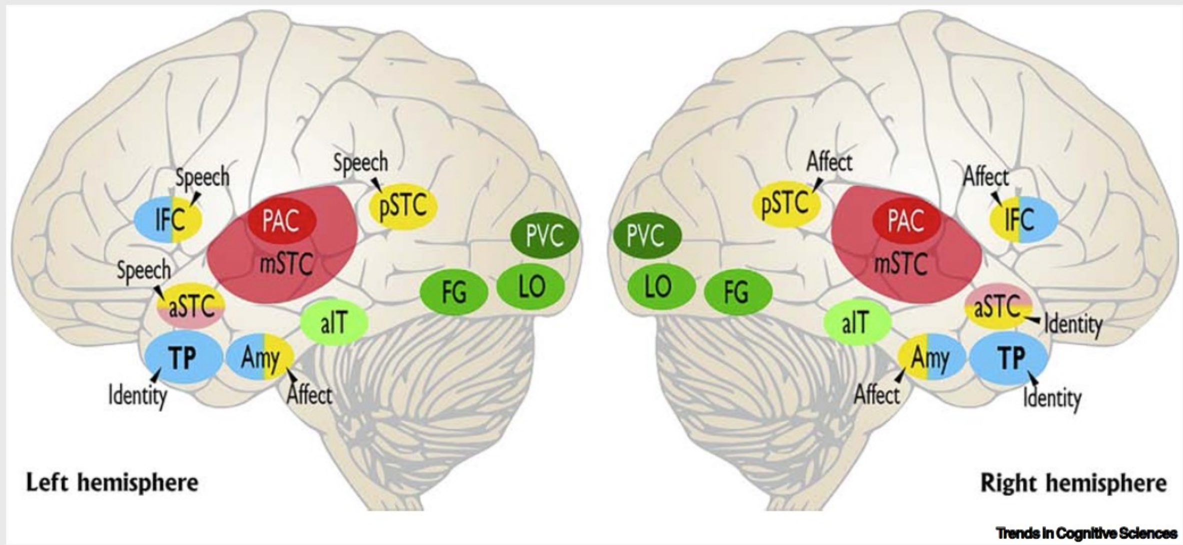


Figure I. Brain Regions Responsive to Faces, Voices, or Both. Abbreviations: a/m/pSTC, anterior/mid/posterior superior temporal cortex; aIT, anterior inferior temporal lobe; Amy, amygdala; FG, fusiform gyrus; IFC, inferior frontal cortex; LO, lateral occipital cortex; MFC, medial frontal cortex; PAC, primary auditory cortex; PVC, primary visual cortex; TP, temporal pole.

Source: Young, A.W., Frühholz, S., & Schweinberger, S.R. (2020). Face and Voice Perception: Understanding Commonalities and Differences. *Trends in Cognitive Sciences, 25(4)*, 398-410.

Temporal Aspects of Face Perception

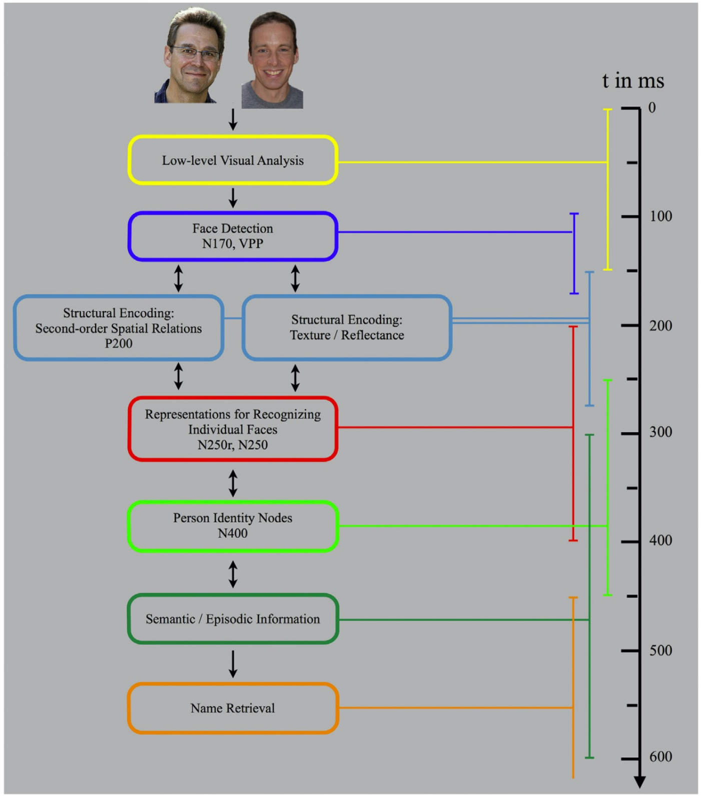
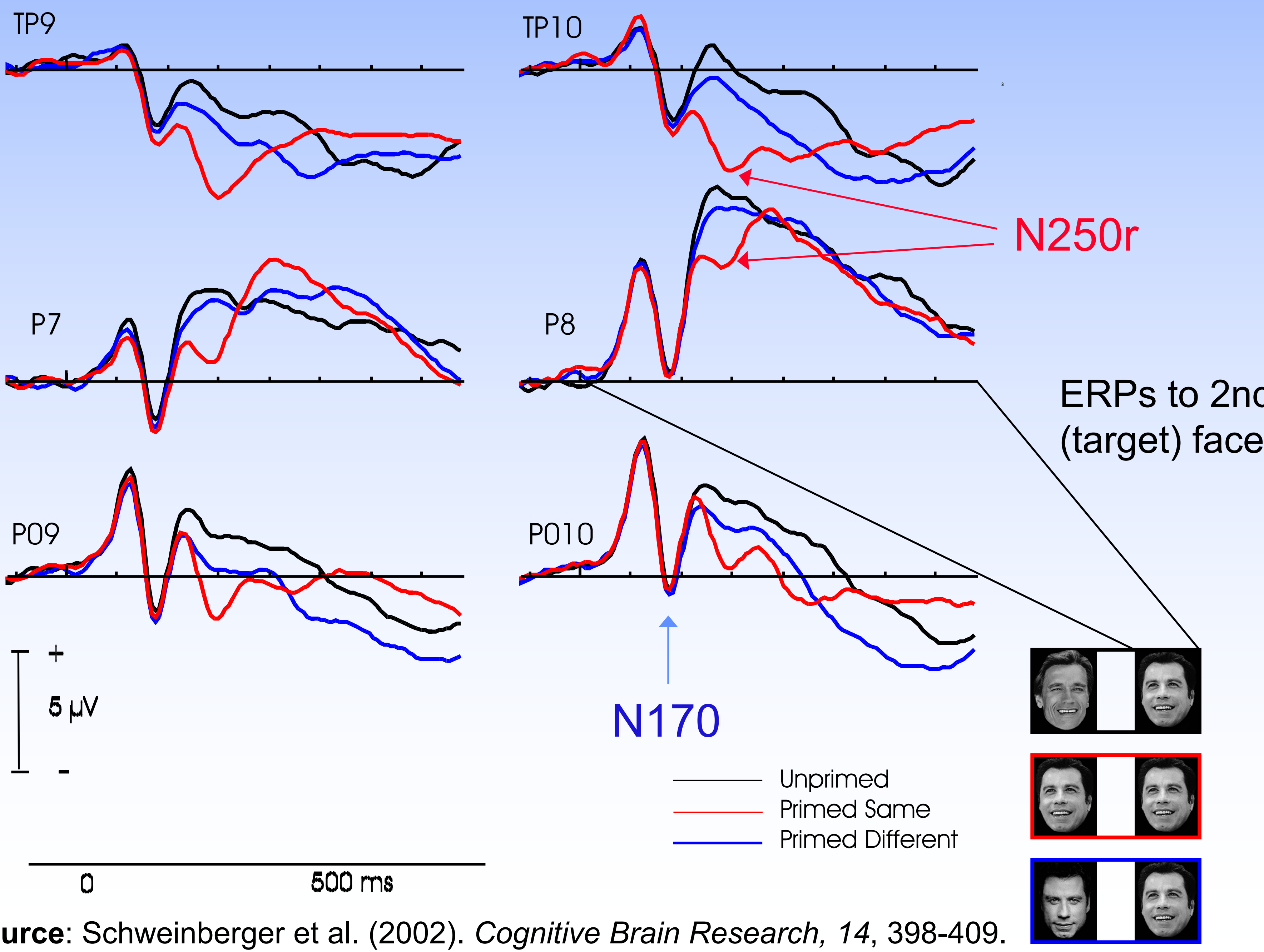


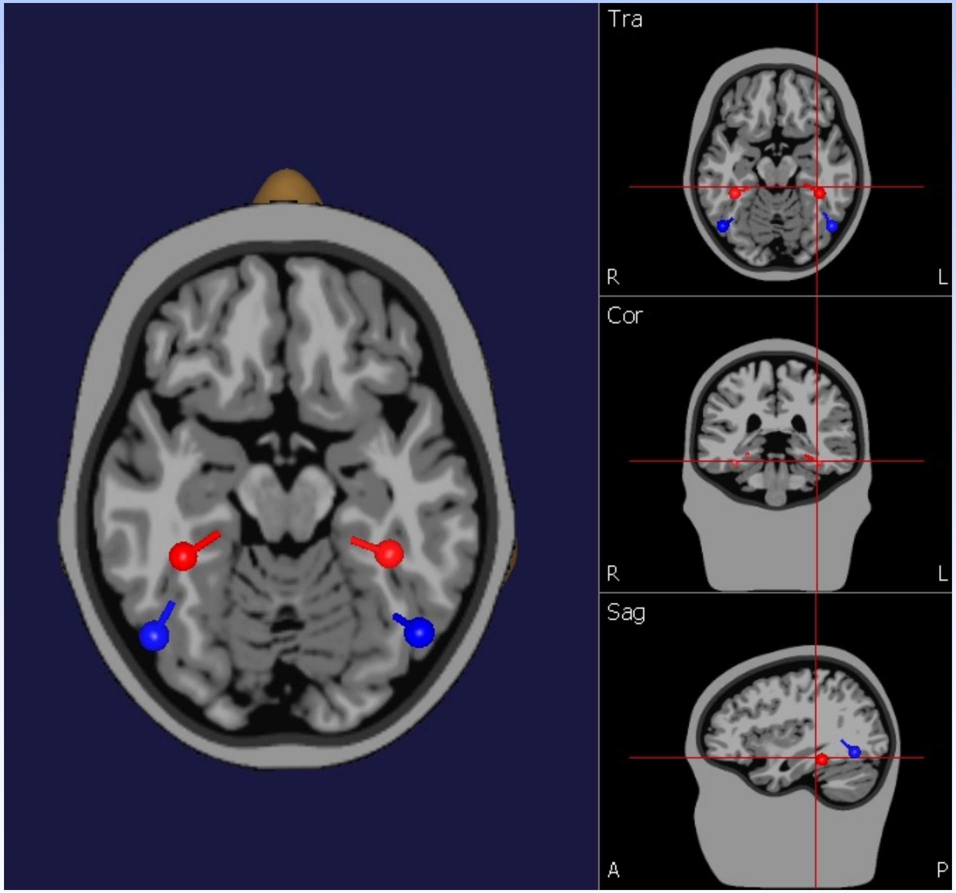
Fig. 1 – Simplified cognitive model of face perception (modified from Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000; Schweinberger & Burton, 2003). The approximate time course of the sub-processes involved in face perception, as well as the ERP components that are sensitive to the different types of face repetition effects, are also shown. Note that most of the processes are linked by bidirectional arrows, indicating the operation of both bottom-up and top-down (predictive coding) mechanisms in face perception. In particular, ERP evidence for top-down influences has been reported at the levels of face detection (e.g., Ganis & Schendan, 2008) and both face identity and person identity processing (e.g., Trenner, Schweinberger, Jentzsch, & Sommer, 2004). A possible exception to this is name retrieval, which may be sequential to, and contingent on, semantic access (Abdel Rahman, Sommer, & Schweinberger, 2002).

Source: Schweinberger, S.R., & Neumann, M.F. (2016). Repetition effects in Human ERPs to Faces. *Cortex, 80*, 141-153.



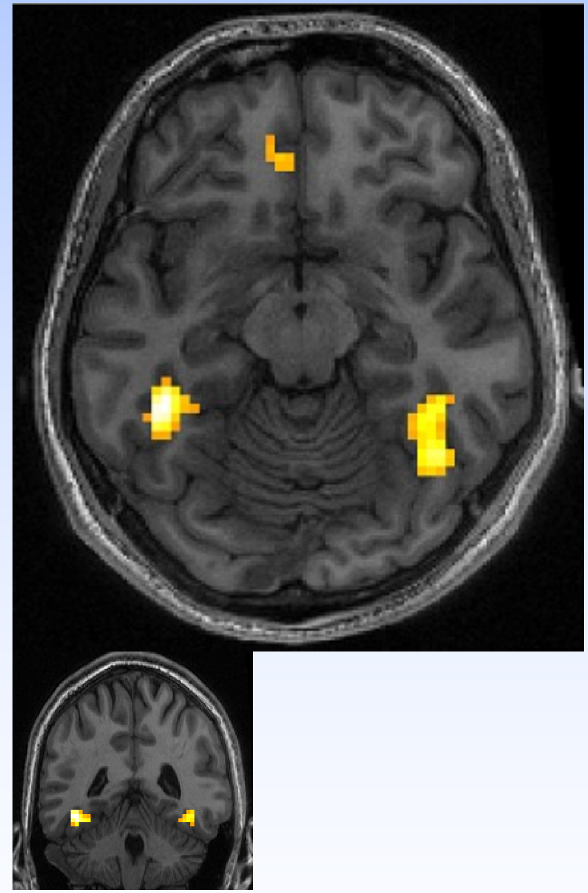
Source: Schweinberger et al. (2002). *Cognitive Brain Research, 14*, 398-409.

ERP-Correlates of Familiar Face Repetitions (N250r; in red)

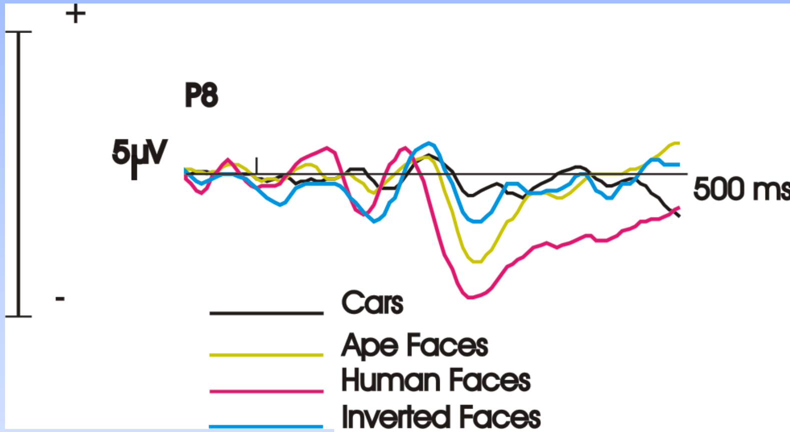


Source: S.R. Schweinberger et al. (2002). Event-related brain potential evidence for a response of inferior temporal cortex to familiar face repetitions. *Cognitive Brain Research, 14*, 398-409.

Corresponding fMRI-Modulation by Face Rep.



Source: E. Eger, S.R. Schweinberger, R.J. Dolan, and R.N. Henson (2005). Familiarity enhances invariance of face representations in human ventral visual cortex: fMRI evidence. *NeuroImage, 26,* 1128-1139.



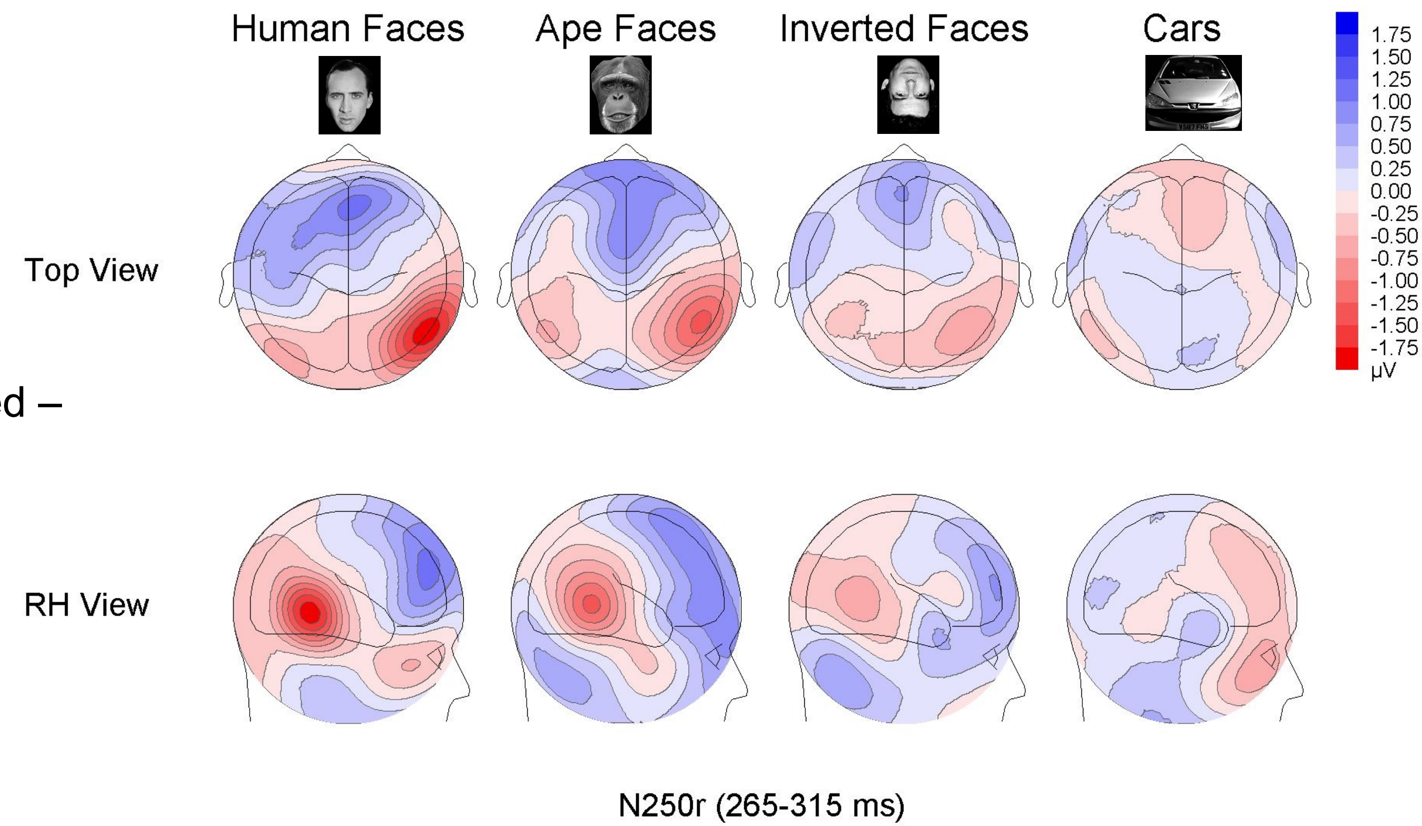
N250r:

•Human Faces > Ape Faces

•The N250r does NOT like Car Fronts !

Source: Schweinberger, Huddy, & Burton, 2004. *NeuroReport.*

N250r Voltage Map
(Difference Repeated – Nonrepeated)



64 channels, voltage maps, spherical spline interpolation

Interim Summary

- N250r is a “face-selective” ERP
- sensitive to repetition
- typically larger over the right hemisphere
- probably generated in fusiform gyrus
- can relate to individual face recognition

Font-specific and font-independent repetition priming for written names

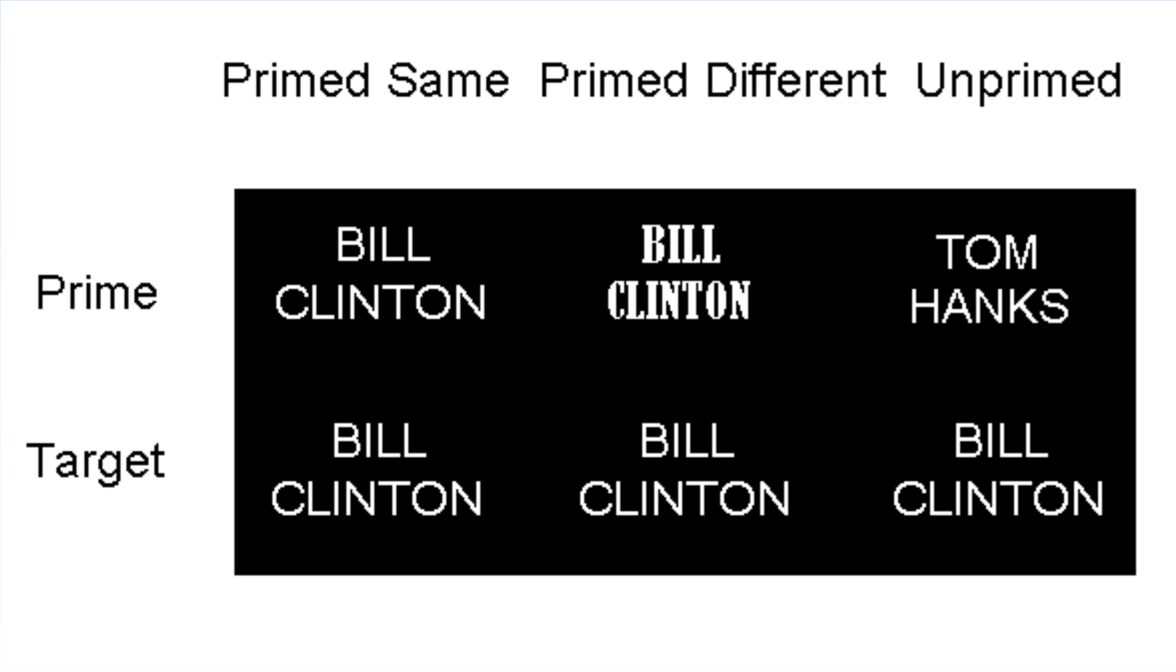


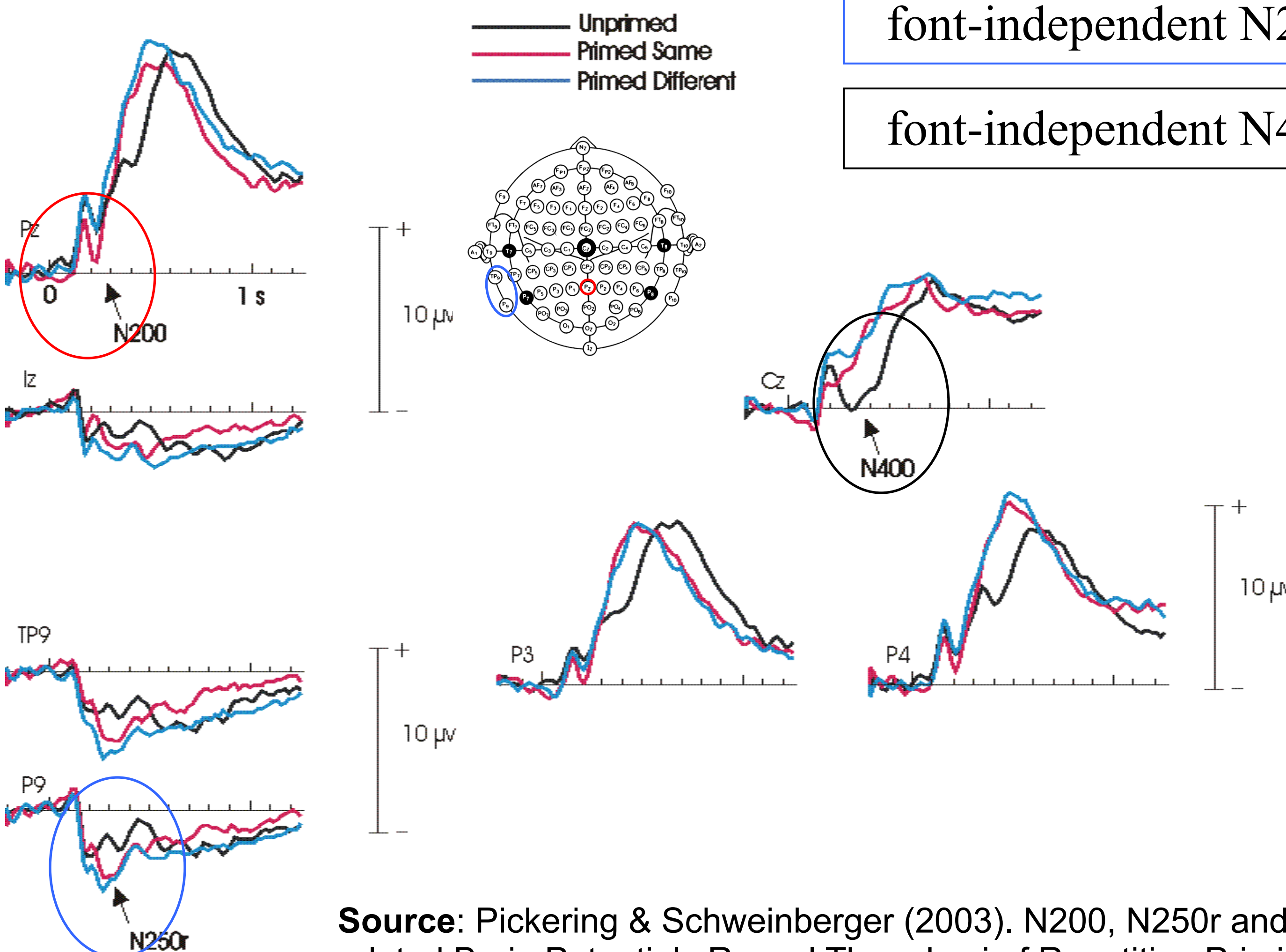
Figure 1. Examples of the prime and target names in Experiment 1. Bottom row: target names. Top row: prime names for the primed same, primed different, and unprimed conditions, respectively.

Source: Pickering, E.C., & Schweinberger S.R. (2003). N200, N250r and N400 Event-related Brain Potentials Reveal Three Loci of Repetition Priming for Familiar Names. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 1298-1311.

font-specific N200 effect

font-independent N250 effect

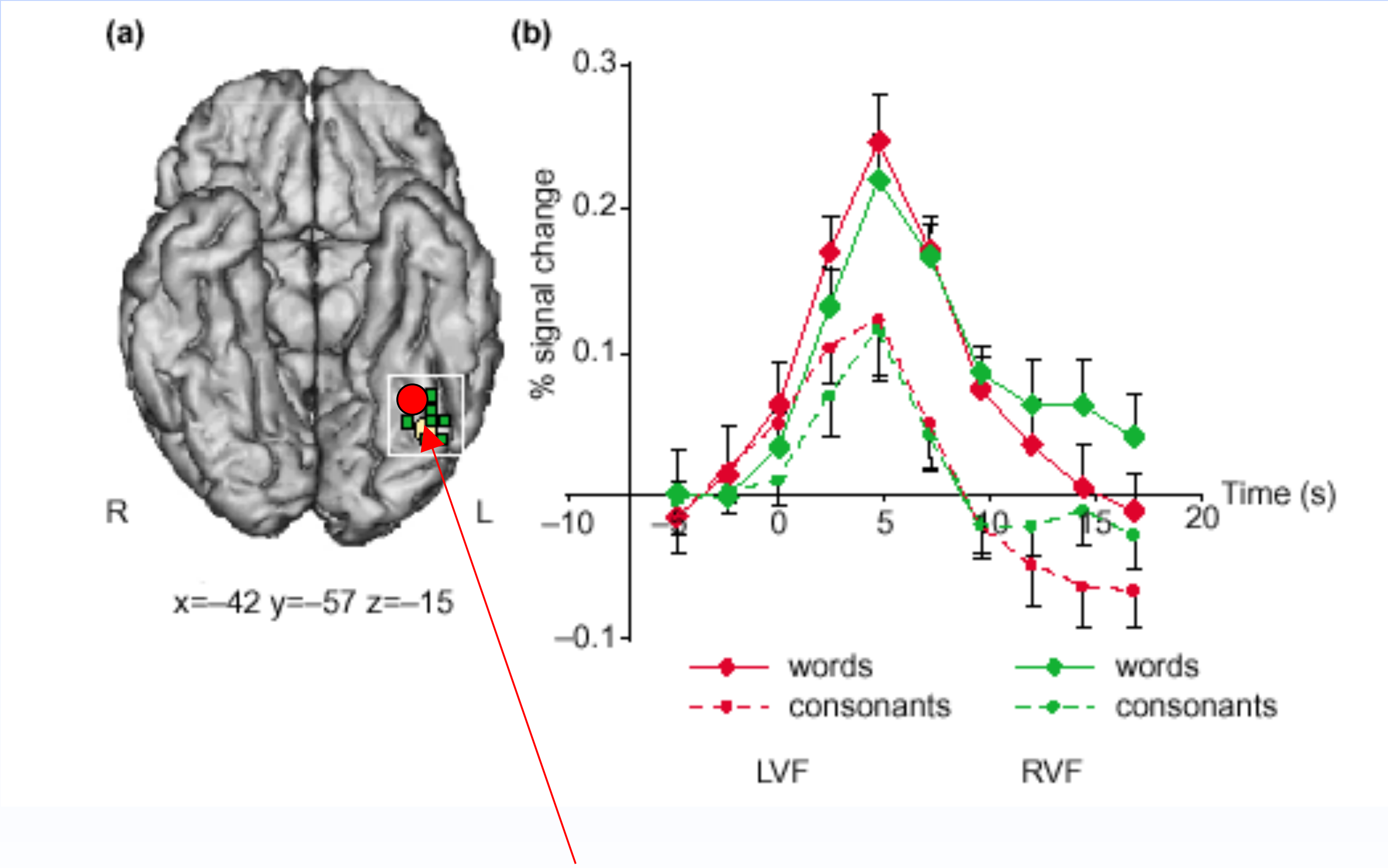
font-independent N400 effect



Source: Pickering & Schweinberger (2003). N200, N250r and N400 Event-related Brain Potentials Reveal Three Loci of Repetition Priming for Familiar Names. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 1298-1311.

The Visual Word Form Area

(McCandliss, Cohen, Dehaene, 2003. Trends in Cognitive Sciences)



Names (N250r ERP): x=36,y=-43, z=-6

Interim Conclusions

- ERPs can distinguish separate stages at which priming facilitates processing during word/name reading:
- Posterior N200: font-specific featural processing
- Left temporal N250r: lexical representation (visual word-form)
- Central-parietal N400: semantic processing

Applied Language Research

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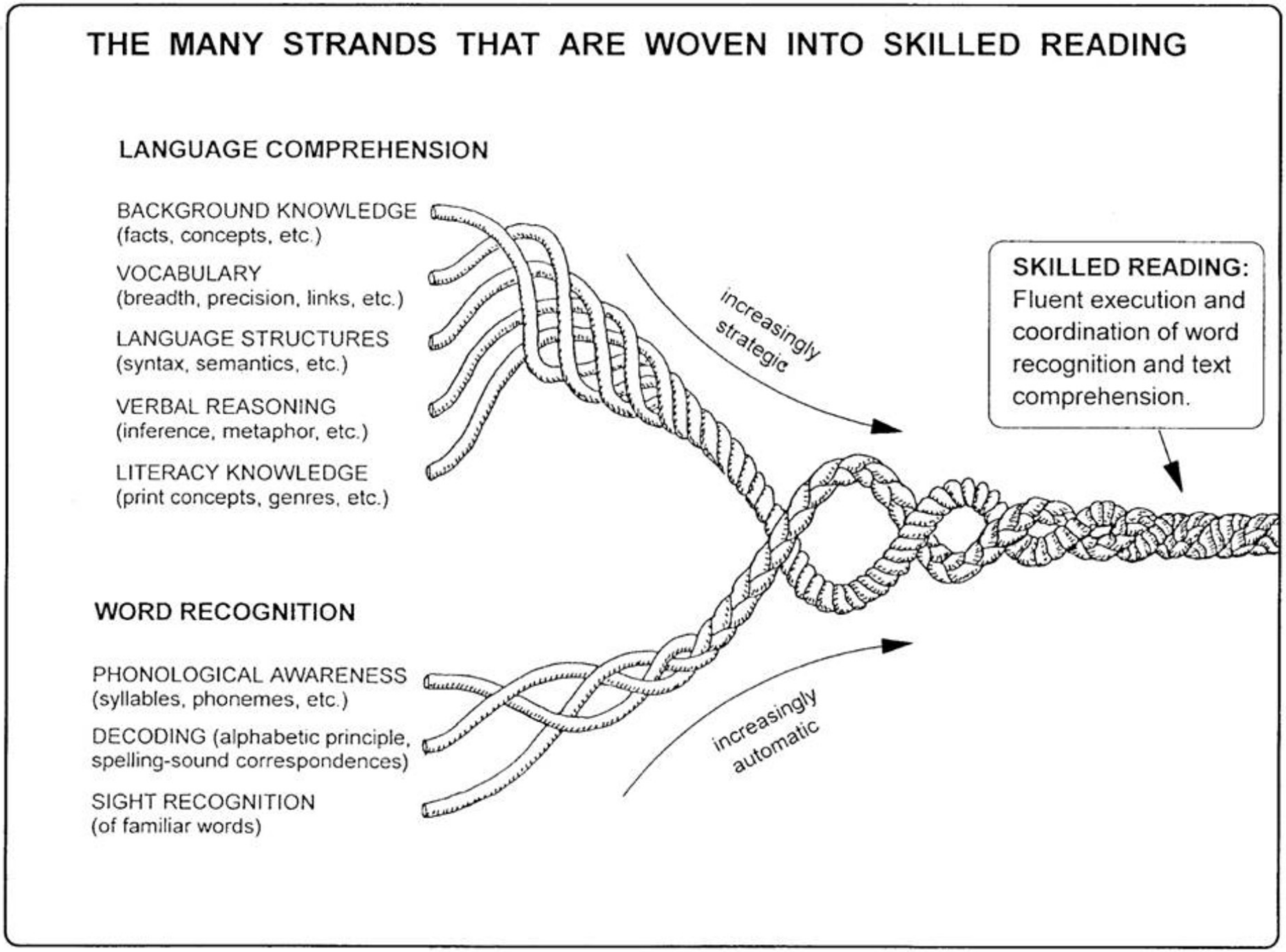
The Contribution of Early Communication Quality to Low-Income Children's Language Success

Kathy Hirsh-Pasek[1], Lauren B. Adamson[2], Roger Bakeman[2], Margaret Tresch Owen[3], Roberta Michnick Golinkoff[4], Amy Pace[1], Paula K. S. Yust[1], and Katharine Suma[2]
[1]Temple University, [2]Georgia State University, [3]The University of Texas at Dallas, and [4]University of Delaware

Abstract
The disparity in the amount and quality of language that low-income children hear relative to their more-affluent peers is often referred to as the *30-million-word gap*. Here, we expand the literature about this disparity by reporting the relative contributions of the quality of early parent-child communication and the quantity of language input in 60 low-income families. Including both successful and struggling language learners from the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development, we noted wide variation in the quality of nonverbal and verbal interactions (symbol-infused joint engagement, routines and rituals, fluent and connected communication) at 24 months, which accounted for 27% of the variance in expressive language 1 year later. These indicators of quality were considerably more potent predictors of later language ability than was the quantity of mothers' words during the interaction or sensitive parenting. Bridging the word gap requires attention to how caregivers and children establish a communication foundation within low-income families.

Keywords
language development, social interaction, psycholinguistics, relationship quality



Source: Scarborough, H. S. (2001). Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In S. Neuman & D. Dickinson (Eds.), Handbook for research in early literacy (pp. 97–110). New York, NY: Guilford Press.

Hirsh-Pasek (2019, BPS)

- Do not just train word recognition – think about language acquisition
- Language ability in early childhood is the single best predictor for school readiness and later success in school (e.g., Hoff, 2013)
- Number of words heard per hour differs massively according to SES, with children in poverty hearing significantly fewer words (*the 30-million-word gap;* Hart & Risley, 1995)
- But the quality of communication may be even more important than the quantity of language input

Hirsh-Pasek et al. (2015, Psych. Science): Questions

1. Do low-income children who are successful language learners experience a higher quality communication during early mother-child interaction than their less-verbal peers?
2. How important is the quantity of language that children hear, relative to the quality of their communication foundation?
3. Does the quality of the communication foundation, the quantity of language input, or both, predict subsequent language outcome over and above what is predicted by sensitive parenting?

Hirsh-Pasek et al. (2015, Psych. Science): Methods

- 60 low-income children (income-to-needs ratios < 1.8) selected from the archived NICHD SECCYD longitudinal study (birth to age 15 years)
- Examined video records of mother-child interactions **at age 24 months** (3 semi-structured games, 3 x 15 minutes)
- Examined outcome data for expressive language (Reynell expressive-language scores) **at age 36 months**
- 158 children fulfilled criteria and were categorized into three standard tertiles of low (N = 85), middle (N = 48) and high (N = 25) Reynell scores
- Of these, 20 (10 M/F each) children were selected per tertile. Selection achieved balanced maternal education and ethnicity but was blind to sensitivity ratings of parent-child interactions

Hirsh-Pasek et al. (2015): Results

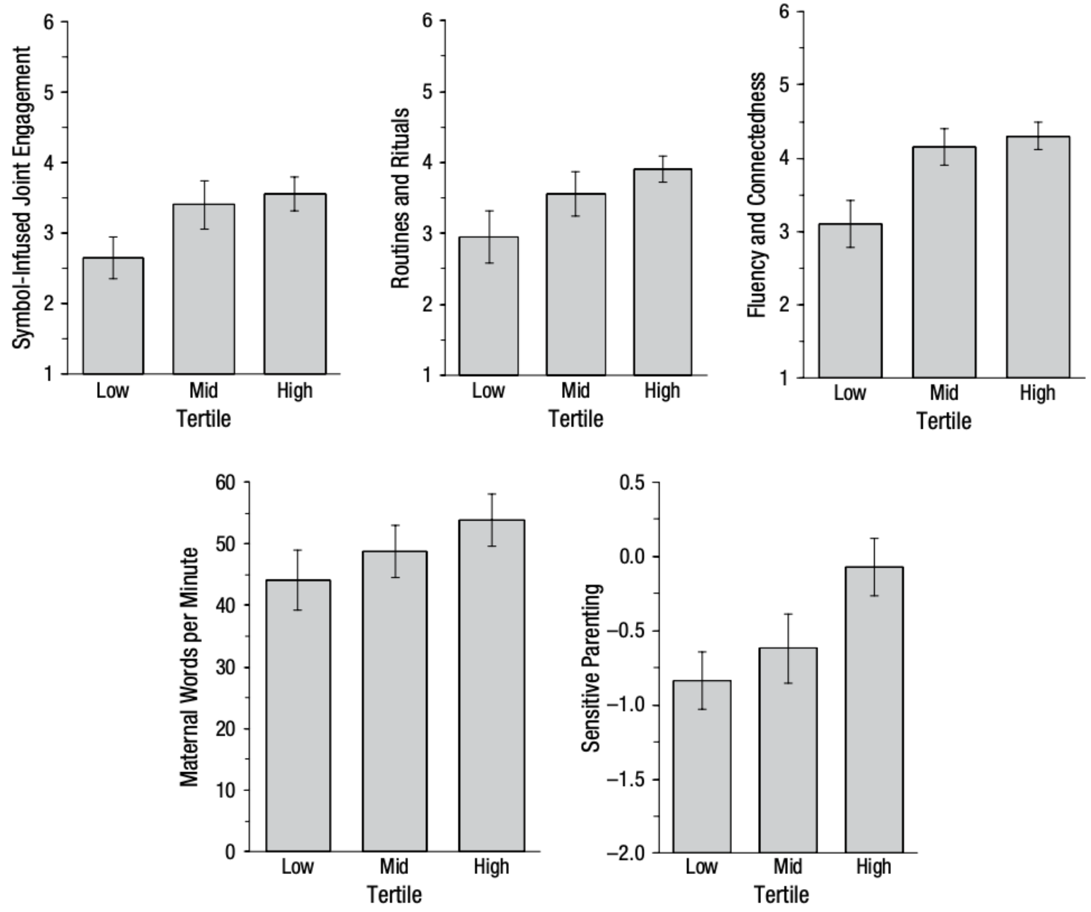


Fig. 1. Mean ratings for the three measures of communication-foundation quality (symbol-infused joint engagement, routines and rituals, and fluency and connectedness), maternal words per minute, and the sensitive-parenting composite score. Each measure is shown as a function of children's expressive-language tertile. Error bars indicate 95% confidence intervals.

Source: Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P. K. S., & Suma, K. (2015, Jul). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological Science, 26*(7), 1071-1083.

Hirsh-Pasek et al. (2015): Results

Table 5. Results From the Tertile-by-Child-Gender Analysis of Variance

Variable	M			Tertile effect		Child-gender effect		Interaction effect	
	Low tertile	Mid tertile	High tertile	η^2	p	η^2	p	η^2	p
Symbol-infused joint engagement	2.65_a	3.40_{ab}	3.55_b	.11	.042	< .01	1.0	.050	.25
Routines and rituals	2.95_a	3.55_{ab}	3.90_b	.11	.042	.014	.38	.032	.42
Fluency and connectedness	3.10_a	4.15_b	4.30_b	.23	.001	< .01	.71	.033	.41
Maternal words per minute	44.1	48.7	53.8	.056	.21	< .01	.90	.10	.051
Sensitive parenting	-0.84_a	-0.62_{ab}	-0.08_b	.14	.016	< .01	.83	.028	.47

Note: $N = 60$, 10 boys and 10 girls for each tertile. Within a row, means that do not share a common subscript differ at $p < .05$, as determined with a Tukey honestly-significant-difference test.

Source: Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P. K. S., & Suma, K. (2015, Jul). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological Science, 26*(7), 1071-1083.

Hirsh-Pasek et al. (2015): Results

Table 6. Changes in Variance Accounted for Depending on the Order in Which Quality and Quantity of Language Are Added to Models With and Without Sensitive Parenting Included

Step and predictor	R^2	ΔR^2	Additional variance accounted for		
			df	*p*	95% CI
Model 1					
1. Communication-foundation-quality ratings	.27	.27	3, 56	.001	[.12, .49]
2. Maternal words per minute	.28	.01	1, 55	.40	[.0, .08]
Model 2					
1. Maternal words per minute	.11	.11	1, 58	.008	[.004, .32]
2. Communication-foundation-quality ratings	.28	.16	3, 55	.010	[.07, .35]
Model 3					
1. Sensitive parenting	.12	.12	1, 58	.007	[.03, .25]
2. Communication-foundation-quality ratings	.30	.18	3, 55	.006	[.07, .38]
3. Maternal words per minute	.30	.003	1, 54	.65	[.0, .06]
Model 4					
1. Sensitive parenting	.12	.12	1, 58	.007	[.03, .25]
2. Maternal words per minute	.16	.04	1, 57	.090	[.0, .19]
3. Communication-foundation-quality ratings	.30	.14	3, 54	.021	[.05, .31]

Note: CI = confidence interval.

Source: Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P. K. S., & Suma, K. (2015, Jul). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological Science, 26*(7), 1071-1083.

Hirsh-Pasek et al. (2015, Psych. Science): Answers

1. Do low-income children who are successful language learners experience a higher quality communication during early mother-child interaction than their less-verbal peers? → yes
2. How important is the quantity of language that children hear, relative to the quality of their communication foundation? → quality is more important than quantity
3. Does the quality of the communication foundation, the quantity of language input, or both, predict subsequent language outcome over and above what is predicted by sensitive parenting? → yes for quality, which is more important than sensitive parenting

Hirsh-Pasek (2019, BPS)

Six principles are important for interventions that try to create high-quality environment to foster language development

1. Children learn what they hear most
2. Children learn words for things that interest them
3. Interactive and responsive environments are important for learning (much current research on this topic)
4. Children learn best in meaningful contexts
5. Children need to hear diverse examples of words and language structures
6. Vocabulary and grammar are reciprocal (vocabulary alone does not help much)

Conclusions

1. The visual word form area supports reading at the level of word recognition, and is implicated in dyslexia/reading difficulties
2. This area in the left fusiform gyrus responds specifically to know words irrespective of font, size, or writing style
3. Beyond the level of word recognition, further components contribute to the development of successful and skilled reading
4. Specifically, the quality of social communication is a key factor that can promote language learning (over and above the quantity of word/language input, or sensitive parenting)
5. Equal education chances are among the top priorities of many societies and educational systems – but the challenge remains how these can be best achieved
6. Where needed, it can be expected that interventions to improve the quality of social communication promote language learning in underprivileged children, and equalize chances by improving language success in children at-risk

Control Questions

1. What is meant by the so-called word superiority effect?
2. Please define and describe the so-called visual word form area (VWFA)?
3. Which properties of the visual word form area do you know (for instance, according to McCandliss et al., 2003)?
4. Which aspects of skilled reading should we differentiate according to Scarborough (2001)? Please discuss for which of these aspects processing within the visual word form area will be relevant!
5. What is meant by the term „30-million-word gap“ in relation to language development in children from families with low socioeconomic status (SES)?
6. Please discuss which aspects of early parent-child communication are relevant for a child´s later language development, following work by Hirsh-Pasek et al. (2015). Consider particularly the relative roles of the quality of parent-child communication, the quantity of language input, and sensitive parenting.
7. Please illustrate (using the study by Hirsh-Pasek et al. (2015) or a different example of your choice) how scientists measure concepts such as the quality and the quantity of verbal parent-child communication, sensitive parenting, socioeconomic status, or expressive language skills in children.

Kontrollfragen

1. Was versteht man unter dem sogenannten Wortüberlegenheitseffekt (word superiority effect)?
2. Was ist das sog. Visuelle Wortform-Areal (visual word form area; VWFA)?
3. Welche Eigenschaften des visuellen Wortform-Areals kennen Sie (beispielsweise nach McCandliss et al., 2003)?
4. Welche Aspekte der trainierten Fähigkeit zu lesen sollten wir nach Scarborough (2001) unterscheiden? Kommentieren Sie, für welche dieser Aspekte die Verarbeitung im visuellen Wortform-Areal relevant ist!
5. Was versteht man unter dem sogenannten „30-million-word gap“ in der Sprachentwicklung von Kindern aus Familien mit geringem sozioökonomischen Status?
6. Diskutieren Sie, welche Aspekte der frühen Eltern-Kind Kommunikation für die spätere Sprachentwicklung entsprechend der Arbeit von Hirsh-Pasek et al. (2015) von Bedeutung sind. Gehen sie dabei besonders auf die relative Bedeutung der Qualität der Eltern-Kind Kommunikation, der Quantität des sprachlichen Inputs, sowie der sensiblen Elternschaft ein.
7. Illustrieren sie bitte (am Beispiel der Studie von Hirsh-Pasek et al. (2015) oder einem anderen Beispiel ihrer Wahl, wie Wissenschaftler Konzepte wie die Qualität und die Quantität sprachlicher Eltern-Kind Kommunikation, sensible Elternschaft, sozioökonomischen Status, sowie expressive Sprachfertigkeiten bei Kindern messen.

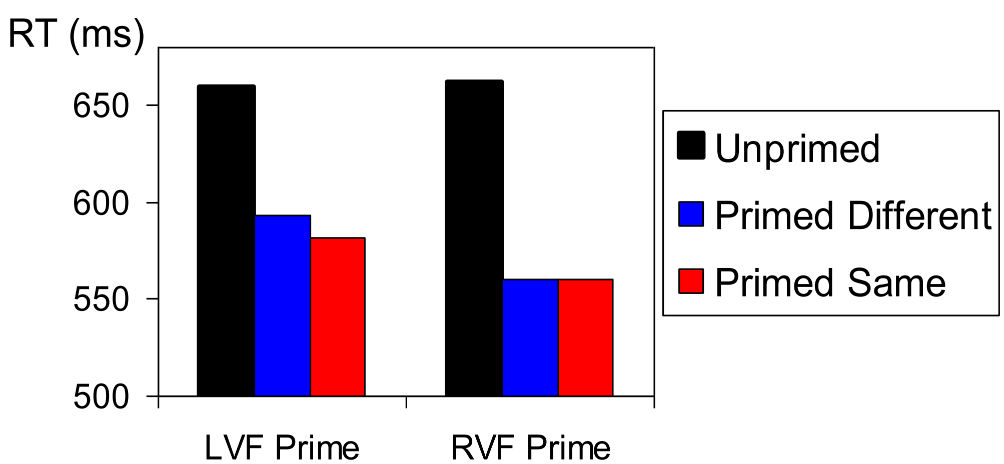
Lateralized Repetition Priming for Names: Font-specific vs. Abstractive Priming

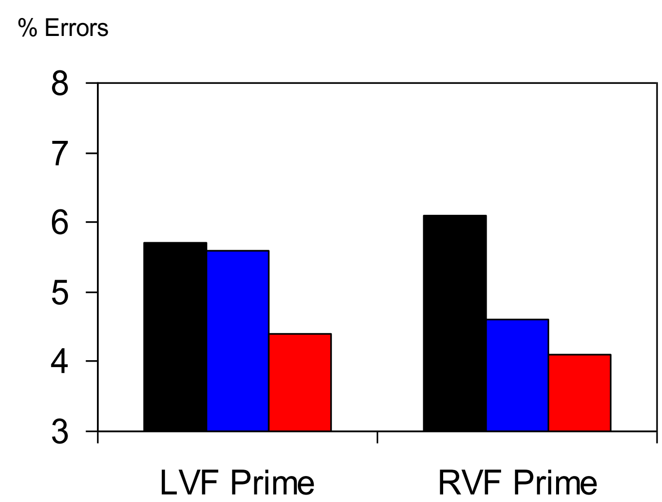
Prime presented to LVF or RVF for 150 ms

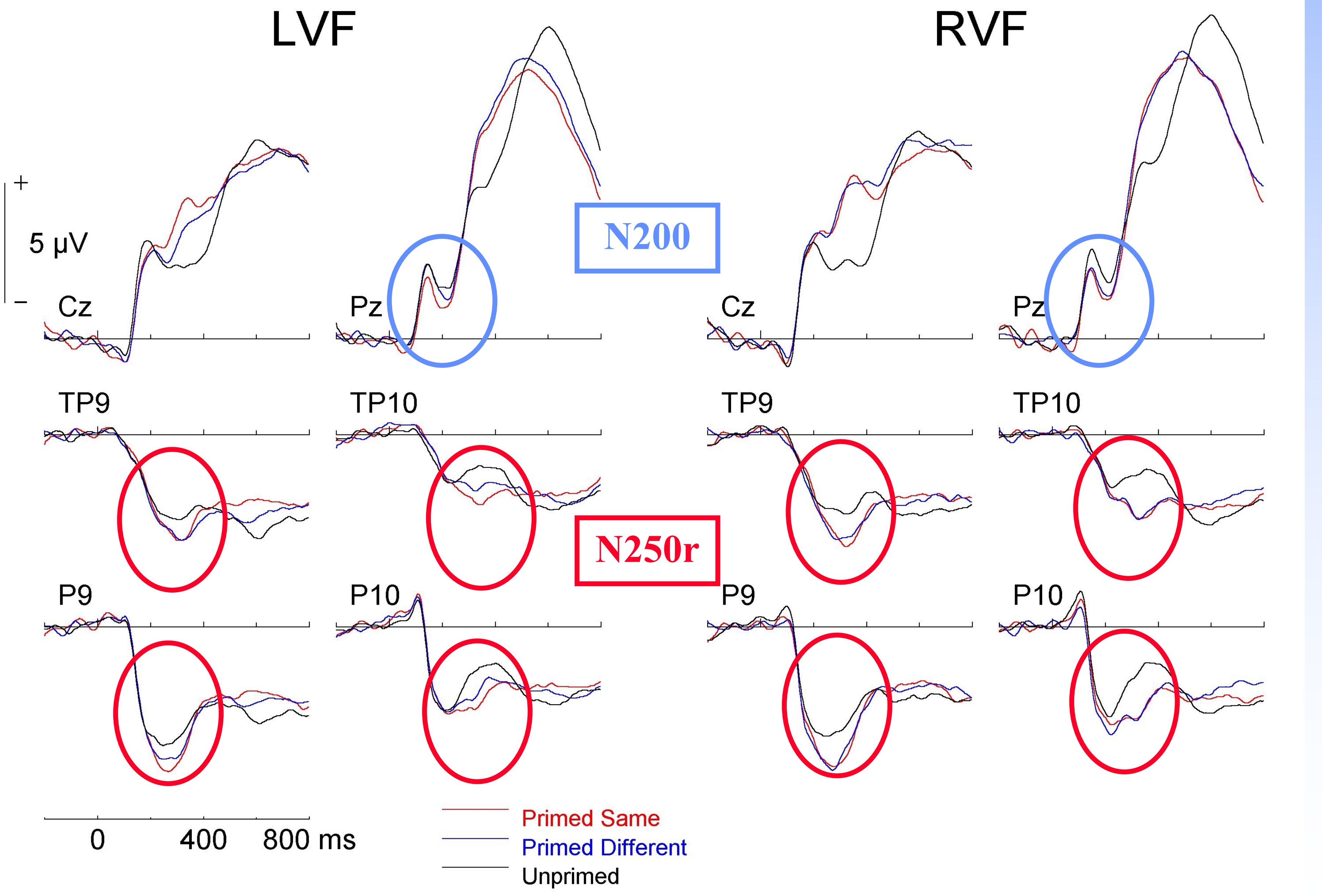
Prime-Target SOA: 1500 ms

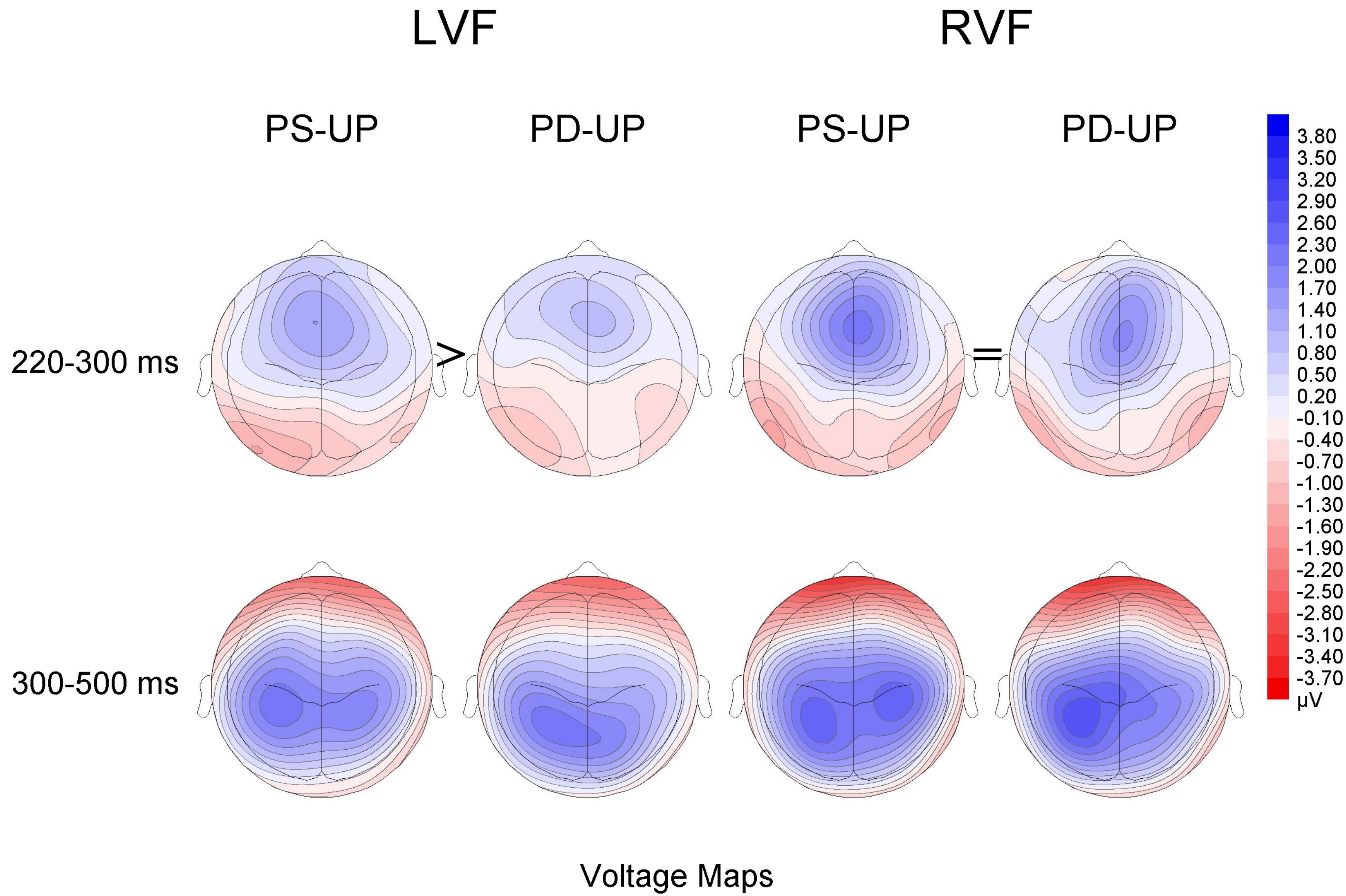
Target presented centrally

Task: Target familiar (yes/no)






LVF
RVF
+
5 µV
−
Cz
Pz
Cz
Pz
N200
TP9
TP10
TP9
TP10
N250r
P9
P10
P9
P10
0
400
800 ms
Primed Same
Primed Different
Unprimed



Source: Schweinberger, S.R., Ramsay, A.L., & Kaufmann, J.M. (2006). Hemispheric asymmetries in font-specific and abstractive priming of written personal names: Evidence from event-related brain potentials. **Brain Research, 1117**, 195-205.

Schlussfolgerungen

- Die rechte Hemisphäre (speziell der rechte fusiforme Gyrus) repräsentiert Stimuli auf bildspezifische Art und Weise und ist eine zentrale Struktur für die Repräsentation von Gesichtern.
- Diese bildspezifische Art der Repräsentation komplexer visueller Stimuli in der RH zeigt sich auch für Wörter.
- Die linke Hemisphäre (spez. der linke fusiforme gyrus) repräsentiert Stimuli auf abstrakte Art und Weise und ist eine zentrale Struktur für die Repräsentation von geschriebenen Worten.
- Diese Ergebnisse bestätigen und erweitern andere Befunde (Marsolek et al., 1992, 1995, 1999, DeHaene et al., 2001)