



Asymmetrical hemisphere activation enhances global–local processing



Philip A. Gable*, Bryan D. Poole, Mary S. Cook

The University of Alabama, United States

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ABSTRACT

Decades of research focusing on the neurophysiological underpinnings related to global–local processing of hierarchical stimuli have associated global processing with the right hemisphere and local processing with the left hemisphere. The current experiment sought to expand this research by testing the causal contributions of hemisphere activation to global–local processing. To manipulate hemisphere activation, participants engaged in contralateral hand contractions. Then, EEG activity and attentional scope were measured. Right-hand contractions caused greater relative left-cortical activity than left-hand contractions. Participants were more narrowly focused after left-hemisphere activation than after right-hemisphere activation. Moreover, N1 amplitudes to local targets in the left hemisphere were larger after left-hemisphere activation than after right-hemisphere activation. Consistent with past research investigating hemispheric asymmetry and attentional scope, the current results suggest that manipulating left (right) hemisphere activity enhanced local (global) attentional processing.

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1. Introduction

For over 20 years, research has examined how we process stimuli comprised of multiple levels of analysis, or hierarchical stimuli (Kimchi, 1992). In a natural environment, hierarchical processing is akin to seeing the forest (global) or the trees (local). The most prominent measure of hierarchical processing is Navon's (1977) global–local letter task, where a large (global) letter is comprised of closely spaced, smaller (local) letters (see Fig. 1). Since Navon's (1977) experiment, much past research has examined the concept of global–local attention (see Förster & Dannenberg, 2010, for a review), but most recently, research has focused on the neurophysiological bases of global and local processing (Lux, Marshall, Thimm, & Fink, 2008; Staudinger, Fink, Mackay, & Lux, 2011).

Broadly, global–local processing is thought to be lateralized in the brain (Volberg, Kliegl, Hanslmayr, & Greenlee, 2009). Specifically, the right central–parietal hemisphere is associated with processing global features of hierarchical stimuli, and the left central–parietal hemisphere is associated with processing local features of hierarchical stimuli (Boksem, Kostermans, Tops, & De Cremer, 2012; Volberg & Hübner, 2004). Evidence supporting these findings comes from research showing that right-hemisphere lesions cause patients to respond slower to global stimuli, and left-hemisphere lesions cause patients to respond slower to local stimuli (Lamb, Robertson, & Knight, 1990; Lux et al., 2003; Robertson, Lamb, & Knight, 1988). Directing attention toward global features of a target causes greater relative right-hemisphere

activation, whereas attention toward local features of a target causes greater relative left-hemisphere activation (Fink et al., 1996, 1997). Also, stimuli activating greater left-hemisphere activity (e.g., appetitive pictures) cause greater local than global attentional scope (Gable & Harmon-Jones, 2010; Harmon-Jones & Gable, 2009).

Recently, Volberg et al. (2009) examined lateralization of attentional scope using the alpha frequency band activity derived from electroencephalography (EEG) recordings, because alpha activity is inversely related to cortical activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998; Davidson, Chapman, Chapman, & Henriques, 1990; Lindsley & Wicke, 1974). Volberg et al. found that fast responses to global features of target stimuli were associated with high alpha power (less cortical activity) in the left hemisphere, whereas fast responses to local features of target stimuli were associated with high alpha power in the right hemisphere. Romei, Thut, Mok, Schyns, and Driver (2012) used rhythmic transcranial magnetic stimulation (TMS) at the alpha band frequency (10 Hz) to impair the left or right parietal hemisphere. TMS bursts to the right parietal hemisphere impaired global processing, whereas TMS bursts to the left parietal hemisphere impaired local processing. Together, this past research suggests that global processing is predominant in the right hemisphere, but local processing is predominant in the left hemisphere.

Although this past work provides support that hierarchical processing is asymmetrically related in the brain, more research investigating the causal role of hemispheric activation needs to be conducted. Romei et al. (2012) causally examined the role of asymmetrical hemispheric deactivation disrupting local or global processing. However, this raises the question of whether the

* Corresponding author.

E-mail address: pagable@gmail.com (P.A. Gable).

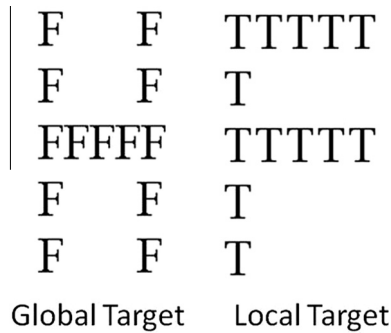


Fig. 1. Examples of the Navon letter stimuli.

converse is also true. That is, does causal activation of the central-parietal cortex facilitate local or global attentional processing?

In the current experiment, we sought to answer this critical question by testing whether activating the hemisphere associated with hierarchical processing facilitates local or global processing and influences neural activity during the processing of such stimuli. To manipulate relative hemisphere activity, we used unilateral hand contractions. Past research has shown that hand contractions cause contra-lateral hemisphere activation over the central-parietal cortex (Harmon-Jones, 2006; Peterson, Shackman, & Harmon-Jones, 2008). Right-hand contractions activate greater left-hemisphere activity (as measured by the inverse of alpha power) than left-hand contractions (Andrew & Pfurtscheller, 1997; Pineda, 2005). Therefore, we predicted that right-hand contractions would cause greater relative left-cortical activation (and vice versa). Moreover, we predicted that hemisphere activation would modulate attentional scope as measured by the Navon (1977) letters task. Specifically, left-hemisphere activation should cause faster responses to local targets than global targets. In contrast, right-hemisphere activation should cause faster responses to global targets than local targets.

Past research has also found that the N1 event-related potential component is a sensitive measure of the processing of global and local stimuli (Poverbio, Minniti, & Zani, 1998; Yamaguchi, Yamagata, & Kobayashi, 2000). Research has also shown that manipulations of a local vs. global attentional scope enhance N1 amplitudes to affective stimuli (Gable & Harmon-Jones, 2011, 2012). Because the N1 is related to global-local attentional processing, we predicted that hemisphere activation would also modulate N1 amplitudes to Navon (1977) letters. Specifically, after left-hemisphere activation, N1 amplitudes should be larger to local targets than global targets. In contrast, after right-hemisphere activation, N1 amplitudes should be larger to global targets than local targets.

2. Method

2.1. Participants and design

Thirty-three (13 female) right-handed introductory psychology students participated in exchange for partial course credit. Handedness was assessed based on participant self-report of hand dominance and behavioral inspection (e.g., writing and button presses).

Hemisphere activity was manipulated using contralateral hand contractions (Harmon-Jones, 2006; Peterson et al., 2008). Participants were instructed to squeeze a 2.8-in.-diameter rubber ball as hard as they could for four 45-s trials, with a 15-s period to relax between each trial. Half the participants (16) squeezed the ball in their left hand. The other half of participants (17) squeezed the ball in their right hand. A between-subjects design was utilized to pre-

vent possible carryover effects from participants squeezing the opposite hand. Left- and right-hand contractions were verified through visual inspection. All participants correctly complied with instructions.

Immediately after hand contractions, participants completed Navon's (1977) letters task to assess attentional scope. The stimuli in the letters task were large letters composed of smaller letters (Fig. 1). Each vertical and horizontal line of a large letter was made up of five closely spaced local letters (e.g., an *H* made up of *F*s). Large letters had a visual angle of 2.29° (height) by 1.15° (width); small letters had a visual angle of 0.57° by 0.29°. Each letter was presented in the center of a 20-in. computer monitor, and was superimposed over a black background. Participants were asked to indicate "as quickly as possible" whether the picture contained the letter *T* or the letter *H* by pressing one of two corresponding buttons on a button box using their thumbs. Local targets were those in which a large *L* or *F* was composed of smaller *T*s or *H*s. Global targets were those in which a *T* or an *H* was composed of smaller *L*s or *F*s. Faster responses to the small than to the large letters indicated a local scope, whereas faster responses to the large than to the small letters indicated a global scope. Navon letters were displayed until participants responded. A 500 ms inter-trial-interval occurred after each letter. Participants completed 32 local- and 32 global-target trials that were pseudo-randomly presented, such that targets of the same type (local or global) or same letter never appeared more than five consecutive times (Gable & Harmon-Jones, 2012).

Data from all 33 participants were included in the EEG asymmetry analyses. Thirteen participants' data (6 in the left-hand squeeze condition, 7 in the right-hand squeeze condition) were excluded from reaction-time and ERP analyses because they did not follow instructions during the letters task (e.g., failure to push the correct button corresponding to the local or global targets). Two participants were excluded from ERP analyses due to equipment failure. Consistent with past research (Gable & Harmon-Jones, 2008, Gable & Harmon-Jones, 2010; Harmon-Jones & Gable, 2009) and guidelines for statistical analyses with reaction time data (Fazio, 1990), reaction times (RT) to local and global targets were logarithmically transformed to normalize the distributions. Incorrect responses and trials with RTs more than 3 standard deviations from the mean (2% right-hand squeeze condition; 3% left-hand squeeze condition) were excluded from analyses.

2.2. EEG assessment and processing

Electroencephalography, recorded with 59 tin electrodes mounted in a stretch lycra cap (Electro-Caps, Eaton, OH), was referenced to the left earlobe. A ground electrode was mounted midway between FPZ and FZ. Electrode impedances were under 5000 Ω and homologous sites were within 1000 Ω of each other. Signals were amplified with Neuroscan SynAmps RT amplifier unit (El Paso, TX), low-pass filtered at 100 Hz, high-pass filtered at 0.05 Hz, notch filtered at 60 Hz, and digitized at 500 Hz. Artifacts (e.g., aberrant signals due to muscle movement or large non-blink eye movements) were removed by hand. Then, a regression-based eye movement correction was applied to remove blinks (Semlitsch, Anderer, Schuster, & Presslich, 1986), after which the data were again visually inspected to ensure proper correction.

2.3. Cortical asymmetry assessment

Power spectra epochs 1.022 s in duration during the four 45 s hand contractions were extracted through a Hamming window (50% taper of distal ends). Data were re-referenced using a common average reference. Consecutive epochs were overlapped by 50% to minimize data loss due to windowing. Consistent with

previous research showing that alpha power is the inverse of cortical activity (Lindsley & Wicke, 1974), power values within the alpha band (8–13 Hz) were obtained using a fast Fourier transformation and aggregated across all four contraction periods. Asymmetry indexes (log right minus log left) were computed for central-parietal sites corresponding to the motor strip (C4/C3, C2/C1, CP4/CP3, CP2/CP1; Pockett, Whalen, McPhail, & Freeman, 2007; Pulvermüller, Härle, & Hummel, 2001). Higher scores indicate greater left-hemisphere activity.

2.4. N1. Assessment

Data were epoched 100 ms before Navon (1977) letter onset until 400 ms after picture onset and re-referenced using a common average reference. Epochs were filtered with a low pass of 35 Hz. Aggregated waveforms for each target type were created and baseline corrected using the pre-stimulus interval. Based on visual inspection of the ERP waveform, N1 amplitude was measured as the minimum amplitude within a window of 50–170 ms (Barry et al., 2004; Jonkman et al., 2000; Pérez-Edgar & Fox, 2005). Because past work has found the N1 to be maximal at midline central-parietal sites (Foti, Hajcak, & Dien, 2009; Gable & Harmon-Jones, 2012; Weinberg & Hajcak, 2010), we examined N1 amplitudes at an index of midline central-parietal sites CPZ and PZ.

3. Results

3.1. Hemisphere activity

To observe the influence of hand contractions on hemisphere activation, we examined alpha power for asymmetry indices at central-parietal sites. Results revealed that right-hand contractions caused greater relative left central-parietal activation than left-hand contractions, $F(1, 31) = 4.76$, $p = .036$, $\eta_p^2 = .13$ (see Fig. 2). Subsequent analyses will refer to the right and left hand-contraction conditions as left- and right-hemisphere activation, respectively.

3.2. Global–local attentional scope

A 2 (hemisphere activation: left or right) \times 2 (target type: local or global) ANOVA revealed a significant interaction, $F(1, 18) = 11.39$, $p = .003$, $\eta_p^2 = .39$ (Fig. 3). Left-hemisphere activation

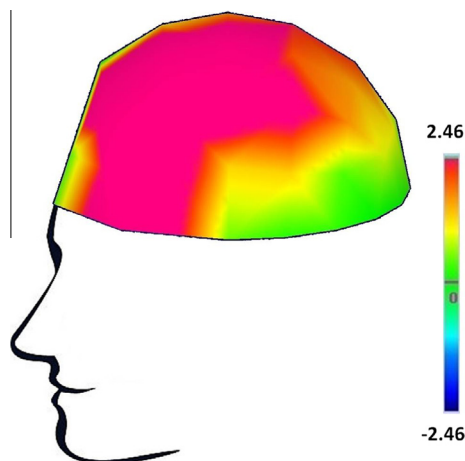


Fig. 2. Distribution of F values between left and right hand-squeeze conditions for relative left-hemisphere activation. Darker (red) areas indicate areas of greater relative activation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

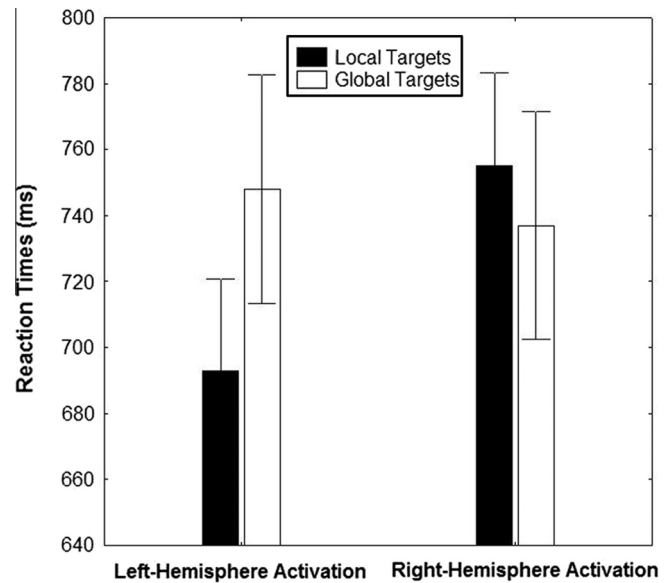


Fig. 3. Reaction times (not logarithmically transformed) for local and global targets as a function of hemisphere activation.

caused participants to respond faster to local targets than global targets, $p = .007$.¹ In contrast, right-hemisphere activation caused participants to respond marginally faster to global targets than local targets, $p = .09$. RTs to local and global targets did not differ between left- and right-hemisphere activation, $ps > .14$. These results suggest that activating the left hemisphere caused a local attentional scope, but activating the right hemisphere caused a global attentional scope.

3.3. N1 Amplitude effects

A 2 (hemisphere activation: left or right) \times 2 (target type: local or global) ANOVA revealed a marginal interaction, $F(1, 16) = 3.41$, $p = .08$, $\eta_p^2 = .18$ (Fig. 4). Left-hemisphere activation caused slightly larger N1 amplitudes to local targets than global targets, $p = .09$. For right-hemisphere activation, N1 amplitudes were similar to local and global targets, $p = .43$. N1 amplitudes to local and global targets did not differ between left- and right-hemisphere activation, $ps > .51$. These results suggest that activating the left hemisphere enhanced early attentional processing of local stimuli but not global stimuli.

4. Discussion

The current experiment found that contralateral hand contractions modulated hemisphere activity and global–local attentional scope. Right-hand contractions caused greater relative left-hemisphere activity, whereas left-hand contractions caused greater relative right-hemisphere activity. Moreover, hemisphere activation enhanced attentional processing: activation of the left hemisphere enhanced local processing, but activation of the right hemisphere enhanced global processing. Hemisphere activation also modulated early neurophysiological measures of attentional processing assessed by N1 amplitudes to Navon (1977) letters. Specifically, N1 amplitudes were larger to local targets after left-hemisphere activation than after right-hemisphere activation.

¹ Errors to local targets were similar between left-hemisphere activation ($M = 0.90$, $SD = 0.99$) and right-hemisphere activation ($M = 1.40$, $SD = 0.97$), $t(18) = 1.14$, $p = .27$. Also, errors to global targets were similar after left-hemisphere activation ($M = 0.60$, $SD = 0.84$) and right-hemisphere activation ($M = 0.80$, $SD = 0.79$) $t(18) = 0.54$, $p = .59$.

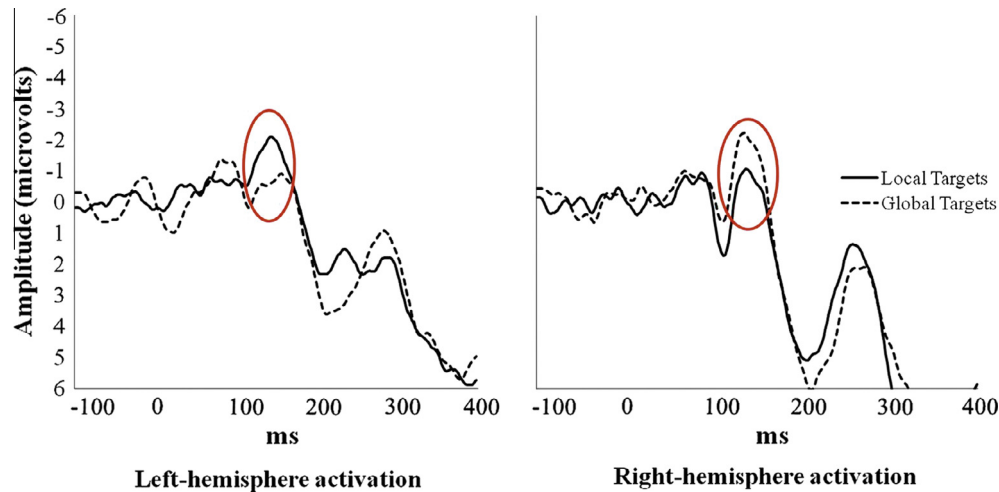


Fig. 4. ERP waveforms to local and global targets in the left- and right-hemisphere activation conditions using an index at CPZ and PZ. Greater (more negative) amplitudes indicate larger N1 amplitudes to local or global targets. N1 component circled.

Contraction of unilateral muscles is associated with activation of the contralateral motor cortex near the central-parietal hemisphere (Andrew & Pfurtscheller, 1997; Harmon-Jones, 2006; Peterson et al., 2008; Pineda, 2005). In addition, activation of the central-parietal cortex is associated with hierarchical attentional processing (Boksem et al., 2012; Volberg & Hübner, 2004). Asymmetric activation of the sensory-motor cortex likely spread to nearby regions in the central-parietal cortex related to hierarchical processing. For example, spreading of activation from the contralateral motor cortex has been demonstrated to extend to even more distant areas of cortex, such as the dorsolateral prefrontal cortex (Harmon-Jones, 2006; Peterson et al., 2008; Schiff & Lamon, 1989, 1994). Research has suggested that this spreading of activation may be caused by coherence between regions connected by white matter tracts (Peterson et al., 2008; Thatcher, Krause, & Hrybyk, 1986).

The association between hand-dominance and hierarchical processing may have functional adaptations. For example, right-hand dominant individuals use the right hand for most detailed and sensitive sensory-motor activities (e.g., writing). Activating left central-parietal cortical areas through these activities may enhance local attentional processing. Greater local processing may facilitate greater task focus and attention to detail, thereby benefiting performance. Future research should more directly investigate the potential interaction of hemispheric activation and local vs. global perception on behavioral processes.

In sum, results from the current experiment demonstrate that activation of the left hemisphere facilitates local processing, but activation of the right hemisphere facilitates global processing. Consistent with past research, the current experiment supports that local processing is associated with the left hemisphere, but global processing is associated with the right hemisphere (Lamb et al., 1990; Lux et al., 2003; Robertson et al., 1988; Stone & Tesche, 2009; Volberg & Hübner, 2004; Volberg et al., 2009). However, these results extend this past work by showing that causal manipulations enhancing hemisphere activity facilitate ipsilateral processing of global or local stimuli.

References

- Andrew, C., & Pfurtscheller, G. (1997). On the existence of different alpha band rhythms in the hand area of man. *Neuroscience Letters*, 222, 103–106.
- Barry, R. J., Rushby, J. A., Johnstone, S. J., Clarke, A. R., Croft, R. J., & Lawrence, C. A. (2004). Event-related potentials in the auditory oddball as a function of EEG alpha phase at stimulus onset. *Clinical Neurophysiology*, 115, 2593–2601.

- Boksem, M. A., Kostermans, E., Tops, M., & De Cremer, D. (2012). Individual differences in asymmetric resting-state frontal cortical activity modulate ERPs and performance in a global-local attention task. *Journal of Psychophysiology*, 26(2), 51–62.
- Cook, I. A., O'Hara, R. O., Uijtdehaage, S. H. J., Mandelkern, M., & Leuchter, A. F. (1998). Assessing the accuracy of topographic EEG mapping for determining local brain function. *Electroencephalography and Clinical Neurophysiology*, 107(6), 408–414.
- Davidson, R. J., Chapman, J. P., Chapman, L. J., & Henriques, J. B. (1990). Asymmetrical brain electrical activity discriminates between psychometrically-matched verbal and spatial cognitive tasks. *Psychophysiology*, 27(5), 528–543.
- Fazio, R. H. (1990). A practical guide to the use of response latencies in social psychological research. In C. Hendrick & M. S. Clark (Eds.), *Review of personality and social psychology* (Vol. 11, pp. 74–97). Newbury Park, CA: Sage.
- Fink, G. R., Halligan, P. W., Marshall, J. C., Frith, C. D., Frackowiak, R. S. J., & Dolan, R. J. (1996). Where in the brain does visual attention select the forest and the trees? *Nature*, 382, 626–628.
- Fink, G. R., Halligan, P. W., Marshall, J. C., Frith, C. D., Frackowiak, R. S. J., & Dolan, R. J. (1997). Neural mechanisms involved in the processing of global and local aspects of hierarchically organized visual stimuli. *Brain*, 120, 1779–1791.
- Förster, J., & Dannenberg, L. (2010). GLOMOsys: A systems account of global versus local processing. *Psychological Inquiry*, 21(3), 175–197.
- Foti, D., Hajcak, D., & Dien, J. (2009). Differentiating neural responses to emotional pictures: Evidence from temporal-spatial PCA. *Psychophysiology*, 46, 521–530.
- Gable, P. A., & Harmon-Jones, E. (2008). Approach-motivated positive affect reduces breadth of attention. *Psychological Science*, 19, 476–482.
- Gable, P. A., & Harmon-Jones, E. (2010). Late positive potential to appetitive stimuli and local attentional bias. *Emotion*, 10(3), 441–446.
- Gable, P. A., & Harmon-Jones, E. (2011). Attentional states influence early neural responses associated with motivational processes: Local vs. global attentional scope and N1 amplitude to appetitive stimuli. *Biological Psychology*, 87, 303–305.
- Gable, P. A., & Harmon-Jones, E. (2012). Reducing attentional capture of emotion by broadening attention: Increased global attention reduces early electrophysiological responses to negative stimuli. *Biological Psychology*, 90, 150–153.
- Harmon-Jones, E. (2006). Unilateral right-hand contractions cause contralateral alpha power suppression and approach motivational affective experience. *Psychophysiology*, 43, 598–603.
- Harmon-Jones, E., & Gable, P. A. (2009). Neural activity underlying the effect of approach-motivated positive affect on narrowed attention. *Psychological Science*, 20(4), 406–409.
- Jonkman, L. M., Kemner, C., Verbaten, M. N., Van Engeland, H., Camfferman, G., Buitelaar, J. K., et al. (2000). Attentional capacity, a probe ERP study: Differences between children with attention-deficit hyperactivity disorder and normal control children and effects of methylphenidate. *Psychophysiology*, 37, 334–346.
- Kimchi, R. (1992). Primacy of wholistic processing and global/local paradigm: A critical review. *Psychological Bulletin*, 112(1), 24–38.
- Lamb, M. R., Robertson, L. C., & Knight, R. T. (1990). Component mechanisms underlying the processing of hierarchically organized patterns: Inferences from patients with unilateral cortical lesions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16(3), 471–483.
- Lindsley, D. B., & Wicke, J. D. (1974). The electroencephalogram: Autonomous electrical activity in man and animals. In R. Thompson & M. N. Patterson (Eds.), *Bioelectric recording techniques* (pp. 3–79). New York: Academic Press.
- Lux, S., Marshall, J. C., Ritzl, A., Weiss, P. H., Pietrzyk, U., Shah, N. J., et al. (2003). A functional magnetic resonance imaging study of local/global processing with

- stimuli presentation in the peripheral visual hemifields. *Neuroscience*, 124, 113–120.
- Lux, S., Marshall, J. C., Thimm, M., & Fink, G. R. (2008). Differential processing of hierarchical visual stimuli in young and older healthy adults: Implications for pathology. *Cortex*, 44(1), 21–28.
- Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology*, 9, 353–383.
- Pérez-Edgar, K., & Fox, N. A. (2005). A behavioral and electrophysiological study of children's selective attention under neutral and affective conditions. *Journal of Cognition and Development*, 6(1), 89–118.
- Peterson, C. K., Shackman, A. J., & Harmon-Jones, E. (2008). The role of asymmetrical frontal cortical activity in aggression. *Psychophysiology*, 45, 86–92.
- Pineda, J. A. (2005). The functional significance of mu rhythms: Translating "seeing" and "hearing" into "doing". *Brain Research Reviews*, 50, 57–68.
- Pockett, S., Whalen, S., McPhail, A. V. H., & Freeman, W. J. (2007). Topography, independent component analysis and dipole source analysis of movement related potentials. *Cognitive, Neurodynamics*, 1(4), 327–340.
- Poverbio, A. M., Minniti, A., & Zani, A. (1998). Electrophysiological evidence of a perceptual precedence of global vs. local visual information. *Cognitive Brain Research*, 6(4), 321–334.
- Pulvermüller, F., Härle, M., & Hummel, F. (2001). Walking or talking?: Behavioral and neurophysiological correlates of action verb processing. *Brain and Language*, 78, 143–168.
- Robertson, L. C., Lamb, M. R., & Knight, R. T. (1988). Effects of lesions of temporal-parietal junction on perceptual and attentional processing in humans. *The Journal of Neuroscience*, 8(10), 3757–3769.
- Romei, V., Thut, G., Mok, R. M., Schyns, P. G., & Driver, J. (2012). Causal implication by rhythmic transcranial magnetic stimulation of alpha frequency in feature-based local vs. global attention. *European Journal of Neuroscience*, 35(6), 968–974.
- Schiff, B. B., & Lamon, M. (1989). Inducing emotion by unilateral contraction of facial muscles: A new look at hemispheric specialization and the experience of emotion. *Neuropsychologia*, 27, 923–935.
- Schiff, B. B., & Lamon, M. (1994). Inducing emotion by unilateral contraction of hand muscles. *Cortex*, 30, 247–254.
- Semlitsch, H. V., Anderer, P., Schuster, P., & Presslich, O. (1986). A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. *Psychophysiology*, 23(6), 695–703.
- Staudinger, M. R., Fink, G. R., Mackay, C. E., & Lux, S. (2011). Gestalt perception and the decline of global precedence in older subjects. *Cortex*, 47(7), 854–862.
- Stone, D. B., & Tesche, C. D. (2009). Transcranial direct current stimulation modulates shifts in global/local attention. *Neuroreport*, 20(12), 1115–1119.
- Thatcher, R. W., Krause, P. J., & Hrybyk, M. (1986). Cortico-cortical associations and EEG coherence: A two-compartmental model. *Electroencephalography and Clinical Neurophysiology*, 64, 123–143.
- Volberg, G., & Hübner, R. (2004). On the role of response conflicts and stimulus position for hemispheric differences in global/local processing: An ERP study. *Neuropsychologia*, 42, 1805–1813.
- Volberg, G., Kliegl, K., Hanslmayr, S., & Greenlee, M. W. (2009). EEG alpha oscillations in the preparation for global and local processing predict behavioral performance. *Human Brain Mapping*, 30(7), 2173–2183.
- Weinberg, A., & Hajcak, G. (2010). Beyond good and evil: The time-course of neural activity elicited by specific picture content. *Emotion*, 10(6), 767–782.
- Yamaguchi, S., Yamagata, S., & Kobayashi, S. (2000). Cerebral asymmetry of the "top-down" allocation of attention to global and local features. *The Journal of Neuroscience*, 20, 1–5.