COMPSCI-773
Literature review/Experimental protocol design

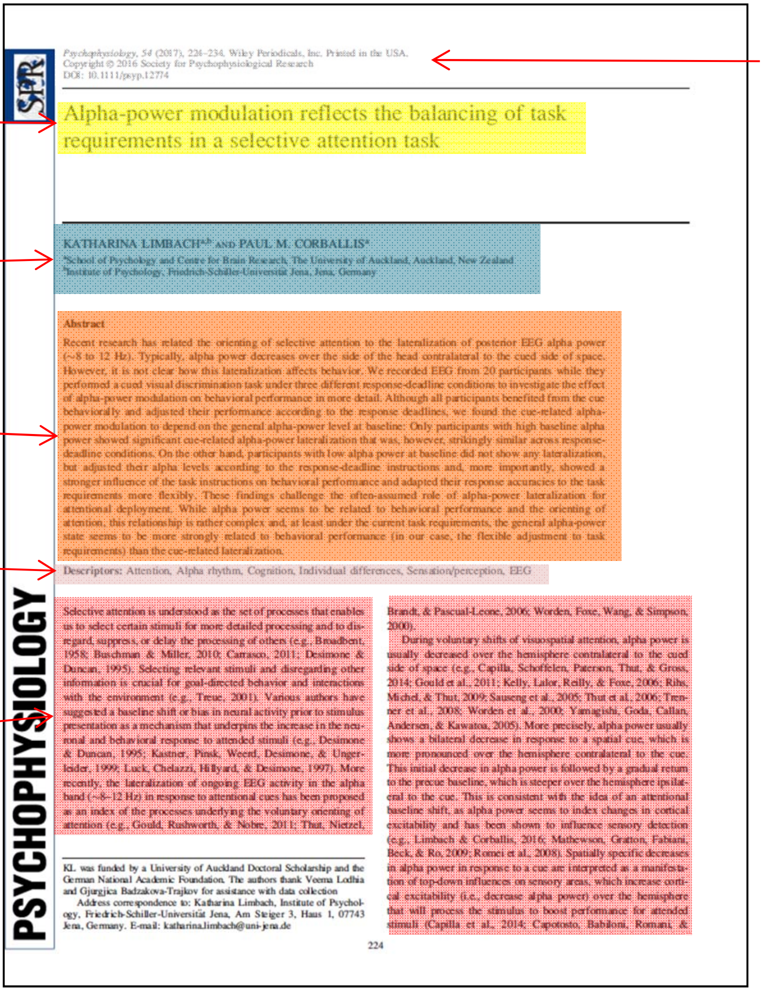
Slides:

Patrice Delmas/Paul Corbalis

Literature review

1. Decide on a topic
2. Identify the literature to review
3. Analyse the literature
4. Use maps/tables to roughly summarize the literature
5. Synthetize your notes along the nodes created in item 4.
6. Write the review

Anatomy of a Journal Article



Citation and DOI

Title

Authors and Affiliations

Abstract

Key Words/Descriptors

Introduction/Literature Review

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PSYCHOPHYSIOLOGY

Alpha-power modulation reflects the balancing of task requirements in a selective attention task

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Abstract

Recent research has related the orienting of selective attention to the lateralization of posterior EEG alpha power (~8 to 12 Hz). Typically, alpha power decreases over the side of the head contralateral to the cued side of space. However, it is not clear how this lateralization affects behavior. We recorded EEG from 20 participants while they performed a cued visual discrimination task under three different response-deadline conditions to investigate the effect of alpha-power modulation on behavioral performance in more detail. Although all participants benefited from the cue behaviorally and adjusted their performance according to the response deadlines, we found the cue-related alpha-power modulation to depend on the general alpha-power level at baseline: Only participants with high baseline alpha power showed significant cue-related alpha-power lateralization that was, however, strikingly similar across response-deadline conditions. On the other hand, participants with low alpha power at baseline did not show any lateralization, but adjusted their alpha levels according to the response-deadline instructions and, more importantly, showed a stronger influence of the task instructions on behavioral performance and adapted their response accuracies to the task requirements more flexibly. These findings challenge the often-assumed role of alpha-power lateralization for attentional deployment. While alpha power seems to be related to behavioral performance and the orienting of attention, this relationship is rather complex and, at least under the current task requirements, the general alpha-power state seems to be more strongly related to behavioral performance (in our case, the flexible adjustment to task requirements) than the cue-related lateralization.

Descriptors: Attention, Alpha rhythm, Cognition, Individual differences, Sensation/perception, EEG

Selective attention is understood as the set of processes that enables us to select certain stimuli for more detailed processing and to disregard, suppress, or delay the processing of others (e.g., Broadbent, 1958; Buschman & Miller, 2010; Carrasco, 2011; Desimone & Duncan, 1995). Selecting relevant stimuli and disregarding other information is crucial for goal-directed behavior and interactions with the environment (e.g., Treue, 2001). Various authors have suggested a baseline shift or bias in neural activity prior to stimulus presentation as a mechanism that underpins the increase in the neuronal and behavioral response to attended stimuli (e.g., Desimone & Duncan, 1995; Kastner, Pinsk, Weerd, Desimone, & Ungerleider, 1999; Luck, Chelazzi, Hillyard, & Desimone, 1997). More recently, the lateralization of ongoing EEG activity in the alpha band (~8–12 Hz) in response to attentional cues has been proposed as an index of the processes underlying the voluntary orienting of attention (e.g., Gould, Rushworth, & Nobre, 2011; Thut, Nietzel, Brandt, & Pascual-Leone, 2006; Worden, Foxe, Wang, & Simpson, 2000).

During voluntary shifts of visuospatial attention, alpha power is usually decreased over the hemisphere contralateral to the cued side of space (e.g., Capilla, Schoffelen, Paterson, Thut, & Gross, 2014; Gould et al., 2011; Kelly, Lalor, Reilly, & Foxe, 2006; Rihs, Michel, & Thut, 2009; Sauseng et al., 2005; Thut et al., 2006; Trenner et al., 2008; Worden et al., 2000; Yamagishi, Goda, Callan, Andersen, & Kawatoa, 2005). More precisely, alpha power usually shows a bilateral decrease in response to a spatial cue, which is more pronounced over the hemisphere contralateral to the cue. This initial decrease in alpha power is followed by a gradual return to the precue baseline, which is steeper over the hemisphere ipsilateral to the cue. This is consistent with the idea of an attentional baseline shift, as alpha power seems to index changes in cortical excitability and has been shown to influence sensory detection (e.g., Limbach & Corballis, 2016; Mathewson, Gratton, Fabiani, Beck, & Ro, 2009; Romei et al., 2008). Spatially specific decreases in alpha power in response to a cue are interpreted as a manifestation of top-down influences on sensory areas, which increase cortical excitability (i.e., decrease alpha power) over the hemisphere that will process the stimulus to boost performance for attended stimuli (Capilla et al., 2014; Capotosto, Babiloni, Romani, &

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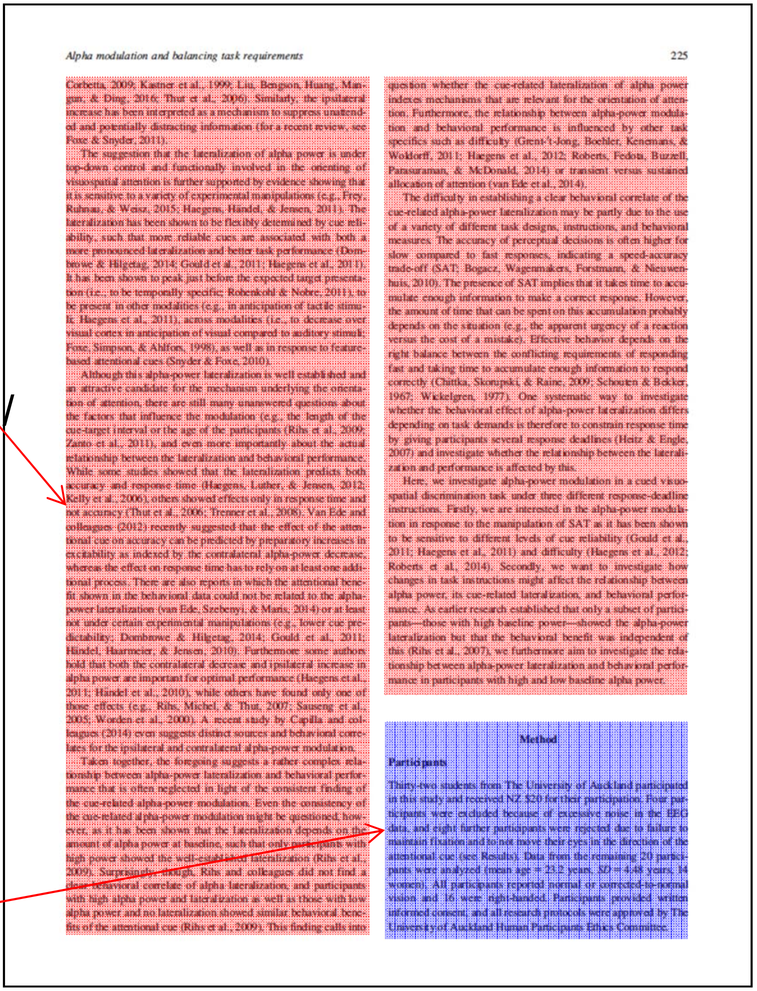

Alpha modulation and balancing task requirements 225

Corbetta, 2009; Kastner et al., 1999; Liu, Bengson, Huang, Mangun, & Ding, 2016; Thut et al., 2006). Similarly, the ipsilateral increase has been interpreted as a mechanism to suppress unattended and potentially distracting information (for a recent review, see Foxe & Snyder, 2011).

The suggestion that the lateralization of alpha power is under top-down control and functionally involved in the orienting of visuospatial attention is further supported by evidence showing that it is sensitive to a variety of experimental manipulations (e.g., Frey, Ruhnau, & Weisz, 2015; Haegens, Händel, & Jensen, 2011). The lateralization has been shown to be flexibly determined by cue reliability, such that more reliable cues are associated with both a more pronounced lateralization and better task performance (Dombrowe & Hilgetag, 2014; Gould et al., 2011; Haegens et al., 2011). It has been shown to peak just before the expected target presentation (i.e., to be temporally specific; Rohenkohl & Nobre, 2011), to be present in other modalities (e.g., in anticipation of tactile stimuli; Haegens et al., 2011), across modalities (i.e., to decrease over visual cortex in anticipation of visual compared to auditory stimuli; Foxe, Simpson, & Ahlfors, 1998), as well as in response to feature-based attentional cues (Snyder & Foxe, 2010).

Although this alpha-power lateralization is well established and an attractive candidate for the mechanism underlying the orientation of attention, there are still many unanswered questions about the factors that influence the modulation (e.g., the length of the cue-target interval or the age of the participants (Rihs et al., 2009; Zanto et al., 2011), and even more importantly about the actual relationship between the lateralization and behavioral performance. While some studies showed that the lateralization predicts both accuracy and response time (Haegens, Luther, & Jensen, 2012; Kelly et al., 2006), others showed effects only in response time and not accuracy (Thut et al., 2006; Trenner et al., 2008). Van Ede and colleagues (2012) recently suggested that the effect of the attentional cue on accuracy can be predicted by preparatory increases in excitability as indexed by the contralateral alpha-power decrease, whereas the effect on response time has to rely on at least one additional process. There are also reports in which the attentional benefit shown in the behavioral data could not be related to the alpha-power lateralization (van Ede, Szebenyi, & Maris, 2014) or at least not under certain experimental manipulations (e.g., lower cue predictability; Dombrowe & Hilgetag, 2014; Gould et al., 2011; Händel, Haarmeier, & Jensen, 2010). Furthermore some authors hold that both the contralateral decrease and ipsilateral increase in alpha power are important for optimal performance (Haegens et al., 2011; Händel et al., 2010), while others have found only one of those effects (e.g., Rihs, Michel, & Thut, 2007; Sauseng et al., 2005; Worden et al., 2000). A recent study by Capilla and colleagues (2014) even suggests distinct sources and behavioral correlates for the ipsilateral and contralateral alpha-power modulation.

Taken together, the foregoing suggests a rather complex relationship between alpha-power lateralization and behavioral performance that is often neglected in light of the consistent finding of the cue-related alpha-power modulation. Even the consistency of the cue-related alpha-power modulation might be questioned, however, as it has been shown that the lateralization depends on the amount of alpha power at baseline, such that only participants with high power showed the well-established lateralization (Rihs et al., 2009). Surprisingly, though, Rihs and colleagues did not find a clear behavioral correlate of alpha lateralization, and participants with high alpha power and lateralization as well as those with low alpha power and no lateralization showed similar behavioral benefits of the attentional cue (Rihs et al., 2009). This finding calls into question whether the cue-related lateralization of alpha power indexes mechanisms that are relevant for the orientation of attention. Furthermore, the relationship between alpha-power modulation and behavioral performance is influenced by other task specifics such as difficulty (Grent-'t-Jong, Boehler, Kenemans, & Woldorff, 2011; Haegens et al., 2012; Roberts, Fedota, Buzzell, Parasuraman, & McDonald, 2014) or transient versus sustained allocation of attention (van Ede et al., 2014).

The difficulty in establishing a clear behavioral correlate of the cue-related alpha-power lateralization may be partly due to the use of a variety of different task designs, instructions, and behavioral measures. The accuracy of perceptual decisions is often higher for slow compared to fast responses, indicating a speed-accuracy trade-off (SAT; Bogacz, Wagenmakers, Forstmann, & Nieuwenhuis, 2010). The presence of SAT implies that it takes time to accumulate enough information to make a correct response. However, the amount of time that can be spent on this accumulation probably depends on the situation (e.g., the apparent urgency of a reaction versus the cost of a mistake). Effective behavior depends on the right balance between the conflicting requirements of responding fast and taking time to accumulate enough information to respond correctly (Chittka, Skorupski, & Raine, 2009; Schouten & Bekker, 1967; Wickelgren, 1977). One systematic way to investigate whether the behavioral effect of alpha-power lateralization differs depending on task demands is therefore to constrain response time by giving participants several response deadlines (Heitz & Engle, 2007) and investigate whether the relationship between the lateralization and performance is affected by this.

Here, we investigate alpha-power modulation in a cued visuospatial discrimination task under three different response-deadline instructions. Firstly, we are interested in the alpha-power modulation in response to the manipulation of SAT as it has been shown to be sensitive to different levels of cue reliability (Gould et al., 2011; Haegens et al., 2011) and difficulty (Haegens et al., 2012; Roberts et al., 2014). Secondly, we want to investigate how changes in task instructions might affect the relationship between alpha power, its cue-related lateralization, and behavioral performance. As earlier research established that only a subset of participants—those with high baseline power—showed the alpha-power lateralization but that the behavioral benefit was independent of this (Rihs et al., 2007), we furthermore aim to investigate the relationship between alpha-power lateralization and behavioral performance in participants with high and low baseline alpha power.

Method

Participants

Thirty-two students from The University of Auckland participated in this study and received NZ $20 for their participation. Four participants were excluded because of excessive noise in the EEG data, and eight further participants were rejected due to failure to maintain fixation and to not move their eyes in the direction of the attentional cue (see Results). Data from the remaining 20 participants were analyzed (mean age = 23.2 years, *SD* = 4.48 years, 14 women). All participants reported normal or corrected-to-normal vision and 16 were right-handed. Participants provided written informed consent, and all research protocols were approved by The University of Auckland Human Participants Ethics Committee.

Introduction/ Literature Review

Method

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Figure 1. Experimental task. The placeholders were positioned at 2° below and 5.5° to the left and right of fixation. The edges of the target and mask spanned 0.5° visual angle. Participants had to indicate via button press whether the gap in the target was on the left or right. The cue indicated the correct target location in 80% of the trials. Figure not drawn to scale.

Stimulation and Procedure

Participants were seated in an electrically shielded, darkened booth. Experimental stimuli were presented on a 21-inch LCD (60 Hz refresh rate) monitor using E-Prime 2.0 Professional presentation software (Psychology Software Tools Inc., Pittsburgh, PA). The monitor was positioned at 57 cm in front of the participant, and the viewing distance was maintained by a chin rest.

Participants completed 15 blocks of a spatially cued discrimination task under three different response deadlines. Participants were instructed to maintain fixation on a central fixation cross that was displayed throughout the trial. The outlines of two squares (positioned 2° below and 5.5° to the left and right of fixation; size 1.5° × 1.5° visual angle; see Figure 1) in the lower left and lower right visual field also remained present throughout the trial and served as placeholders for the targets. Each trial started with the presentation of the fixation array (fixation cross and two placeholders). After 250 ms, an arrowhead appeared for 170 ms on either the left or right leg of the fixation cross and pointed to one of the placeholders. The subsequent cue-target interval, during which the participants were instructed to covertly shift their attention to the cued location, lasted for a randomized time between 1,000 and 1,500 ms. The target was then presented for 50 ms. The target was a modified Landolt C, a stimulus that is often used in the assessment of visual acuity (Landolt, 1889). The Landolt Cs used here were the outline of a square (0.5° × 0.5°) that had a small gap (0.1°) either on the left or the right side. Following the target-mask interval of 50 ms, the unbroken outline of the square was presented for 100 ms and served as the mask to interfere with target discrimination (see Figure 1 for a schematic representation of the stimuli and timing). Participants had to indicate via button press on a standard keyboard whether the opening was on the left or right side of the target square during the following response interval (index fingers of left and right hand for opening on the left or right side, respectively). If the participant did not respond fast enough, a warning to respond faster was presented for 400 ms prior to the intertrial interval (1,000 ms, blank screen). The cue pointed to the left and the right on half of the trials and was valid in 80% of the trials (i.e., when the cue pointed to the left, the target appeared at that location on 80% of the trials and at the opposite, right, location on 20% of the trials). The target was equally likely to be open to the left and the right, and the side of the opening was determined independently of its location on the screen. Therefore, the cue only indicated the target location (left or right placeholder) but not response (i.e., the side of the gap). The stimuli were black and presented on a light gray background (luminance: 23.6 cd/m²).

Response-deadline instructions (three levels, see below) varied between blocks. Each block started with an instruction of whether participants had either the longest, intermediate, or shortest time to respond in the upcoming block. These are referred to as the *slow*, *medium*, and *fast* block. At the beginning of the experiment, participants were instructed verbally that, during the blocks in which they had the longest time to respond, they should focus on making an accurate response, whereas they should focus on making a fast response during the blocks in which they had the least time to respond. Participants received a warning ("Too slow, respond faster") when their response time was longer than the deadline in the current block and received feedback on their performance (%corr) twice within a block. The feedback was presented for 5 s and reinstated the response-deadline instruction that they should either focus on accuracy, speed, or both in the current block.

The response deadline for the slow block was 1,000 ms for all participants. Response deadlines for the medium and fast blocks were determined individually according to performance in two practice blocks before the experiment. The median response time in the two practice blocks plus 50 ms was taken as the deadline for the medium blocks, and the median of the fastest 50% trials was taken as the deadline for the fast blocks (25% fastest trials). The minimum deadline in the fast blocks was 450 ms, and deadlines were adjusted so that they differed by at least 50 ms between the fast and medium blocks. On average, the deadline for the medium blocks was 671.25 ms (*SD* = 92.22) and 570.13 ms (*SD* = 71.36) in the fast blocks (see Figure 2 for median response times per response deadline condition). Participants completed five blocks of 40 trials each per deadline (600 trials in total, 200 per response deadline). There were self-paced breaks (with a minimum duration of 30 s) between blocks, and each block started with a 10-s countdown during which participants were instructed to settle into the chin rest and to get ready for the task.

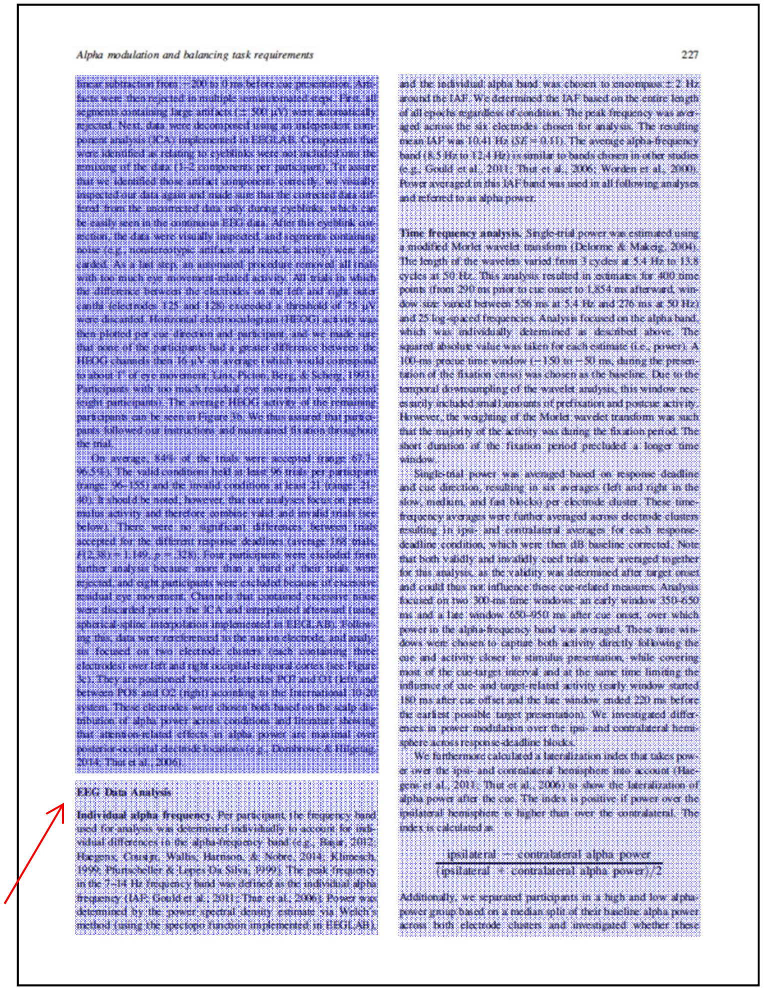
Before the practice blocks and the start of the experiment, participants were given both written and verbal instructions. They were especially instructed not to move their eyes but to covertly shift their attention to either the left or the right placeholder. Trials in which participants failed to respond or did not respond between 260 to 1,200 ms (on average 0.4% of trials) were excluded from further analysis. The duration of the experiment was approximately 1 h, depending on the duration of the self-paced breaks.

Electrophysiological Recording and Preprocessing

The EEG was recorded using a 128-sensor Geodesic Sensor Net and Net Amps 300 amplifiers (Electrical Geodesics Inc., EGI, Eugene, OR). It was digitized at 250 Hz and acquired with respect to the vertex electrode. Individual sensor impedance was kept below 40 kΩ and measured both prior and half way through the experiment. Offline, the data were analyzed using the EEGLAB toolbox (Delorme & Makeig, 2004) and custom-written scripts for MATLAB (The Math Works Inc., Natick, MA). Continuous EEG was first digitally high-pass filtered at 0.1 Hz using a finite impulse response filter.

The continuous EEG was segmented into 2,710-ms segments, starting 600 ms before cue presentation. Each segment contained the cue, target, and mask presentation regardless of the length of the cue-target interval. Segments were first baseline corrected via

Results



linear subtraction from −200 to 0 ms before cue presentation. Artifacts were then rejected in multiple semiautomated steps. First, all segments containing large artifacts (± 500 µV) were automatically rejected. Next, data were decomposed using an independent component analysis (ICA) implemented in EEGLAB. Components that were identified as relating to eyeblinks were not included into the remixing of the data (1–2 components per participant). To assure that we identified those artifact components correctly, we visually inspected our data again and made sure that the corrected data differed from the uncorrected data only during eyeblinks, which can be easily seen in the continuous EEG data. After this eyeblink correction, the data were visually inspected, and segments containing noise (e.g., nonstereotypic artifacts and muscle activity) were discarded. As a last step, an automated procedure removed all trials with too much eye movement-related activity. All trials in which the difference between the electrodes on the left and right outer canthi (electrodes 125 and 128) exceeded a threshold of 75 µV were discarded. Horizontal electrooculogram (HEOG) activity was then plotted per cue direction and participant, and we made sure that none of the participants had a greater difference between the HEOG channels then 16 µV on average (which would correspond to about 1° of eye movement; Lins, Picton, Berg, & Scherg, 1993). Participants with too much residual eye movement were rejected (eight participants). The average HEOG activity of the remaining participants can be seen in Figure 3b. We thus assured that participants followed our instructions and maintained fixation throughout the trial.

On average, 84% of the trials were accepted (range 67.7–96.5%). The valid conditions hold at least 96 trials per participant (range: 96–155) and the invalid conditions at least 21 (range: 21–40). It should be noted, however, that our analyses focus on prestimulus activity and therefore combine valid and invalid trials (see below). There were no significant differences between trials accepted for the different response deadlines (average 168 trials, $F(2,38) = 1.149$, $p = .328$). Four participants were excluded from further analysis because more than a third of their trials were rejected, and eight participants were excluded because of excessive residual eye movement. Channels that contained excessive noise were discarded prior to the ICA and interpolated afterward (using spherical-spline interpolation implemented in EEGLAB). Following this, data were rereferenced to the nasion electrode, and analysis focused on two electrode clusters (each containing three electrodes) over left and right occipital-temporal cortex (see Figure 3c). They are positioned between electrodes PO7 and O1 (left) and between PO8 and O2 (right) according to the International 10-20 system. These electrodes were chosen both based on the scalp distribution of alpha power across conditions and literature showing that attention-related effects in alpha power are maximal over posterior-occipital electrode locations (e.g., Dombrowe & Hilgetag, 2014; Thut et al., 2006).

EEG Data Analysis

Individual alpha frequency. Per participant, the frequency band used for analysis was determined individually to account for individual differences in the alpha-frequency band (e.g., Bajar, 2012; Haegens, Cousijn, Wallis, Harrison, & Nobre, 2014; Klimesch, 1999; Pfurtscheller & Lopes Da Silva, 1999). The peak frequency in the 7–14 Hz frequency band was defined as the individual alpha frequency (IAF; Gould et al., 2011; Thut et al., 2006). Power was determined by the power spectral density estimate via Welch's method (using the spectopo function implemented in EEGLAB), and the individual alpha band was chosen to encompass ± 2 Hz around the IAF. We determined the IAF based on the entire length of all epochs regardless of condition. The peak frequency was averaged across the six electrodes chosen for analysis. The resulting mean IAF was 10.41 Hz ($SE = 0.11$). The average alpha-frequency band (8.5 Hz to 12.4 Hz) is similar to bands chosen in other studies (e.g., Gould et al., 2011; Thut et al., 2006; Worden et al., 2000). Power averaged in this IAF band was used in all following analyses and referred to as alpha power.

Time frequency analysis. Single-trial power was estimated using a modified Morlet wavelet transform (Delorme & Makeig, 2004). The length of the wavelets varied from 3 cycles at 5.4 Hz to 13.8 cycles at 50 Hz. This analysis resulted in estimates for 400 time points (from 290 ms prior to cue onset to 1,854 ms afterward, window size varied between 556 ms at 5.4 Hz and 276 ms at 50 Hz) and 25 log-spaced frequencies. Analysis focused on the alpha band, which was individually determined as described above. The squared absolute value was taken for each estimate (i.e., power). A 100-ms precue time window (−150 to −50 ms, during the presentation of the fixation cross) was chosen as the baseline. Due to the temporal downsampling of the wavelet analysis, this window necessarily included small amounts of prefixation and postcue activity. However, the weighting of the Morlet wavelet transform was such that the majority of the activity was during the fixation period. The short duration of the fixation period precluded a longer time window.

Single-trial power was averaged based on response deadline and cue direction, resulting in six averages (left and right in the slow, medium, and fast blocks) per electrode cluster. These time-frequency averages were further averaged across electrode clusters resulting in ipsi- and contralateral averages for each response-deadline condition, which were then dB baseline corrected. Note that both validly and invalidly cued trials were averaged together for this analysis, as the validity was determined after target onset and could thus not influence these cue-related measures. Analysis focused on two 300-ms time windows: an early window 350–650 ms and a late window 650–950 ms after cue onset, over which power in the alpha-frequency band was averaged. These time windows were chosen to capture both activity directly following the cue and activity closer to stimulus presentation, while covering most of the cue-target interval and at the same time limiting the influence of cue- and target-related activity (early window started 180 ms after cue offset and the late window ended 220 ms before the earliest possible target presentation). We investigated differences in power modulation over the ipsi- and contralateral hemisphere across response-deadline blocks.

We furthermore calculated a lateralization index that takes power over the ipsi- and contralateral hemisphere into account (Haegens et al., 2011; Thut et al., 2006) to show the lateralization of alpha power after the cue. The index is positive if power over the ipsilateral hemisphere is higher than over the contralateral. The index is calculated as

$$\frac{\text{ipsilateral} - \text{contralateral alpha power}}{(\text{ipsilateral} + \text{contralateral alpha power})/2}$$

Additionally, we separated participants in a high and low alpha-power group based on a median split of their baseline alpha power across both electrode clusters and investigated whether these

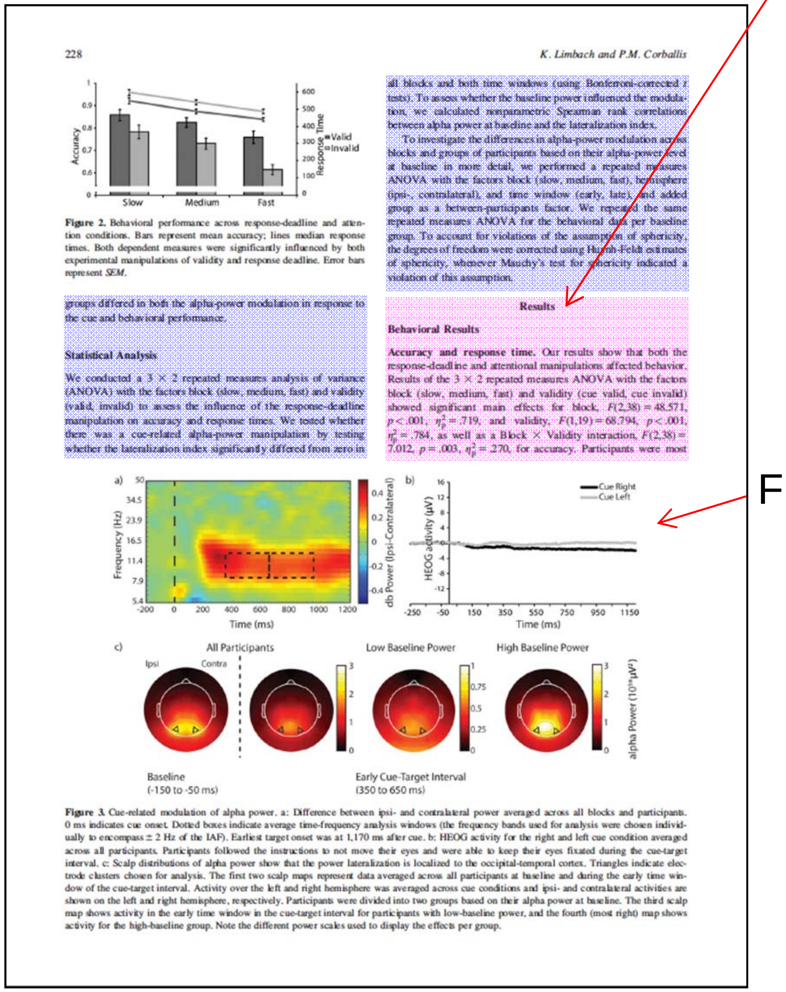


Figure 2. Behavioral performance across response-deadline and attention conditions. Bars represent mean accuracy; lines median response times. Both dependent measures were significantly influenced by both experimental manipulations of validity and response deadline. Error bars represent *SEM*.

groups differed in both the alpha-power modulation in response to the cue and behavioral performance.

Statistical Analysis

We conducted a 3 × 2 repeated measures analysis of variance (ANOVA) with the factors block (slow, medium, fast) and validity (valid, invalid) to assess the influence of the response-deadline manipulation on accuracy and response times. We tested whether there was a cue-related alpha-power manipulation by testing whether the lateralization index significantly differed from zero in all blocks and both time windows (using Bonferroni-corrected *t* tests). To assess whether the baseline power influenced the modulation, we calculated nonparametric Spearman rank correlations between alpha power at baseline and the lateralization index.

To investigate the differences in alpha-power modulation across blocks and groups of participants based on their alpha-power level at baseline in more detail, we performed a repeated measures ANOVA with the factors block (slow, medium, fast), hemisphere (ipsi-, contralateral), and time window (early, late), and added group as a between-participants factor. We repeated the same repeated measures ANOVA for the behavioral data per baseline group. To account for violations of the assumption of sphericity, the degrees of freedom were corrected using Huynh-Feldt estimates of sphericity, whenever Mauchy's test for sphericity indicated a violation of this assumption.

Results

Behavioral Results

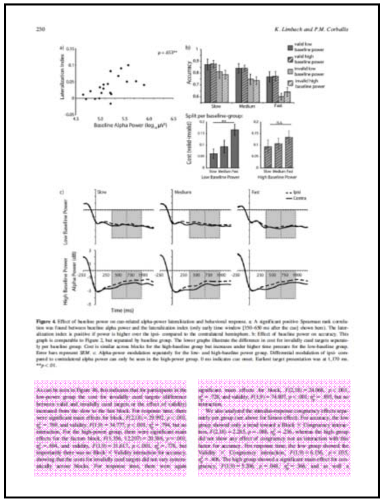
Accuracy and response time. Our results show that both the response-deadline and attentional manipulations affected behavior. Results of the 3 × 2 repeated measures ANOVA with the factors block (slow, medium, fast) and validity (cue valid, cue invalid) showed significant main effects for block, $F(2,38) = 48.571$, $p < .001$, $\eta_p^2 = .719$, and validity, $F(1,19) = 68.794$, $p < .001$, $\eta_p^2 = .784$, as well as a Block × Validity interaction, $F(2,38) = 7.012$, $p = .003$, $\eta_p^2 = .270$, for accuracy. Participants were most

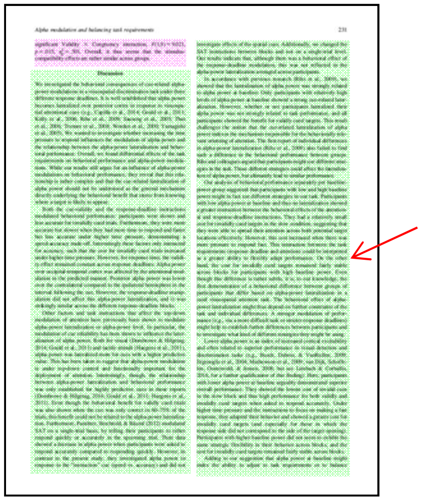
Figure 3. Cue-related modulation of alpha power. a: Difference between ipsi- and contralateral power averaged across all blocks and participants. 0 ms indicates cue onset. Dotted boxes indicate average time-frequency analysis windows (the frequency bands used for analysis were chosen individually to encompass ± 2 Hz of the IAF). Earliest target onset was at 1,170 ms after cue. b: HEOG activity for the right and left cue condition averaged across all participants. Participants followed the instructions to not move their eyes and were able to keep their eyes fixated during the cue-target interval. c: Scalp distributions of alpha power show that the power lateralization is localized to the occipital-temporal cortex. Triangles indicate electrode clusters chosen for analysis. The first two scalp maps represent data averaged across all participants at baseline and during the early time window of the cue-target interval. Activity over the left and right hemisphere was averaged across cue conditions and ipsi- and contralateral activities are shown on the left and right hemisphere, respectively. Participants were divided into two groups based on their alpha power at baseline. The third scalp map shows activity in the early time window in the cue-target interval for participants with low-baseline power, and the fourth (most right) map shows activity for the high-baseline group. Note the different power scales used to display the effects per group.

Figures

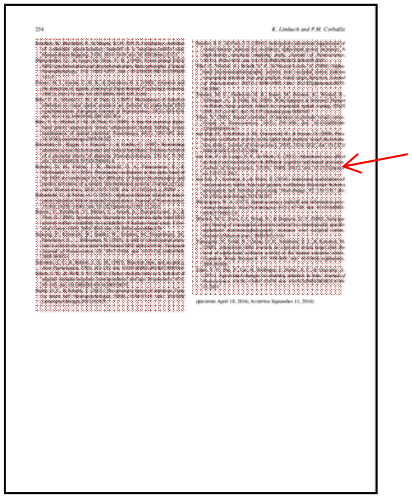
Analysis

Results





Discussion



References

Literature Review

- What is it? Why do you need it?
- How to do it:
  - Identify the topic & relevant literature
    - Google Scholar
    - Library resources
    - Subject-specific databases/search engines
  - Summarise and map the literature
    - Summary of articles
      - Tables
      - Concept map
      - Paper!
  - Synthesise in outline form
  - Write the review
- http://www.duluth.umn.edu/~hrallis/guides/researching/litreview.html

Analyze the literature (1)

- Group level:

1. Decide on the scope, extend and boundaries of your literature review
2. Skim through the articles chosen (abstract, intro, results, conclusion) to verify that they align with your literature review goals
3. Group the articles into categories
4. Decide on media for review; Most convenient nowadays is cloud-based shared resource (google docs) -> share with group/supervisor
5. Decide on a template for the reviews.
6. You are ready to start reading!!

The template for review

1. Usually write down:
    1. The title,
    2. Keywords
    3. Summary (concentrated abstract)
    4. Focus (which problem is solved using which technique(s) for which results)
    5. Theoretical or experimental procedure (bullet points)
    6. Results brief (qualitative and quantitative)
    7. Advantages over competition
    8. Your take on the paper scope and content (useful, scientific honesty, quality and scope of results, practicability of implementation)

Analyze the literature (2)

Individual level:

General

1. Note key terms employed, keep track of their definition
2. Note strengths/weaknesses and emphases/focus of the paper as given by the authors

Introduction

1. Identify the problem statement and article structure in the introduction
2. Look at how the authors position themselves w.r.t. competing approaches
3. Check the references provided in introduction for the founding papers (usually oldest referred). They may hold the keys for a clearer description of the techniques/methodology introduced
4. Identify major trends or patterns and gaps in the literature review produced
5. Identify relationships between article read and literature review provided (helps to eliminate subsidiary papers)

Analyze the literature (3)

Methods

1. Try to produce a synthetic overview of the materials section: which methods for which output
2. Make track of the founding theoretical concepts (and a reference) behind the methods introduced
3. Make note of what you see as uniqueness of the methods employed (a specific equation, a variation from commonly employed theory)
4. Assess the strengths of the theoretical section. Good theory can be judged by the quality of the theoretical section. A poor theoretical section may point out to an end-user’s paper rather than an inventor’s publication

Materials

1. Gives a clear indication of whether a promising techniques can be replicated and thus of the extend to which you must read the paper
2. If not replicable (cost, conditions, equipment or software needed, etc..) then limited interest to the literature review.
3. If replicable, make an exhaustive list of all that is required and rank in categories (doable, maybe, impossible)
4. Write an exhaustive step-by-step experimental process allowing replication
5. Make sure to write down the experimental conditions and boundaries of a given experiment

Results

1. Assess the strengths of the results section. A good results section must contain qualitative and quantitative data. Ideally, the authors will produce sound statistical outputs, tables, figures and so on.
2. The results will be criticized and potential solutions to correct undesirable results will be provided
3. Rare but very good: articles providing failed results and discussing the potential reasons for such failure are difficult to find but do teach you so much more. Such articles are difficult to publish…
4. Synthetize interesting results and keep a very brief note on expected results

Analyze the literature (4)

Conclusion

1. Provides a concise summary of what was attempted (so maybe read first the conclusion)
2. Little interest unless providing a clear indication of the next step in the author's research

Bibliography

1. Gives a clear indication of whether the authors did an updated literature review for their publication
2. Search for the oldest references: They may hold the key to the founding papers
3. Search for the newest references: They may be the key to other competing approaches
4. Learn from the bibliography formatting and note differences between journals
5. Integrate the most promising references into your overall bibliography database (Endnote, else?)

Summarizing

Reduce your literature review to a one pager (no exception)

Experimental protocol

- Compulsory in environmental and medical studies
- Allows others to repeat your experiment
- May include H&S instructions and reference to applicable laws and regulation applicable to the procedures
  - e.g. Drones
- Describes the experiment environment, equipment required and a very detailed step-by-step description of the experiment
- May include operation instructions for all equipment involved
- May include all calculations and statistics used for the experiment

Experimental protocoles

- Names of users
- Location of experiment
- Goals
- Techniques used
- Equipment required
- Step by step process
- Diagrams detailing placement of equipment
- Possibly photos of equipment and their functions

Examples

http://www.nature.com/nprot/journal/v9/n3/fig_tab/nprot.2014.035_F1.html

Look for other examples online

Questions?