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**The peripheral preview effect with faces: Combined EEG and eye-tracking suggests multiple stages of trans-saccadic predictive and non-predictive processing**

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25 Abstract

26 The world appears stable despite saccadic eye-movements. One possible explanation for this  
27 phenomenon is that the visual system predicts upcoming input across saccadic eye-  
28 movements based on peripheral preview of the saccadic target. We tested this idea using  
29 concurrent electroencephalography (EEG) and eye-tracking. Participants made cued  
30 saccades to peripheral upright or inverted face stimuli that changed orientation (invalid  
31 preview) or maintained orientation (valid preview) while the saccade was completed.  
32 Experiment 1 demonstrated better discrimination performance and a reduced fixation-  
33 locked N170 component (fN170) with valid than with invalid preview, demonstrating  
34 integration of pre- and post-saccadic information. Moreover, the early fixation-related  
35 potentials (FRP) showed a preview face inversion effect suggesting that some pre-saccadic  
36 input was represented in the brain until around 170 ms post fixation-onset. Experiment 2  
37 replicated Experiment 1 and manipulated the proportion of valid and invalid trials to test  
38 whether the preview effect reflects context-based prediction across trials. A whole-scalp  
39 *Bayes factor* analysis showed that this manipulation did not alter the fN170 preview effect  
40 but did influence the face inversion effect before the saccade. The pre-saccadic inversion  
41 effect declined earlier in the mostly invalid block than in the mostly valid block, which is  
42 consistent with the notion of pre-saccadic expectations. In addition, in both studies, we  
43 found strong evidence for an interaction between the pre-saccadic preview stimulus and the  
44 post-saccadic target as early as 50 ms (Experiment 2) or 90 ms (Experiment 1) into the new  
45 fixation. These findings suggest that visual stability may involve three temporal stages:  
46 prediction about the saccadic target, integration of pre-saccadic and post-saccadic  
47 information at around 50-90 ms post fixation onset, and post-saccadic facilitation of rapid  
48 categorization.

49 Keywords

50 Trans-saccadic perception; preview effect; prediction; EEG; eye tracking, fixation-related

51 potentials (FRP)

## 52 1. Introduction

53 Visual perception is surprisingly stable despite being interrupted by saccadic eye movements  
54 about three times per second. One source of visual stability may be the integration of pre-  
55 and post-saccadic visual information (Helmholtz, 1867; Melcher, 2011; Wurtz, 2008). Recent  
56 gaze-contingent experimental designs have revealed that orientation (Ganmor et al., 2015;  
57 Wolf and Schütz, 2015; Zimmermann et al., 2017), object size (Valsecchi and Gegenfurtner,  
58 2016), visual motion (Fabius et al., 2016), and even whole-object information (Castelhano  
59 and Pereira, 2017; Schut et al., 2016) are integrated across saccades in a statistically optimal  
60 fashion that takes into account the relative reliability of pre-saccadic and post-saccadic input  
61 (Ganmor et al., 2015; Herwig, 2015; Wolf and Schütz, 2015). Nonetheless, the time-course of  
62 trans-saccadic perception and, in particular, the contents of perception immediately after  
63 fixation-onset remain controversial (for review, Melcher and Morrone, 2015).

64 Here, we investigated the time-course of trans-saccadic perception with combined EEG and  
65 eye-tracking (Huber-Huber et al., 2016; Kovalenko and Busch, 2016). Using a similar  
66 methodology, reading research has discovered a *preview positivity* in the fixation-locked  
67 potentials (FRP) starting at around 140-200 ms in which the evoked response is more  
68 positive after valid as compared to invalid parafoveal previews (Dimigen et al., 2012;  
69 Kornrumpf et al., 2016; Niefind and Dimigen, 2016), suggesting that pre- and post-saccadic  
70 information about the target word are compared and integrated as soon as 140-200 ms after  
71 fixation onset.

72 Here we investigated whether the preview positivity known from reading research is also  
73 elicited by non-word stimuli, namely by faces. One advantage of using face stimuli is that the  
74 time course of face processing has been extensively studied (e.g. Bentin et al., 1996). In  
75 Experiment 1, participants made saccades to peripheral face stimuli. During the saccade, the

76 orientation of the face (upright, inverted) could change (invalid preview) or remain the same  
77 (valid preview). After the saccade, participants reported by button press whether the post-  
78 saccadic target face was slightly tilted to the left or right. If the preview positivity observed  
79 in reading reflects a general trans-saccadic integration mechanism, a change in the FRP  
80 component around 200 ms, as found with reading, should be elicited by a valid preview of  
81 the target face. However, we hypothesized that faces might show an earlier preview effect  
82 than words (Edwards et al., 2018), possibly influencing the N170 ERP index of face  
83 processing (Buonocore et al., 2019).

84 The N170 has been closely associated with face processing in the fusiform gyrus and lateral  
85 occipitotemporal cortex (Rossion & Jacques, 2011, for review) and is known to be sensitive  
86 to contextual effects. For example, repeated presentation of faces reduces the N170  
87 component (Caharel et al., 2009; Ewbank et al., 2008) and inverting faces generates a larger  
88 and sometimes later N170. This face inversion effect in the N170 is considered to reflect the  
89 configural or structural encoding of faces, supporting detection of face stimuli rather than  
90 more detailed resolution of face identity (Bentin et al., 1996; Eimer, 2000; Eimer et al., 2010;  
91 Itier and Taylor, 2004a, 2004b; Rossion et al., 2000; Towler et al., 2012; Watanabe et al.,  
92 2003). However, face inversion effects also emerge when faces are not explicitly present but  
93 can be inferred from context (Brandman & Yovel, 2012).

94 Trans-saccadic preview effects are usually expressed as more pronounced neural responses  
95 in invalid compared to valid conditions (Dimigen et al., 2012; Näätänen and Kreegipuu,  
96 2011). As such they can be interpreted in terms of prediction errors in predictive coding  
97 frameworks (Friston, 2010, 2005; Friston and Kiebel, 2009; Garrido et al., 2008; Stefanics et  
98 al., 2014) and in current frameworks of predictive perception (De Lange et al., 2018). With  
99 respect to trans-saccadic perception, the interpretation of the preview effect as a predictive

100 process is particularly intriguing, because one explanation for visual stability is that  
101 upcoming foveal visual input is predicted based on pre-saccadic peripheral information and a  
102 copy of the motor command (Cavanaugh et al., 2016; Friston et al., 2012; Melcher and  
103 Colby, 2008; Wurtz, 2008). Finding predictive preview effects would therefore foster the  
104 prediction hypothesis of visual stability.

105 Setting out to test the predictive nature of the trans-saccadic preview effect, in Experiment  
106 2, we asked whether the trans-saccadic preview effect reflected a relatively long-term  
107 predictive process that extends across multiple trials. We manipulated the proportion of  
108 valid and invalid trials to generate blocks with mostly valid (66.6% valid) and mostly invalid  
109 (33.3% valid) previews. Proportion manipulations have successfully demonstrated the  
110 predictive nature of sensory processing (Grotheer et al., 2014; Kovács et al., 2012;  
111 Mayrhauser et al., 2014; Summerfield et al., 2011, 2008), with the rationale that a more  
112 frequent event is more expected than a less frequent event and, therefore, elicits a reduced  
113 neural response. Thus, if the preview effect reflects a predictive process that is sensitive to  
114 the task context, it should become smaller in the mostly invalid and larger in the mostly valid  
115 block.

## 116 2. Materials & Methods

### 117 2.1. Participants

118 Twenty volunteers participated in each experiment in return for a monetary reimbursement,  
119 with no overlap in participants between the two experiments. All participants provided  
120 written informed consent and reported normal or corrected-to-normal visual acuity that was  
121 additionally confirmed by an eyesight test using a Snellen chart. In Experiment 1, two  
122 participants had to be excluded due to poor performance in the tilt discrimination task. Of

123 the remaining 18 participants, 16 were right-handed, 7 were male, and their mean age was  
124 24.3 years (range: 19-30 years). In Experiment 2, one participant had to be excluded because  
125 of a technical problem during EEG data collection. Of the 19 remaining participants, 16 were  
126 right-handed, 6 were male, and their mean age was 25.0 years (range 20-40 years). The  
127 procedures of both experiments were approved by the local ethics committee.

128

## 129 2.2. Stimuli

130 Stimuli were presented on a VIEWPixx/EEG monitor (VPixx Technologies Inc., Canada) at  
131 120 Hz screen refresh rate and 1920 × 1080 display resolution. The experiment was  
132 programmed in Matlab (version 2014b, The Mathworks Inc.) using the Psychophysics  
133 toolbox (Brainard, 1997; Pelli, 1997). For Experiment 1, 42 face images were taken from the  
134 Nottingham face database (<http://pics.stir.ac.uk/zips/nottingham.zip>) as well as from the  
135 Faces 1999 (Front) dataset (<http://www.vision.caltech.edu/archive.html>), with half of the  
136 images being female faces and the other half male faces. For Experiment 2, we selected a set  
137 of 16 face images only from the Nottingham face database, with half of the images showing  
138 female faces and half male faces. The face images in this reduced set were more uniform  
139 concerning the distribution of facial features like eyes, nose, and mouth across images.  
140 For the face images of both experiments, a circular mask with a diameter of 2.88° was  
141 centered at the tip of the nose and the image was sized to contain the internal facial  
142 features. Face images were centered bilaterally at  $\pm 8^\circ$  eccentricity from the screen center.  
143 For each original face image, we generated a phase-scrambled counterpart that was  
144 presented as a transient (for the duration of 2 display frames, i.e. 16.7 ms) during the  
145 saccade to match the level of intrasaccadic visual change of the display between the valid  
146 and invalid preview conditions. In order to equate low-level image features that could

147 otherwise confound the EEG signal, stimuli were matched with the SHINE toolbox  
148 (Willenbockel et al., 2010). Specifically, we used the function *histMatch* with the mask  
149 option to match the luminance histogram of all face cut-outs and their scrambled  
150 counterparts to the average histogram of all face cut-outs within each of the two  
151 experiments.

152

### 153 2.3. Procedure

154 Each trial started with a placeholder display consisting of a fixation cross ( $0.5^\circ \times 0.5^\circ$ ) at the  
155 screen center and two white rings (width 1 pixel) framing the position of the upcoming faces  
156 (Figure 1A). In Experiment 1, one white ring appeared on either side of the fixation cross (as  
157 illustrated in Figure 1A), in Experiment 2, only one ring appeared to the left of fixation (not  
158 illustrated). Stable fixation within an area of  $2^\circ$  around the screen center for 1 s triggered the  
159 preview display. In Experiment 1, the preview display contained two faces, one at either side  
160 from fixation; in Experiment 2, there was only one face to the left of fixation. The face  
161 images replaced the placeholder rings. Once the eye tracker detected a stable fixation at the  
162 center of the preview display for 500 ms, the color cue was presented. In Experiment 1, the  
163 fixation cross turned either blue or green indicating the saccade direction (color-to-direction  
164 assignment counterbalanced across participants). In Experiment 2, the fixation cross turned  
165 grey, prompting for a saccade to the single face on the left. Participants were instructed to  
166 respond as quickly and accurately as possible to the cue by making one single eye-  
167 movement to the corresponding face stimulus. Saccade onsets were detected online (see  
168 section *EEG and eye-tracking data recording* for details), and upon detection, a scrambled  
169 version of the preview face was presented for two frames (16.7 ms); in Experiment 1, the  
170 faces on both sides were scrambled. The transient occurred no more than 3.5 frames ( $\sim 30$



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171 ms) after saccade onset, with the delay reflecting the computational requirements of  
172 saccade detection and the screen refresh rate (Figure 1C). Given a total saccade duration of  
173 around 40-60 ms, the target face was presented before fixation onset in most trials (Figure  
174 1D). The purpose of this transient was to roughly equalize the amount of change in the  
175 display across all conditions.

176 During the saccade the faces could change their overall orientation from upright to inverted  
177 (or vice versa) or they could remain the same. In Experiment 1, all possible combinations of  
178 target and non-target face orientations and changes were realized once with each individual  
179 target face, yielding a total set of 672 trials (168 per cell in the crossing of *Preview* [valid,  
180 invalid] and *Target Face* [upright, inverted] conditions; Figure 2A). In Experiment 2, which  
181 employed a smaller set of face images, all possible combinations of target orientations and  
182 changes were repeated 16 times for each face. In addition, to investigate whether the  
183 preview effect found in Experiment 1 reflected active predictions accumulating across blocks  
184 of trials, Experiment 2 consisted of two blocks, one containing mostly valid trials (66.6%  
185 valid, 33.3% invalid) and the other one containing mostly invalid trials (33.3% valid, 66.6%  
186 invalid) (Figure 2B). We were interested whether the preview effect - the difference in the  
187 dependent variables between invalid minus valid trials - would be larger in the mostly valid  
188 block and smaller in the mostly invalid block (Figure 3). Block order was counterbalanced  
189 across participants.

190 Experiment 2 thus comprised 1024 trials (with either 171 or 85 per cell in the crossing of  
191 *Preview* [valid, invalid], *Target face* [upright, inverted], and *Proportion* [mostly valid, mostly  
192 invalid] conditions). For instance, in the mostly valid block, there were 171 valid trials with  
193 target upright, 171 valid trials with target inverted, 85 invalid trials with target upright, and

194 85 invalid trials with target inverted. Importantly, the proportion manipulation was not  
195 mentioned to the participants at any point.

196 In addition to its main orientation (upright or inverted), each target face was slightly tilted  
197 ( $1.8^\circ$ ) either to the left or right, counterbalanced across trials. The non-target face in  
198 Experiment 1 had the same amount of tilt as the target face (on the other side of fixation),  
199 but its direction (left or right) was random. The target face tilt direction had to be reported  
200 by the participants via a computer keyboard with the left and right index finger after they  
201 had made an eye-movement to the target face. Figure 1B shows the true-to-scale tilt of  $1.8^\circ$   
202 which was hard to see even in the fovea but sufficient for above-chance performance (mean  
203 error rates per condition between 15% and 20%, cf. section 3.1.). The purpose of the tilt  
204 discrimination task was to ensure that participants paid attention to the target face and gave  
205 a response that was orthogonal to all experimental manipulations. In fact, the preview  
206 images were not tilted, making them task-irrelevant for the perceptual tilt discrimination  
207 response. Correct saccades (end point at least within  $2.16^\circ$  of the target face center) were  
208 detected online, and participants received feedback in case of incorrect response or if the  
209 recorded gaze position was too far from the expected saccade start or end locations. Before  
210 data collection, the eye-tracker was calibrated with a default 5-point rectangular grid. The  
211 eye-tracker was manually recalibrated when it failed to correctly track gaze position, that is,  
212 when the gaze position suggested that the participant was not following the instructed gaze  
213 procedure anymore.

214

#### 215 2.4. EEG and eye-tracking data recording

216 The electroencephalogram (EEG) was recorded with a 64-channel DC system (Brain Products  
217 GmbH, software: BrainVision Recorder version 1.21) in an electromagnetically shielded

218 booth. Sixty-three electrodes were placed at a subset of the locations of the 10-10 system:  
219 Fp1, Fpz, Fp2, AF7, AF3, AF4, AF8, F9, F7, F5, F3, F1, Fz, F2, F4, F6, F8, F10, FT7, FC5, FC3, FC1,  
220 FCz, FC2, FC4, FC6, FT8, C5, C3, C1, Cz, C2, C4, C6, T8, TP7, CP5, CP3, CP1, CPz, CP2, CP4, CP6,  
221 TP8, P7, P5, P3, P1, Pz, P2, P4, P6, P8, PO9, PO7, PO3, POz, PO4, PO8, PO10, O1, Oz, and O2.  
222 The right mastoid served as online reference and electrode AFz was used as ground. Eye-  
223 movement data was recorded by a desktop-mounted EYELINK 1000 video-based eye-tracker  
224 (SR Research, Ontario, Canada). Default settings for saccade detection were used (velocity  
225 threshold  $35^\circ/\text{s}$ , acceleration threshold  $9500^\circ/\text{s}^2$ ). The online saccade detection that  
226 triggered the intrasaccadic scrambled transient (see *Procedure*) was, however, based on a  
227 custom-made algorithm, since the default saccade start events were not transferred quickly  
228 enough from the eye-tracking host computer to the experiment workspace in Matlab. We  
229 set the heuristic filter option of the eye-tracker to level 2 in order to receive cleaner gaze  
230 position data, despite the minimal additional delay introduced by the higher filter level. A  
231 gaze position difference of  $0.18^\circ$  between two subsequent samples, converted to screen  
232 pixels depending on individually measured viewing distance of each participant, triggered  
233 presentation of the scrambled transient at the next possible screen refresh. This procedure  
234 resulted in quick and satisfactory saccade detection in most trials (cf. Figure 1C).  
235 Both eye-tracking and EEG data were recorded at 1000 Hz. Trigger signals were sent to both  
236 data acquisition systems by means of a parallel port splitter cable. The trigger signals were  
237 used offline to synchronize both data streams for subsequent analysis.

238

### 239 2.5. EEG and eye-tracking data analysis

240 EEG and eye-tracking data were processed in Matlab (version R2016b, The Mathworks Inc.)  
241 using EEGLAB (version 14.1.1, Delorme and Makeig, 2004). The eye-tracking data was

242 synchronized with the EEG by means of the EYE-EEG toolbox (version 0.81, Dimigen et al.,  
243 2011). After synchronization, the synchronized signals were down-sampled to 250 Hz. The  
244 EEG was then low-pass filtered (Hamming windowed sinc FIR filter, edge of the passband  
245 40 Hz, transition band width 10 Hz, -6dB cutoff frequency 45 Hz), and re-referenced to  
246 average reference (Hinojosa et al., 2015). The EEG data was then visually inspected for major  
247 artifacts. Portions of data with severe artifacts were removed and bad channels were  
248 spherical-spline interpolated.

249 In order to correct for eye movement artifacts in the EEG, we applied independent  
250 component analysis (ICA; Makeig, Bell, Jung, & Sejnowski, 1996). Eye-movement related  
251 components were determined based on the variance ratio of component activation during  
252 periods of eye-movements (blinks and saccades) versus periods of fixations (Plöchl et al.,  
253 2012). ICA was conducted in a separate processing pipeline containing an additional high-  
254 pass filter (Hamming windowed sinc FIR, edge of the passband: 1 Hz, -6 dB cutoff frequency:  
255 0.5 Hz) that was applied after down-sampling and before low-pass filtering (Dimigen, 2018;  
256 Winkler et al., 2011). The ICA algorithm was Infomax (Bell and Sejnowski, 1995) with the  
257 “pca” option activated to account for the reduced rank of some of the datasets that  
258 contained interpolated channels. The ICA results (sphere and weights) were transferred to  
259 the corresponding datasets in the original processing pipeline, which lacked a high-pass filter  
260 (cf. Acunzo et al., 2012). Components were then rejected if the mean variance of their  
261 activity time course during eye-movement periods was 10% greater than the mean variance  
262 during fixation periods (Plöchl et al., 2012; Dimigen, 2018).

263 In both experiments, we extracted epochs of interest time-locked to the target fixation.  
264 Target fixation epochs were extracted from -200 to 600 ms around the onset of the first face  
265 fixation. Baseline correction was conducted with respect to the 200 ms period before onset

266 of the preview display. This approach was adopted for two reasons: first, to compare the  
267 post-saccadic activity to a period in which there was no visual input, and, second, to prevent  
268 possible residual eye-movement-related activity from confounding the baseline. In  
269 Experiment 2, we also extracted epochs of interest aligned to the onset of the preview  
270 display, from -200 to 800 ms with respect to preview display onset, with the baseline  
271 defined as the interval from -200 to 0 ms prior to preview display onset.

272 Only trials with correct responses and trials in which participants had followed the gaze  
273 instructions in the experimental procedure were included in the analysis. These were trials in  
274 which participants kept a stable fixation within 2° of the screen center, made no saccades  
275 before cue onset, and the saccade endpoint was within 2.16° of the target face center. If the  
276 target had not been presented before fixation onset, due to a delay in saccade detection,  
277 the time difference between fixation onset and target onset was less than 20 ms (see Figure  
278 1D and Procedure for details), which is largely within the time course of saccadic suppression  
279 (Benedetto and Morrone, 2017; Bremmer et al., 2009; Diamond et al., 2000). This restriction  
280 was disregarded in Experiment 2 for the preview-locked analysis only, because this analysis  
281 focused on the time period before the saccade and disregarding this criterion increased the  
282 number of available trials. Finally, trials with very fast and very slow responses in the tilt  
283 discrimination task were excluded by a median absolute deviation filter with a conservative  
284 criterion of 3 (Leys et al., 2013).

285 In Experiment 1, these strict criteria led to acceptance of a median number of 104 trials  
286 (range 58 to 139 across participants) per cells of the experimental design (*Preview × Target*  
287 *Orientation*). In the FRP analysis of Experiment 2, the median number of accepted trials was  
288 78 (range 32 to 165) per cell of the design (*Preview × Target Orientation × Proportion*). For  
289 the preview-locked analysis of Experiment 2, the median number was 79, and the range was

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290 the same. The extended range in Experiment 2 compared to Experiment 1 was due to the  
291 proportion manipulation, which lead to an unbalanced number of trials across cells of the  
292 design.

293 To determine how the pre-saccadic preview affected processing of the post-saccadic target  
294 face, we investigated the time course of *Preview orientation* (upright, inverted) and *Target*  
295 *orientation* (upright, inverted) effects in the EEG with a whole-scalp Bayes factor analysis.

296 ERP components are known to differ across tasks, and since we used a novel gaze-  
297 contingent task, such an analysis reduces the risk of false positive findings (Luck and  
298 Gaspelin, 2017). Note, that the same conditions resulting from the factors *Preview*  
299 *orientation* (upright, inverted) and *Target orientation* (upright, inverted) can be modelled  
300 equally well by either of the factors *Target* or *Preview orientation* (upright, inverted)  
301 together with a *Preview* factor (valid, invalid) that indicates whether the target and the  
302 preview face were of the same (valid) or different (invalid) orientation.

303 Experiment 1 also included the factor *Cue Direction* (left, right; synonymous with saccade  
304 direction) and, for lateral electrodes, also the factor *Laterality* (contra, ipsi; with respect to  
305 cue direction). To create the *Laterality* factor, EEG data from trials with saccades to the left  
306 were swapped across hemispheres in order to assign left hemisphere electrodes to the  
307 contralateral, and right hemisphere electrodes to the ipsilateral condition. For instance, the  
308 signal at electrode PO7 was assigned the label *ipsilateral* for leftward saccade trials and the  
309 label *contralateral* for rightward saccades trials. The signal at electrode PO8 was treated in  
310 the opposite way. With a visually balanced display of one face at either side of the screen,  
311 the face at the future target location, i.e. the preview face, projects primarily to the  
312 contralateral hemisphere. Analyzing the data with the laterality factor ensured that any  
313 lateralized preview-related activity could be captured by our design. The alternative would

314 have been to keep the signal at corresponding electrodes separate (e.g. PO7 separate from  
315 PO8), which would have meant averaging activity ipsilateral to the preview face with activity  
316 contralateral to the preview face, and that might have cancelled out any lateralized preview-  
317 related effects. In contrast to Experiment 1, Experiment 2 omitted the factors *Cue Direction*  
318 and *Laterality*, because there was only one target face to the left to which saccades were  
319 directed, but instead it included the factor *Proportion* (mostly valid, mostly invalid). For  
320 Experiment 2, we additionally analyzed the data time-locked to the preview display in order  
321 to determine any pre-saccadic expectation effects introduced by the proportion  
322 manipulation.

323 The preview-display locked analysis of the EEG data revealed an unexpected result, with the  
324 face inversion effect in the N170 triggered by the preview display occurring later than the  
325 face inversion effect triggered by the target display. We tested the reliability of this delay by  
326 analyzing onset latencies of the N170 face inversion effect. Since this was a post-hoc  
327 analysis, this result might be less reliable. In addition to the whole-scalp Bayes factor, we  
328 also computed repeated measures ANOVAs on average ERPs at selected electrode sites and  
329 for time-windows of main interest to further consolidate the results.

330

### 331 2.6. Whole-scalp analysis

332 At each electrode and time point, we computed a Bayes factor (BF) based on the average  
333 EEG voltage across trials per participant and condition. We used the BayesFactor package  
334 (version 0.9.12-2) in R (R Core Team, 2013) with fixed-effect priors set to the default Cauchy  
335 distribution at location 0 and scale 0.5. This prior can be verbally expressed as expectation of  
336 a medium-sized effect with smaller effects being more likely than larger effects (Rouder et  
337 al., 2009). In contrast to null-hypothesis significance testing, the Bayes factor provides a

338 measure of graded evidence for the presence versus absence of an effect (Dienes, 2016;  
339 Rouder et al., 2016; Wagenmakers, 2007). In line with common practice, we consider a BF  
340 greater than 3 as positive evidence, a BF lower than 1/3 as negative evidence, and a BF  
341 between 1/3 and 3 as non-decisive (Raftery, 1995).

342 To obtain a BF for a main or an interaction effect in a multifactor design, such as in the  
343 present study, it is advisable to calculate the so-called BF *across matched models*. This is  
344 because the BF is a likelihood ratio that results from comparing two models, which is usually  
345 the likelihood of the data given the alternative hypothesis/model divided by the likelihood of  
346 the data given the null hypothesis/model. A multifactor design offers many pairs of models  
347 with one model containing the effect of interest and the other not. Thus, there are many  
348 possible likelihood ratios that could be considered as providing the BF for a certain effect.

349 The most straightforward way to solve this problem is to compute the sum of the likelihoods  
350 of all of the models with the effect of interest and divide it by the sum of the likelihoods of  
351 all of the corresponding models without the effect of interest. Models containing higher-  
352 order interactions with the effect of interest are disregarded. This procedure is, for instance,  
353 implemented in the software JASP (JASP Team, 2018).

### 354 3. Results

#### 355 3.1. Experiment 1: Valid peripheral preview improves post-saccadic tilt 356 discrimination performance

357 We analyzed manual response times in the tilt discrimination task only for those trials that  
358 entered the EEG analysis, which also excludes tilt discrimination errors. Error trials were,  
359 however, included in the error rate analysis, which still excluded trials with incorrect  
360 saccades (see *Methods*). For both computations the design contained three factors: *Target*



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361 *Orientation* (upright, inverted), *Preview* (valid, invalid), and *Cue Direction* (left, right;  
362 equivalent with saccade direction). Response time was measured from cue onset, which  
363 means that it included saccade latency. Saccade latency was on average 414 ms and did not  
364 differ across conditions, all  $F_s < 1.55$ , all  $p_s > .232$ , all  $BFs < 0.33$ , except for the *Preview* x  
365 *Target Orientation* x *Cue Direction* interaction which had a Bayes factor slightly above the  
366 0.33 threshold but still below 1,  $F(1,17) = 2.25$ ,  $p = .152$ ,  $BF = 0.42$ .

367 As expected, a valid preview led to on average shorter response times than an invalid  
368 preview (valid 1,180 ms, invalid 1,209 ms),  $F(1,17) = 14.54$ ,  $p = .001$ ,  $BF = 7.52$  (Figure 4A)  
369 which is in line with the behavioral preview benefit effect in reading research (Rayner, 1975;  
370 for a review see Schotter et al., 2012). Error rates were the same in both preview conditions  
371 (valid 17 %, invalid 18 %),  $F(1,17) = 1.35$ ,  $p = .261$ ,  $BF = 0.28$  (Figure 4B). Performance was  
372 also affected by target face orientation. Upright target faces led to a faster response than  
373 inverted target faces (1,163 ms versus 1,227 ms),  $F(1,17) = 22.48$ ,  $p < .001$ ,  $BF > 100$ . Upright  
374 faces were also less error prone (15 %) than inverted ones (20 %),  $F(1,17) = 20.68$ ,  $p < .001$ ,  
375  $BF > 100$ . This effect was, however, not of primary interest in the current study.

376 The ANOVA also showed an interaction of *Preview* and *Cue Direction* in the error rates,  
377  $F(1,17) = 8.80$ ,  $p = .009$ . This interaction suggested a larger preview effect for left side targets  
378 than for right side targets. However, a  $BF$  of 0.66 prevented us from drawing strong  
379 conclusions.

380

381 3.2. Experiment 1: Valid peripheral preview reduces the N170 amplitude in the FRP  
382 Results of the FRP whole-scalp Bayes factor analysis are illustrated in Figures 5 and 6. Figure  
383 5 shows the  $BF$  for the theoretically most relevant effects of *Preview Orientation* (panel A,  
384 aka *Preview* x *Target Orientation* interaction), *Target Orientation* (panel B), and the *Preview*

385 effect (panel C, aka *Preview Orientation* × *Target Orientation* interaction). The ERPs  
386 corresponding to these effects are illustrated in panel D. Note that the *Preview Orientation*  
387 (upright, inverted) main effect is expressed as a *Preview* × *Target Orientation* interaction.<sup>1</sup>  
388 Figure 6 shows the remaining and less theoretically important effects.

389 As can be seen from Figure 5, the initial phase of the FRP response already showed some  
390 evidence for an influence of the orientation of the preview face (panel A), which became  
391 decisively positive ( $BF > 3$ , color-coded in blue within white contour lines) from around 110  
392 to 170 ms post fixation onset. During this relatively early period after fixation onset the  
393 preview face was no longer presented on the screen but instead had been replaced by the  
394 target face, which could have had a different orientation than the preview face.

395 Nevertheless, an inverted preview face led to a more negative EEG response than an upright  
396 preview face at posterior-lateral electrodes (see panel D). This effect could reflect a  
397 mechanism relevant for the experience of visual stability, since it indicates that information  
398 about the pre-saccadic preview influenced neural processing in this time period of around  
399 110-170 ms. In other words, immediately after the fixation, the EEG signal initially reflected  
400 what was perceived before the saccade and would be expected to be perceived after the  
401 saccade, until new post-saccadic information was incorporated (Mirpour and Bisley, 2016).

---

<sup>1</sup> We checked the equivalence of the *Preview Orientation* main effect and the *Preview* × *Target Orientation* interaction explicitly with two ANOVAs computed on the average amplitude within 300-400 ms post fixation onset at electrode pair PO7/8. One ANOVA contained the effect of *Preview Orientation* whereas the other ANOVA coded the same data with the effect of *Preview* instead. The first ANOVA showed a main effect of *Preview Orientation* with the values  $F(1,17) = 4.39, p = .051$ . The second ANOVA showed a *Preview* × *Target Orientation* interaction with exactly the same values  $F(1,17) = 4.39, p = .051$ . Besides that, the main effect of *Target Orientation* was also exactly the same for both ANOVAs,  $F(1,17) = 8.92, p = .008$ . Clearly, the *Preview Orientation* main effect translates into a *Preview* × *Target Orientation* interaction, and vice versa.

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402 For face orientation this updating process apparently happened at around 170 ms, which  
403 coincides with the timing of the face-selective N170 component.

404 Almost exactly at 170 ms the main influence on the EEG signal switched from the preview  
405 face to the target face (cf. Figures 5A and 5B) which elicited a more negative response when  
406 inverted compared to when it was upright (Figure 5D). This modulation perfectly matches  
407 the classic N170 face inversion effect (Bentin et al., 1996; Eimer, 2000; Eimer et al., 2010;  
408 Itier and Taylor, 2004a, 2004b; Rossion et al., 2000; Towler et al., 2012; Watanabe et al.,  
409 2003). We therefore consider this target orientation effect around 170-220 ms post fixation  
410 as a modulation of the fixation-locked N170 component, the fN170.

411 Most importantly, for a period of about 80 ms before and after the crucial time point of  
412 170 ms, the preview orientation and target orientation factors interacted (Figure 5C),  
413 showing a more pronounced neural response when the preview face and target face  
414 orientations matched (valid preview) compared to when they did not match (invalid  
415 preview) (Figure 5D). This finding is consistent with theories of trans-saccadic integration  
416 that posit that information about the saccadic target influences post-saccadic processing of  
417 that target in the new fixation (for review see Melcher, 2011). As can be seen from Figure  
418 5D, the fN170 component in particular was more pronounced in invalid (dashed lines) than  
419 in valid preview (solid lines) conditions, which is consistent with the idea of a trans-saccadic  
420 prediction error. The role of prediction was further explored in Experiment 2.

421 As can be seen in Figure 5, panels A and D, the factors *Preview* and *Target Orientation*  
422 interacted again from around 320 ms post fixation for a duration of about 80 ms in particular  
423 at central parietal electrodes. The target orientation effect here consisted in a more negative  
424 deflection for inverted compared to upright target faces and this face inversion effect was  
425 larger for invalid than for valid preview conditions. This interaction likely reflects increased

426 processing of the target face orientation in invalid than in valid preview conditions – after an  
427 invalid preview, the target face requires more in-depth processing of the critical features  
428 related to face processing – which appears intuitively plausible given the literature on the  
429 P300 component (e.g. Polich, 2011).

430 As can be seen from Figure 6, with one exception (three-way interaction with *Cue Direction*,  
431 Figure 6H), the *Preview* and *Target Orientation* factors did not interact with other factors.

432 The interaction with *Cue Direction* showed sufficient positive evidence before and around  
433 the time of the saccade and suggested that the *Preview* × *Target Orientation* interaction –

434 which is the statistical reflection of the *Preview Orientation* effect – consisted of more

435 negative EEG for inverted compared to upright preview faces, which was more pronounced

436 for saccade-right trials than for saccade-left trials (direction of effects not illustrated here).

437 Given the posterior lateral distribution of this effect (electrodes O1/2, PO9/10), and the time

438 periods before and around the time of the saccade, this effect might be attributed to

439 saccade-related perceptual processes.

440 Additional effects of less theoretical significance were identified in our analyses, including a

441 main effect of *Cue Direction* (Figure 6A), and the substantial effects of *Laterality* (Figure 6B)

442 as well as the *Laterality* × *Cue Direction* interaction (Figure 6G). The *Cue Direction* effect

443 indicated evidence for differences between right side and left side saccade trials at posterior

444 lateral electrodes from ca. 100 to 160 ms and at central electrodes from during the saccade

445 to 170 ms post fixation (Figure 6A). The *Laterality* effect showed strong evidence for

446 widespread effects across the whole post-saccadic time period (Figure 6B). Finally, *Laterality*

447 and *Cue Direction* showed a pronounced interaction across several electrode sites and across

448 the whole analysis time window (Figure 6G). Such laterality effects might be related to face

449 processing differences between hemispheres (Frässle et al., 2016; Schweinberger et al.,

450 2004), specifically, a stronger involvement of right posterior parietal cortex in oculomotor  
451 control or remapping processes (for review see Pisella et al., 2011; Prime et al., 2011), or  
452 some other factor beyond the scope of the current study. These factors were modeled in the  
453 analysis in order to control for potential interactions with the preview and target orientation  
454 effects, which were of central theoretical interest here.

455

456 3.3. Experiment 1: ANOVA results in the fN170 time window in line with the whole-  
457 scalp analysis

458 To provide a statistical assessment of the main results from a frequentist perspective, we  
459 computed repeated measures ANOVAs on average ERPs at electrode pair PO7/8, which  
460 typically shows the most pronounced N170 effects (Hinojosa et al., 2015), in the time  
461 window from 165 to 250 ms. This time window is later than the one usually adopted in ERP  
462 studies of the N170 (Bentin et al., 1996), but is appropriate given the extended N170  
463 observed in the invalid preview conditions of our experiment (cf. Figure 5). To assess the  
464 later central-parietal *Preview*  $\times$  *Target Orientation* interaction, we additionally computed a  
465 repeated measures ANOVA at electrode CPz for the later time window of 320 to 400 ms.  
466 The ANOVA results were in line with the evidence from the whole-scalp BF analysis. The  
467 ANOVA showed clear main effects of *Preview*,  $F(1,17) = 36.55$ ,  $p < .001$ , and *Target*  
468 *Orientation*,  $F(1,17) = 8.50$ ,  $p = .010$ , which corroborated the more pronounced N170 in  
469 invalid compared to valid preview conditions and the more pronounced N170 for inverted  
470 compared to upright target faces. The *Target Orientation*  $\times$  *Cue Direction* interaction  
471 approached marginal significance,  $F(1,17) = 4.01$ ,  $p = .062$ , but the corresponding BF = 0.30  
472 suggested that the evidence for this effect is negative. We do not consider this effect any

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473 further. There was also a clear effect of *Laterality*,  $F(1,17) = 20.16$ ,  $p < .001$ , indicating a  
474 more negative ERP contralateral to the side of the target face.

475 One effect differed markedly between the ANOVA on average ERPs and the whole-scalp BF  
476 analysis: The ANOVA showed a highly significant *Preview*  $\times$  *Laterality* interaction,  $F(1,17) =$   
477  $21.53$ ,  $p < .001$ , though a low BF = 0.33 emerged from Bayesian analysis of the same values  
478 (see also Figure 6E). This discrepancy between frequentist and Bayesian results suggests that  
479 the effect is not reliable, although it would have been theoretically meaningful. The direction  
480 of the interaction suggested a larger preview effect – expressed in the difference between  
481 valid and invalid trials – at electrodes contralateral versus ipsilateral to target/saccade  
482 direction. Though the target was foveated, any preview-face-related activity was possibly  
483 lateralized, since the preview face was presented in the periphery and, therefore, projected  
484 primarily to the contralateral hemisphere. Pre-saccadic preview-related activity might have  
485 remained to some degree lateralized across the saccade, and therefore it is plausible that  
486 also the preview effect was larger in the hemisphere contralateral to saccade/cue direction.

487 The ANOVA at electrode CPz on average amplitudes for the 320 to 400 ms time window  
488 confirmed the *Preview*  $\times$  *Target Orientation* interaction,  $F(1,17) = 10.68$ ,  $p = .005$ , and  
489 corroborated the more pronounced target face inversion effect (upright minus inverted)  
490 with an invalid (-1.19  $\mu$ V) compared to with a valid (-0.07  $\mu$ V) preview. This ANOVA also  
491 showed a main effect of *Target Orientation*,  $F(1,18) = 5.90$ ,  $p = .027$ . No other effects were  
492 statistically significant.

493

494 3.4. Experiment 2 replicates the effects from Experiment 1 in tilt discrimination  
495 performance and in the FRP  
496 In contrast to Experiment 1, Experiment 2 contained a more restrictive selection of face  
497 stimuli, which were only presented to the left of fixation, and the proportion of valid and  
498 invalid trials was manipulated to achieve a mostly-valid (66.6% valid, 33.3% invalid) block  
499 and a mostly-invalid (33.3% valid, 66.6% invalid) block. Overall, Experiment 2 replicated the  
500 preview effects in both behavior (Figure 7) and FRP data (Figure 8). Response times in the tilt  
501 discrimination task were faster in valid than in invalid preview conditions,  $F(1,18) = 31.58$ ,  $p$   
502  $< .001$ ,  $BF = 4.89$  (Figure 7A). There was no preview effect in error rates  $F(1,18) < 1$ ,  $BF = 0.19$   
503 (Figure 7B). The FRP again exhibited a pronounced preview effect in the fN170 component  
504 (Figure 8E), which was corroborated by a repeated measures ANOVA on average ERPs at  
505 right hemisphere electrode PO8 in the time window 165 to 250 ms,  $F(1,22) = 41.46$ ,  $p < .001$ .  
506 Note that, since preview face stimuli were only presented in the left visual field in this  
507 experiment, we focused the ERP analysis on the right hemisphere (i.e. electrode PO8). The  
508 evidence for the preview effect was, however, similar at the corresponding electrodes on  
509 the left hemisphere, as can be seen in Figure 8E.  
510 Like the preview effect, also the clear target orientation effect from Experiment 1 was  
511 replicated in Experiment 2. Responses in the tilt discrimination task were faster,  $F(1,18) =$   
512  $14.23$ ,  $p = .001$ ,  $BF = 10.00$ , and clearly more accurate,  $F(1,18) = 36.94$ ,  $p < .001$ ,  $BF > 100$ , for  
513 upright than inverted target faces. Furthermore, the FRP showed again a clear target face  
514 inversion effect from about 150 ms onwards that further extended across the whole post-  
515 fixation period. Importantly, the target orientation effect was present in the fN170  
516 component consisting in a more negative deflection for inverted compared to upright target

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517 faces (BF evidence in Figure 9A, ERPs in Figure 9E). This effect was confirmed by an ANOVA  
518 at PO8, time window 165 to 250 ms, with  $F(1,18) = 14.54, p = .001$ .

519 Additionally, error rates indicated an interaction of *Preview* and *Target Orientation* factors,  
520  $F(1,18) = 7.00, p = .016$ , which can be interpreted as a *Preview Orientation* main effect. This  
521 effect indicated slightly higher error rate with inverted (21.8%) compared to upright (20.5%)  
522 preview faces. The BF for this effect was, however, indecisive and, if anything, suggested the  
523 absence an effect,  $BF = 0.47$ . We do not further consider this effect.

524 As in Experiment 1, the early FRP also showed a clear *Preview*  $\times$  *Target Orientation*  
525 interaction – the statistical expression of a *Preview Orientation* effect – starting already at  
526 around 50 ms and extending to 170 ms post fixation onset (Figure 9C). As can be seen from  
527 Figure 9E, this effect reflected a more negative P1 with inverted compared to upright  
528 preview faces, although the preview face was replaced by the target face at that point of the  
529 trial and the target face could have had a different overall orientation.

530 Again, as in Experiment 1, evidence for the *Preview*  $\times$  *Target Orientation* interaction became  
531 positive again around 350 ms over central-parietal cortex (Figure 9C). When evaluated at  
532 electrodes CPz in the time window 320 to 400 ms, the target orientation effect - consisting  
533 of a stronger negativity for inverted compared to upright targets,  $F(1,18) = 5.59, p = .030$  -  
534 was more pronounced with an invalid ( $-1.20 \mu\text{V}$ ) rather than valid preview ( $0.13 \mu\text{V}$ ),  $F(1,18)$   
535  $= 11.49, p = .003$ . As in Experiment 1, this likely reflects increased processing of the target  
536 face orientation if the target presents information that conflicts with the preview. Overall,  
537 the results of Experiment 2 reproduced the results observed in Experiment 1.

538



539 3.5. Experiment 2: The proportion manipulation affected tilt discrimination  
540 performance and the FRP, but it did not modulate the magnitude of the  
541 preview effect in the fN170

542 Experiment 2 tested whether the preview effect found in Experiment 1 was the result of a  
543 contextual prediction mechanism across trials, in the sense that it is influenced by  
544 expectations based on the frequency of events over an extended period of time rather than  
545 a single saccade. If the preview effect results from such a context-specific prediction  
546 mechanism, then it should be larger in blocks with mostly valid trials compared to blocks  
547 with mostly invalid trials (Figure 3). We therefore expected to find a *Preview × Proportion*  
548 interaction in the behavioral data of the tilt discrimination task and in the N170 component  
549 of the FRP.

550 Interestingly, some hint for a *Preview × Proportion* interaction was provided by response  
551 times,  $F(1,18) = 5.64$ ,  $p = .029$ , suggesting a slightly larger preview effect (57 ms) in the  
552 mostly valid block compared to the mostly invalid block (34 ms), which was the expected  
553 direction of the effect. However, the corresponding  $BF = 0.29$  suggested no effect of this  
554 interaction, which renders the evidence rather uncertain. Another inconsistency in the  
555 response time data manifested in the main effect of *Proportion* which was not significant,  
556  $F(1,18) = 2.14$ ,  $p = .161$ , but exhibited  $BF = 38.23$ .

557 In the error rates, the *Preview × Proportion* interaction was not significant,  $F(1,18) < 1$   
558 (absence of effect confirmed by  $BF = 0.33$ ) and also the *Proportion* main effect was not  
559 significant,  $F(1,18) = 0.05$ ,  $p = .828$  (absence of effect confirmed by  $BF = 0.18$ ).

560 In contrast to these equivocal behavioral results, the EEG data provided compelling evidence  
561 for the same fN170 preview effect in both mostly-valid and mostly-invalid blocks. BF values  
562 less than 0.33 at posterior lateral electrodes, where the fN170 preview effect is located,

563 indicated the clear absence of a *Preview* × *Proportion* interaction (Figure 8F), and this was  
564 supported in repeated measures ANOVA analysis on ERPs at PO8 from 165 to 250 ms,  
565  $F(1,18) = 0.32, p = .581$ , at PO7,  $F(1,18) = 0.57, p = .462$ . As can be seen from the ERPs in  
566 Figure 8G, the difference in the amplitude between valid (solid line) and invalid trials  
567 (dashed line) was the same in mostly-valid and in mostly-invalid blocks. This crucial result  
568 suggests that the magnitude of the trans-saccadic preview effect in the fN170 component is  
569 not the result of context-sensitive predictions, which contrasts ideas about the predictive  
570 nature of the N170 (Johnston et al., 2017).

571 One might argue that the proportion manipulation was simply not strong enough to trigger a  
572 change in the fN170 preview effect. The proportion manipulation had, however, a  
573 pronounced influence on the FRP, in particular contralateral to the target face (right  
574 hemisphere) at posterior electrodes (Figure 9B). The direction of this effect at electrode PO8  
575 is illustrated in Figure 8G, with a more negative fN170 component emerging in the mostly-  
576 valid rather than mostly-invalid condition. This effect emerged in an ANOVA on ERPs at PO8,  
577 time window 165 to 250 ms,  $F(1,18) = 12.77, p = .002$ . This clear influence of the proportion  
578 manipulation demonstrates that the 66.6% versus 33.3% manipulation was strong enough to  
579 influence neural processing. This effect in the EEG was probably linked to a difference in  
580 gaze behavior. As demonstrated in the analysis of gaze behavior (section 3.8. above), there  
581 was also a difference in gaze behavior between the two blocks: a proportion main effect  
582 emerged in the distribution of fixations on the target face. This pattern of results suggest  
583 that the proportion manipulation was indeed strong enough to affect the participants' gaze  
584 behavior and their EEG response, although it did not modulate the magnitude of the preview  
585 effect in the fN170.

586 Apart from these *Proportion* effects of main interest, the factor *Proportion* interacted with  
587 *Target Orientation* later in the FRP and, surprisingly, in ipsilateral electrodes (Figure 9D, 9G).  
588 The effect was significant in an ANOVA on average ERPs at PO7, time window 550 to 800 ms,  
589  $F(1,18) = 6.34, p = .021$ , suggesting that the late target face orientation effect was larger in  
590 the mostly valid than in the mostly invalid block. This effect possibly indicates some variation  
591 in higher-level processing of the target face depending on the long-run frequency of valid  
592 and invalid trials. The reasons for its direction and for its ipsilateral location are, however,  
593 unclear. In any case, this finding does not influence our conclusions about the preview effect  
594 and its modulation by proportion.

595

596 3.6. Experiment 2: Evidence for pre-saccadic expectations in the preview-locked

597 EEG response

598 If the proportion manipulation consisting in a block of mostly valid and a block of mostly  
599 invalid trials introduced expectations about the validity of a single trial, the preview face  
600 might have already been processed differently in mostly valid compared to mostly invalid  
601 blocks. Thus, expectation or prediction effects might already be present before the eye-  
602 movement during the preview period. We therefore analyzed the pre-saccadic period of the  
603 EEG signal, time-locked to the preview face display onset, with the factors *Preview*  
604 *Orientation* (upright, inverted), *Proportion* (mostly valid, mostly invalid), and *Target*  
605 *Orientation* (valid, invalid). It is important to note that target orientation was unknown  
606 during the preview period and that the preview face was actually task-irrelevant since the  
607 task only involved the tilt of the post-saccadic target stimulus.

608 First, we found a classical N170 face inversion effect in response to preview face orientation  
609 as expected from an EEG study using face stimuli. Strong evidence from a whole-scalp BF

610 (Figure 8A) demonstrated a more pronounced N170 for inverted compared to upright  
611 preview faces (Figure 8C). This effect was corroborated by an ANOVA on ERPs at PO8, from  
612 200 to 260 ms,  $F(1,18) = 29.63$ ,  $p < .001$ . Compared to previous EEG studies on face  
613 perception showing an onset of the N170 largely around 150 to 200 ms (Bentin et al., 1996;  
614 Eimer, 2000; Eimer et al., 2010; Itier and Taylor, 2004a, 2004b; Rossion et al., 2000; Towler  
615 et al., 2012; Watanabe et al., 2003), our N170 appeared rather late at 200 ms (Figure 8A).  
616 This discrepancy might be explained by a difference in stimulus position. Previous studies on  
617 the N170 usually presented faces at the fovea (for an exception see Pajani et al., 2017),  
618 whereas our stimuli occurred further from fixation (cf. Buonocore et al., 2019, for a similar  
619 result in this respect).

620 Instead of impacting early stages of post-saccadic processing, the proportion manipulation  
621 influenced later stages of the face inversion effect. Specifically, in the second half of the  
622 preview period, an inverted preview face led to a more negative deflection than an upright  
623 preview face (Figure 8A, 8C), corroborated by an ANOVA on average ERPs at PO8, from 300  
624 to 450 ms,  $F(1,18) = 21.70$ ,  $p < .001$ . This effect possibly reflects a modulation of the N250 or  
625 N400 face processing components (Schweinberger and Neumann, 2015). Interestingly, as  
626 can be seen from Figure 8C, this late preview face orientation effect declined earlier in the  
627 mostly invalid than in the mostly valid block. In particular, between cue onset (at 500 ms)  
628 and saccade onset (see the histogram of saccade latencies in Figure 8D) the preview face  
629 orientation effect had disappeared in the mostly invalid block but was still present in the  
630 mostly valid block. This earlier reduction of the preview face orientation effect in the mostly  
631 invalid compared to the mostly valid blocks around the time of cue onset is further  
632 illustrated in the scalp maps in Figure 10. BF evidence for the corresponding *Preview*  
633 *Orientation*  $\times$  *Proportion* interaction is presented in Figure 8B. An ANOVA on average ERPs at

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634 PO8, 450 to 600 ms post preview onset, corroborated this interaction,  $F(1,18) = 16.99$ ,  $p =$   
635  $.001$ . Critically, this effect could not simply be explained by a difference in saccade latencies  
636 between mostly valid and mostly invalid blocks, because saccade latencies did not differ  
637 between *Preview Orientation* and *Proportion* conditions: *Proportion* main effect,  $F(1,18) =$   
638  $0.63$ ,  $p = .439$ ,  $BF = 1.14$ , *Preview Orientation* main effect,  $F(1,18) = 0.14$ ,  $p = .714$ ,  $BF = 0.17$ ,  
639 *Preview Orientation*  $\times$  *Proportion*,  $F(1,18) = 0.00$ ,  $p = .997$ ,  $BF = 0.24$ . As expected, also the  
640 factor *Target Orientation* did not affect saccade latencies, all  $ps > .089$ , all  $BFs < 0.29$ . The  
641 more sustained preview orientation effect in the mostly valid compared to the mostly invalid  
642 block might therefore reflect the degree to which the target image was processed or the  
643 degree of expectations about the upcoming target orientation based on the pre-saccadic  
644 input.

645 Apart from these effects of main interest, the whole-scalp analysis of the pre-saccadic period  
646 revealed also a main effect of *Proportion* (Figure 11A), and some unsystematic effects  
647 involving *Target Orientation* (Figure 11B-E). The main effect of *Proportion* simply suggests a  
648 more positive ERP primarily at PO10 and at central-parietal electrodes in the mostly invalid  
649 compared to the mostly valid condition between cue onset and saccade onset, corroborated  
650 by an ANOVA on average ERPs, 500 to 650 ms after preview onset, at PO10,  $F(1,18) = 17.54$ ,  
651  $p = .001$ . This effect emphasizes that the influenced of *Proportion* on the EEG response in  
652 general. Compared to the other effects observed in this dataset, the effects involving *Target*  
653 *Orientation* were very short-lived and their spatiotemporal pattern varied considerably  
654 (Figure 11B-E).

655

656 3.7. Experiment 2: The onset of the N170 face inversion effect in the preview  
657 period was later than the onset of the FRP N170 face inversion effect  
658 As can be seen from Figure 8, the N170 in the event-related potential (ERP) elicited by the  
659 onset of the preview display appeared a bit later than the N170 in the FRP (see in particular  
660 Figure 8C and 8G). To determine the statistical evidence for this effect, we computed onset  
661 latencies of the face inversion effect expressed as difference waveform between trials with  
662 upright and inverted faces at electrode PO8. Specifically, we computed upright-minus-  
663 inverted preview orientation ERPs separately for mostly valid and mostly invalid blocks for  
664 the ERP aligned to the preview display. For the FRP, we computed upright-minus-inverted  
665 target orientation ERPs separately for mostly valid and mostly invalid blocks and also  
666 separately for trials with valid and invalid preview. The design for the latency onset analysis  
667 was, thus, a 2 (*Proportion*: mostly valid, mostly invalid)  $\times$  3 (*Preview*: valid/FRP, invalid/FRP,  
668 undefined/ERP) design. Onset latencies of the face inversion effect were defined via a 50%  
669 peak amplitude criterion based on jack-knifed subsamples. In other words, the onset latency  
670 was the time stamp of the sample at which the leave-one-participant-out averaged  
671 difference waves between upright-minus-inverted face ERPs reached the value closest to  
672 50% of its maximum activation within 100 to 250 ms after preview-display-onset/fixation-  
673 onset (Miller et al., 1998; Ulrich and Miller, 2001). These latency onset values were  
674 subjected to a repeated measures ANOVA with the factors *Preview* (valid/FRP, invalid/FRP,  
675 undefined/ERP) and *Proportion* (mostly valid, mostly invalid). The resulting *F* and *p*-values  
676 were corrected for the reduced error introduced by jack-knifing (Ulrich and Miller, 2001). It  
677 is at present unclear how a Bayes factor would have to be corrected for the reduced error  
678 due to jack-knifing. To avoid this issue, we applied the correction factor that counteracts the  
679 reduction in error,  $(n-1)^2$  (Ulrich and Miller, 2001, see in particular Appendix), to the error

680 sum of squares term obtained from the ANOVA, which allows Bayes factor approximations  
681 (Huber-Huber, 2016; Masson, 2011; Nathoo and Masson, 2016; Wagenmakers, 2007).  
682 This latency onset analysis of the preview-locked and the fixation-locked face inversion  
683 difference waves showed a main effect of *Preview* (valid/ERP, invalid/ERP, undefined/FRP),  
684  $F(2,36) = 27.18, p < .001, BF_{\text{approx}} > 100$ . Post-hoc tests based on Scheffe's interval as critical  
685 difference (Ulrich and Miller, 2001) revealed a significantly (at alpha-level .05) shorter  
686 latency of the face inversion effect in the valid/FRP than in both the invalid/FRP and the  
687 undefined/ERP condition, but not between the invalid/FRP and the undefined/ERP condition  
688 (Figure 12). Both the factor *Proportion*,  $F(1,18) = 0.70, p = .413, BF_{\text{approx}} = 0.330$ , and the  
689 *Preview*  $\times$  *Proportion* interaction,  $F(2,36) = 0.15, p = .863, BF_{\text{approx}} = 0.031$ , were not  
690 significant.

691

### 692 3.8. Experiments 1 and 2: Gaze characteristics

693 In order to rule out possible confounds resulting from systematic difference in gaze behavior  
694 across conditions, we analyzed saccade size, fixation duration, and the spatiotemporal  
695 distribution of target fixations in the same designs and with the same set of trials as in the  
696 corresponding behavioral and EEG data analyses.

697 We first checked whether the fN170 preview effect could have been confounded to some  
698 extent by *saccadic amplitudes*. The effect occurred at the time of the first post-saccadic  
699 positive deflection, which is also known as the lambda response, and this component is  
700 certainly influenced by saccade amplitude (e.g. Dimigen et al., 2011, Kaunitz et al., 2014;  
701 Ries et al., 2018). In Experiment 1, no significant effects in saccade amplitude were found;  
702 only Bayes factors provided strong evidence for a difference in saccade amplitude between  
703 saccades to the left ( $8.07^\circ$ ) and right ( $8.28^\circ$ ),  $F(1,17) = 2.76, p = .115, BF > 100$ . This piece of

704 evidence might provide some weak explanation for the saccade/cue direction effect in the  
705 FRP signal (cf. Figure 6A), however, because of the lack of any interaction effects with  
706 preview and face orientation, it cannot fully account for the fN170 preview effect and does,  
707 thus, not present a confound. Saccadic reaction times in Experiment 2 did not differ  
708 significantly across conditions and Bayes factor provided evidence for absence of all effects.  
709 Differences in saccade size across conditions cannot therefore account for the face  
710 orientation effects in the EEG.

711 We then checked whether differences in *fixation durations* across conditions could have  
712 affected the FRP, in particular at later stages, despite ocular artefact correction (see section  
713 2. *Materials & Methods*). Surprisingly, in both Experiments 1 and 2, target fixation durations  
714 differed depending on the orientation of the preview face. In Experiment 1, upright preview  
715 faces led to longer subsequent target fixations (538 ms) than inverted preview faces  
716 (487 ms),  $F(1,17) = 18.24$ ,  $p = .001$ ,  $BF = 30.54$ . This effect further appeared to be modulated  
717 by *Cue Direction*,  $F(1,17) = 16.19$ ,  $p = .001$ , however with a weak  $BF = 1.43$ , which suggested  
718 an influence of preview face orientation primarily for saccades to the right,  $F(1,17) = 29.95$ ,  
719  $p < .001$ ,  $BF > 100$ , and not for saccade to the left,  $F(1,17) = 2.40$ ,  $p = .139$ ,  $BF = 0.38$ . The  
720 same preview orientation effect was present in Experiment 2,  $F(1,18) = 7.53$ ,  $p = .013$ ,  $BF =$   
721  $20.75$  (upright 637 ms, inverted 595 ms), which featured only saccades to the left per design  
722 and therefore contrasts Experiment 1. In addition, in Experiment 2, *Preview Orientation*  
723 interacted with *Target Orientation* presenting a *Preview* effect,  $F(1,18) = 5.52$ ,  $p = .030$ ,  $BF =$   
724  $1.50$ , providing weak evidence for somewhat longer fixations with valid (629 ms) than with  
725 invalid previews (603 ms). These mixed results demonstrate an influence of the preview face  
726 orientation on post-saccadic processing. We can, however, only speculate about the reasons  
727 for this effect. In general, inverted faces are uncommon in our everyday lives. Thus, inverted



728 preview faces might elicit shorter primary fixations in order to more quickly gain additional  
729 information about this surprising (inverted) visual input by a secondary fixation.  
730 Importantly, the difference in fixation durations between upright and inverted preview faces  
731 in Experiment 1 and 2 and in particular the statistically weak difference between valid and  
732 invalid trials in Experiment 2 are unlikely to have confounded the preview and face  
733 orientation effects in the FRP. The early effects (around 100 ms), the fN170 effect, and the  
734 later more central *Preview* × *Target Orientation* interaction occurred in Experiment 1 more  
735 than 100 ms before the average fixation end in the condition with the shorter fixation  
736 duration (inverted preview face, 487 ms, cf. Figure 5), and in Experiment 2 more than  
737 200 ms before (inverted preview face, 595 ms, cf. Figure 9). In other words, the fixation  
738 durations were too long for artifacts from the secondary saccades to influence such early  
739 components. Given this temporal sequence, it seems more likely that the effects in the EEG  
740 were actually precursors for the differences in fixation durations, rather than the other way  
741 around.

742 In theory, a difference in *fixation location* might also have influenced the FRP, because  
743 differences in fixation locations imply differences in low-level visual input that affect visual  
744 ERP responses (De Lissa et al., 2014). To rule out this confound, we analyzed the distribution  
745 of target fixations with *iMap4* (Lao et al., 2017). This toolbox models fixation location and  
746 duration by creating a heat map and by fitting a linear mixed model with predictors  
747 according the experimental design to each pixel of the heat map. As suggested by Lao and  
748 colleagues (2017), we used a Gaussian kernel with full width at half maximum (FWHM) of 1°  
749 visual angle to smooth the pixel-resolved fixation data, thereby accounting for residual  
750 spatial uncertainty and to approximate the span of foveal input. A random intercept for  
751 participants was included in the model, but we omitted random slopes because of

752 convergence errors. Note that omitting random slopes usually overestimates associated  
753 fixed effects (Barr et al., 2013; Matuschek et al., 2017) and should therefore be avoided.  
754 Since we were interested in ruling out potential confounds, such a less conservative  
755 approach was, however, appropriate. Further, we used bootstrapping with  $n=1000$   
756 resamples and the default clustering approach with cluster mass. In order to compare  
757 fixation distributions for both target faces left and right in Experiment 1, we mapped the  
758 fixation locations for right side targets to the left side without mirroring them, that is, by  
759 subtracting the x-axis distance between the centers of the two target faces from the x-axis  
760 coordinates of right target face fixations.

761 Figure 13 shows grand-average heat maps and significant effects for Experiments 1 and 2.  
762 Target fixations accumulated around the nose in both Experiments (Figures 13A and 13B). In  
763 Experiment 1, fixation patterns differed only between saccades to the left and saccades to  
764 the right (Figure 13C). Similar to the saccade amplitude difference mentioned above, this  
765 pattern could be related to the cue direction effects in the FRP (cf. Figure 6A). In Experiment  
766 2, fixation patterns differed only between the mostly valid and mostly invalid proportion  
767 blocks (Figure 13D). This difference in gaze behavior might be related to the proportion main  
768 effect in the FRP signal (Figure 9B). It is possible that the proportion effect in the EEG  
769 resulted from a low-level difference in visual input caused by differences in fixation  
770 distributions between blocks. This result provides further evidence that the proportion  
771 manipulation was in general strong enough to affect the participants' behavior. All other  
772 effects were not significant, which suggests that differences in the distribution of fixations  
773 on the target face cannot explain the preview and target orientation effects of main interest.  
774

## 775 4. Discussion

776 We investigated the time course of trans-saccadic perception in a combined EEG and eye-  
777 tracking study. In Experiment 1, we found a peripheral preview effect both in behavior and  
778 in the lateralized posterior fN170 component. Behaviorally, participants were more efficient  
779 in discriminating target-face tilt after a valid peripheral preview than after an invalid  
780 preview. In line with this result, the fN170 component was clearly more pronounced with an  
781 invalid than with a valid preview, which is the same effect direction as the preview positivity  
782 known from reading research (Dimigen et al., 2012, in particular their Figure 3B). Our  
783 preview effect with faces emerged, however, much earlier than the preview positivity for  
784 reading (ca. 120 ms versus ca. 180 ms post fixation). We also found a later centroparietal  
785 effect similar to the later and more central preview component in reading research (Dimigen  
786 et al., 2012, their Figure 3B). Again, our late effect started earlier and consisted of a *Preview*  
787  $\times$  *Target Orientation* interaction rather than a *Preview* main effect, suggesting more in-depth  
788 processing of the target face orientation after an invalid compared to with valid preview.  
789 These results suggest that trans-saccadic integration effects can be found at different  
790 temporal scales for different types of stimuli, possibly related to the different time course  
791 for processing these stimuli at the level of categorization and meaning (e.g. Herrmann et al.,  
792 2005; Sereno and Rayner, 2003).

793 In addition to the trans-saccadic preview effect in the fN170, we found a clear face inversion  
794 effect (Bentin et al., 1996; Eimer, 2000; Eimer et al., 2010; Itier and Taylor, 2004a, 2004b;  
795 Rossion et al., 2000; Towler et al., 2012; Watanabe et al., 2003). This effect was also present  
796 as expected in response times and error rates, with better performance with upright than  
797 with inverted target faces. Importantly, the target orientation and preview effects were  
798 additive, suggesting that they reflect two independent processes, one for the structural

799 processing of faces (e.g. Bentin et al., 1996) and one for trans-saccadic integration. The  
800 additive nature of these two effects is particularly apparent when comparing the waveforms  
801 for an inverted preview face followed by an upright target face to the waveforms for an  
802 inverted preview face followed by inverted target face (Figure 5D). These two waveforms do  
803 not differ much from each other, very likely because the preview and the face inversion  
804 effects cancelled each other out. An inverted target is expected to elicit a more negative  
805 fN170 than an upright target. Here, the inverted target was preceded by an upright preview  
806 rendering this condition invalid. The upright target was also preceded by an upright preview  
807 rendering this condition in turn valid. If both upright and inverted targets were preceded by  
808 an inverted preview face, the N170 preview effect, with a larger N170 in invalid than in valid  
809 trials, cancelled what would otherwise have appeared as a target face inversion effect.  
810 In addition to increasing the amplitude of the fN170 in general, an invalid preview also  
811 delayed the face inversion effect. This result suggests that EEG studies in controlled  
812 experimental settings without eye movements underestimate the latency of visual EEG  
813 components during natural, unconstrained viewing situations, because real-world  
814 perception usually affords a pre-saccadic preview, resembling the valid condition here.  
815 In Experiment 2, we asked whether the beneficial effect of the preview for post-saccadic  
816 processing, in particular on the fN170 component, was the result of a context-sensitive  
817 prediction process that takes into account validity across multiple events. In other words,  
818 does the trans-saccadic effect across a single eye movement take into account the overall  
819 frequency of valid and invalid trials? The direction of the fN170 preview effect, with a larger  
820 fN170 for invalid than for valid conditions, is consistent with a prediction error signal  
821 (Friston, 2010, 2005; Friston et al., 2012; Summerfield and Egner, 2009; see also Kornrumpf  
822 et al., 2016). If the fN170 preview effect reflected a context-sensitive predictive process, we

823 reasoned that it should adapt to the frequency of events such that it would become larger in  
824 a block with more valid trials and smaller in a block with more invalid trials (Summerfield et  
825 al., 2008). In Experiment 2, however, the same preview effect was found in both blocks and  
826 confirmed by strong statistical evidence from a Bayes factor analysis. Our results therefore  
827 indicate that the fN170 preview effect occurs regardless of context or recent experience,  
828 making it different from many classical prediction effects (at least in the case of 66.6%  
829 versus 33.3% valid blocks). At the same time, we do observe effects of the proportion  
830 manipulation. The N170 preview face inversion effect differed in the mostly valid compared  
831 to the mostly invalid block and there was also a corresponding difference in fixation  
832 distributions between mostly valid and mostly invalid blocks. In sum, this pattern suggests  
833 that the proportion manipulation with 33.3% versus 66.6% was strong enough to influence  
834 gaze behavior and resulting EEG correlates of face processing, but not to impact the  
835 magnitude of the post-saccadic preview effect.

836 Importantly, we also ruled out potentially confounding influences of saccade amplitude and  
837 fixation characteristics on the FRP results. Although we found some evidence for a relation  
838 between gaze behavior and EEG – in particular for the main effect of cue direction in  
839 Experiment 1 and the proportion main effect in Experiment 2 – differences in gaze  
840 characteristics could not explain the preview and target face orientation effects or their  
841 interactions with proportion.

842 The overall pattern of results provides a complex picture of how the N170 is related to visual  
843 predictions. In an elegant study, Johnston and colleagues (2017) showed that violating visual  
844 predictions derived from a sequences of image changes elicited an N170 even in the absence  
845 of eye movements. These authors suggested this component as a potential tool for the study  
846 of sensory predictions across saccadic eye-movements. Moreover, the source of visual

847 prediction errors signals has been localized in the fusiform face area (de Gardelle et al.,  
848 2013a, 2013b) which has also been identified as one of the neural generators of the N170  
849 component (e.g. Corrigan et al., 2009). Our results seem to contrast these findings.  
850 One possibility to resolve this theoretical puzzle is that predictions across saccadic eye  
851 movements (Buonocore et al., 2019; Edwards et al., 2017; Ehinger et al., 2015) might not  
852 obey the same principles as concurrent sensory predictions in the visual system without  
853 saccades (Alink et al., 2010; Johnston et al., 2017). This conjecture implies that the N170 and  
854 the fN170 respond differently to the same type of prediction manipulation, which has not  
855 yet been tested.

856 An alternative is that, although all types of prediction and expectation effects are based on  
857 the regularities and statistics of the environment, there are numerous ways in which these  
858 effects can be instantiated (De Lange et al., 2018) and this might have implications for the  
859 precise neural mechanism that is targeted by the prediction manipulation. For instance,  
860 Johnston and colleagues (2017) studied visual prediction error signals by contrasting  
861 predictable and unpredictable image transitions within systematic sequences of images. The  
862 frequency of predictable and unpredictable trials was, however, balanced. In the present  
863 study, we manipulated the frequency of valid and invalid trials. This methodological  
864 difference may have been critical for the discrepant findings.

865 Finally, although proportion manipulations of 25% versus 75% have been successful in the  
866 past (Summerfield et al., 2008) and our proportion manipulation was of similar magnitude  
867 with 33.3% versus 66.6%, it might still not have been strong enough to trigger an adaptation  
868 of trans-saccadic predictions (Kovács and Vogels, 2014; Mayrhauser et al., 2014). It is well-  
869 known that effects of expectation scale with validity of the prediction just like endogenous  
870 attention scales with cue validity (Giordano et al., 2009; Kok et al., 2012). Hence, more

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871 extensive training with trans-saccadic changes than the one realized in the present design  
872 (e.g. Herwig et al., 2015; Valsecchi and Gegenfurtner, 2016) might modulate the magnitude  
873 or timing of the fN170 preview effect.

874 Overall, our results are consistent with the idea of three stages at which the peripheral  
875 preview might influence visual processing. First, before the saccade, the preview face  
876 inversion effect for the peripherally-presented face was more sustained in blocks with  
877 mostly valid compared to blocks with mostly invalid trials. This suggests that the preview  
878 face orientation is expected to reappear in the mostly valid block, but in the mostly invalid  
879 block participants might rather expect the opposite face orientation after the saccade.

880 Second, at the beginning of the new fixation, we found evidence that neural activity  
881 reflected the preview rather than the image actually present at the fovea, with some  
882 interaction between the preview and post-saccadic stimulus up to the time of the fN170.

883 Third, at the time of the fN170, there was a preview effect consistent with the preview  
884 positivity found previously in studies with visual words but at an earlier latency than in  
885 reading. Interestingly, the trans-saccadic preview effect in the fN170 was independent of the  
886 proportion manipulation. This suggests that some aspects of trans-saccadic integration  
887 might be relatively automatic and resistant to change over the time period of one  
888 experimental session.

889 In any case, the preview effect in the fN170 can still be interpreted as a prediction error in  
890 terms of predictive coding (Grotheer and Kovács, 2016). In a computational sense, predictive  
891 coding only means that, instead of transmitting the complete bottom-up signal from lower  
892 to higher processing levels, only the prediction error is propagated in a feed-forward fashion  
893 (Friston, 2010; Spratling, 2017). Predictive coding therefore does not imply anything about  
894 the critical rate of occurrence of events required for adjusting top-down predictions. Thus,

895 even though the proportion manipulation did not influence the fN170 preview effect, the  
896 preview effect itself might still have resulted from predictive coding circuits (Bastos et al.,  
897 2012), with these circuits not influenced by our proportion manipulation.

898 In conclusion, the current results show a strong effect of a task-irrelevant preview face on  
899 post-saccadic face processing, confirming that perception does not start anew with each  
900 new fixation. We make about three saccades every second, and it takes about 100 - 150 ms  
901 until visual information arrives at ventral-stream areas involved in object recognition (Foxe  
902 and Simpson, 2002). If there was no perception during that time we would miss what is  
903 going on around us for about four hours each day (Melcher and Colby, 2008). In contrast,  
904 the *preview face* orientation effect that we found in the early stage of *post-saccadic*  
905 processing (cf. Mirpour and Bisley, 2016) suggests that, instead of waiting for new visual  
906 input after fixation onset, we perceive what was expected at that location before the eye  
907 movement began.

908

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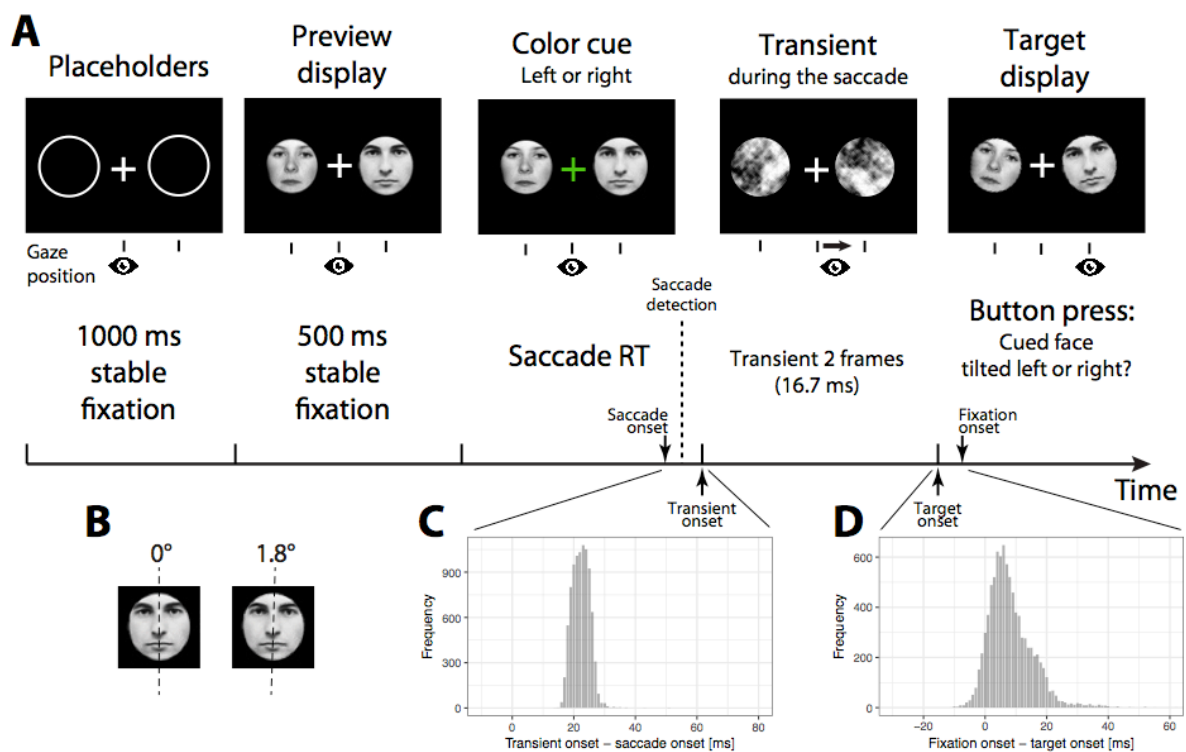
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1209

1210

1211 Figure legends

1212 Figure 1



1213

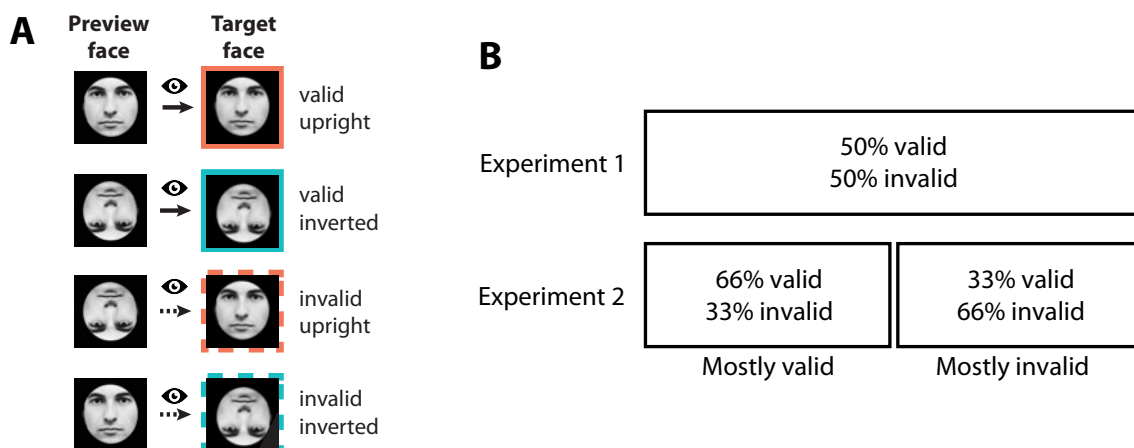
1214 Panel A. Procedure in Experiment 1. A stable fixation for 1000 ms triggered the *Preview*  
 1215 display. Further fixation for 500 ms then triggered the color cue (e.g. green left/blue right,  
 1216 counterbalanced across participants) indicating the required saccade direction and, thus, the  
 1217 target face. Both the target (cued) face and non-target face (opposite side) could be either  
 1218 upright or inverted, and could both either change orientation or remain the same across the  
 1219 saccade. During the saccade, scrambled versions of the faces were presented as transients.

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1220 The transient was replaced by the target display after two frames. The target display  
1221 contained both target and distractor faces with additional slight tilt (left/right, amount of tilt  
1222 is exaggerated in panel A). Panel B shows the true to scale target face tilt of 1.8°. The  
1223 direction of this tilt had to be reported by button press upon fixation onset. Panel C  
1224 illustrates the speed of the online saccade detection. In most trials, the transient was  
1225 presented less than 25-30 ms after saccade onset. The timing of target onset and fixation  
1226 onset is illustrated in panel D. Fixation onset was most of the time after target onset.  
1227 Timeline, stimulus size, and target face tilt in panel A are not drawn to scale.

1228

1229 Figure 2



1230

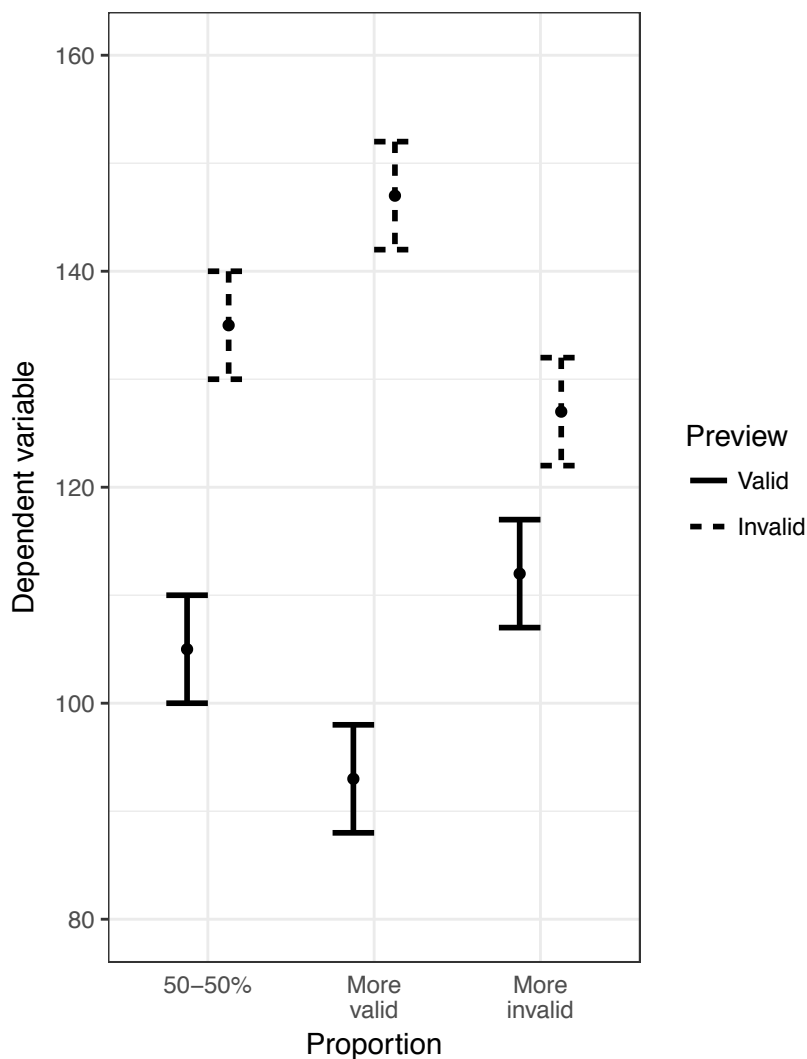
1231 Panel A shows the four possible preview and target face orientation conditions. Both  
1232 *Preview orientation* and *Target orientation* could be upright or inverted leading to in total  
1233 four conditions, two of which contained a valid preview (preview orientation and target  
1234 orientation matched) and two an invalid one (preview orientation and target orientation did  
1235 not match). Panel B shows the proportion of valid and invalid trials in Experiment 1 and 2. In  
1236 Experiment 1, valid and invalid trials occurred at a frequency of 50% throughout the  
1237 experiment. Experiment 2 consisted of two blocks, one with mostly valid (66.6% valid, 33.3%

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1238 invalid) and one with mostly invalid trials (33.3% valid, 66.6% invalid). Block order was  
1239 counterbalanced across participants.

1240

1241 Figure 3



1242

1243 Illustration of the logic of the proportion manipulation to determine the predictive nature of

1244 the preview effect (difference on the y-axis between valid, solid, and invalid, dashed,

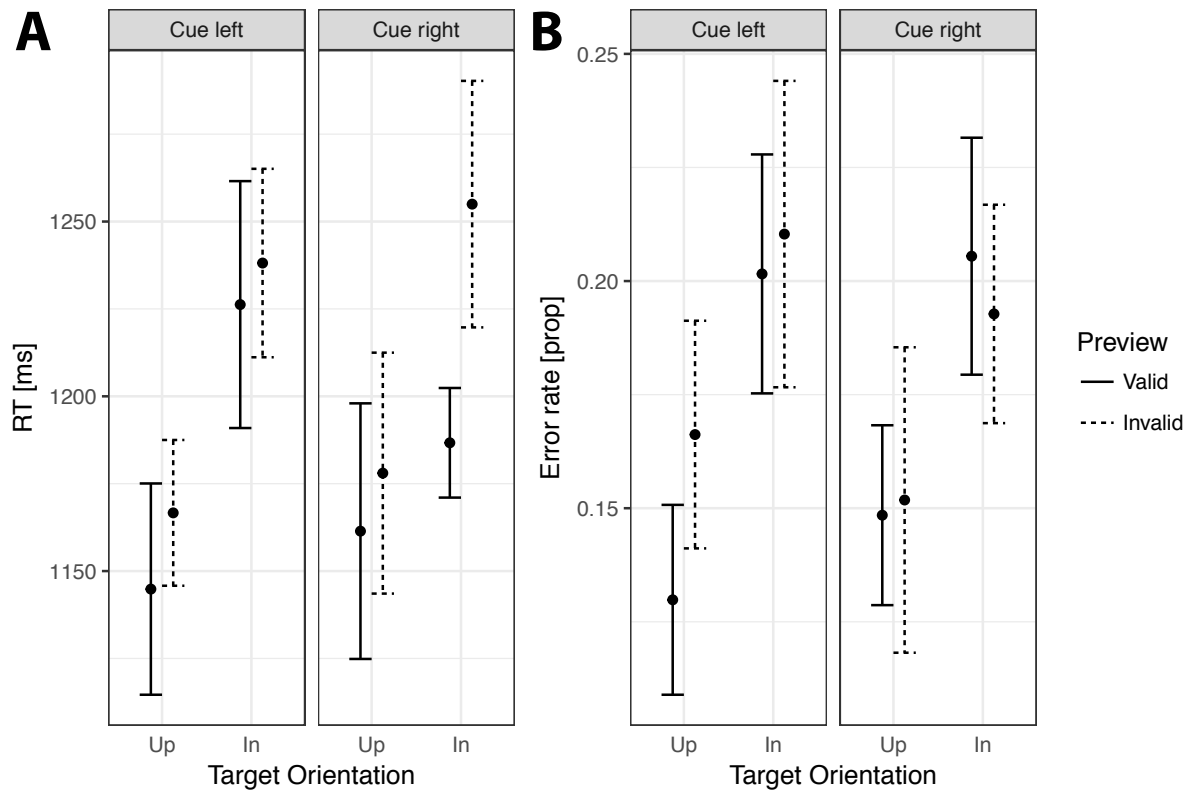
1245 conditions). If the preview effect is predictive, a block with more valid trials is expected to

1246 increase the preview effect, and a block with more invalid trials is expected to decrease the

1247 preview effect.

1248

1249 Figure 4



1250

1251 Mean response times (panel A) and error rates (panel B) in the tilt discrimination task in

1252 Experiment 1, split by the factors *Cue Direction*, *Target Orientation*, and *Preview*.

1253 Participants were faster in valid (solid) than in invalid preview conditions. Target orientation

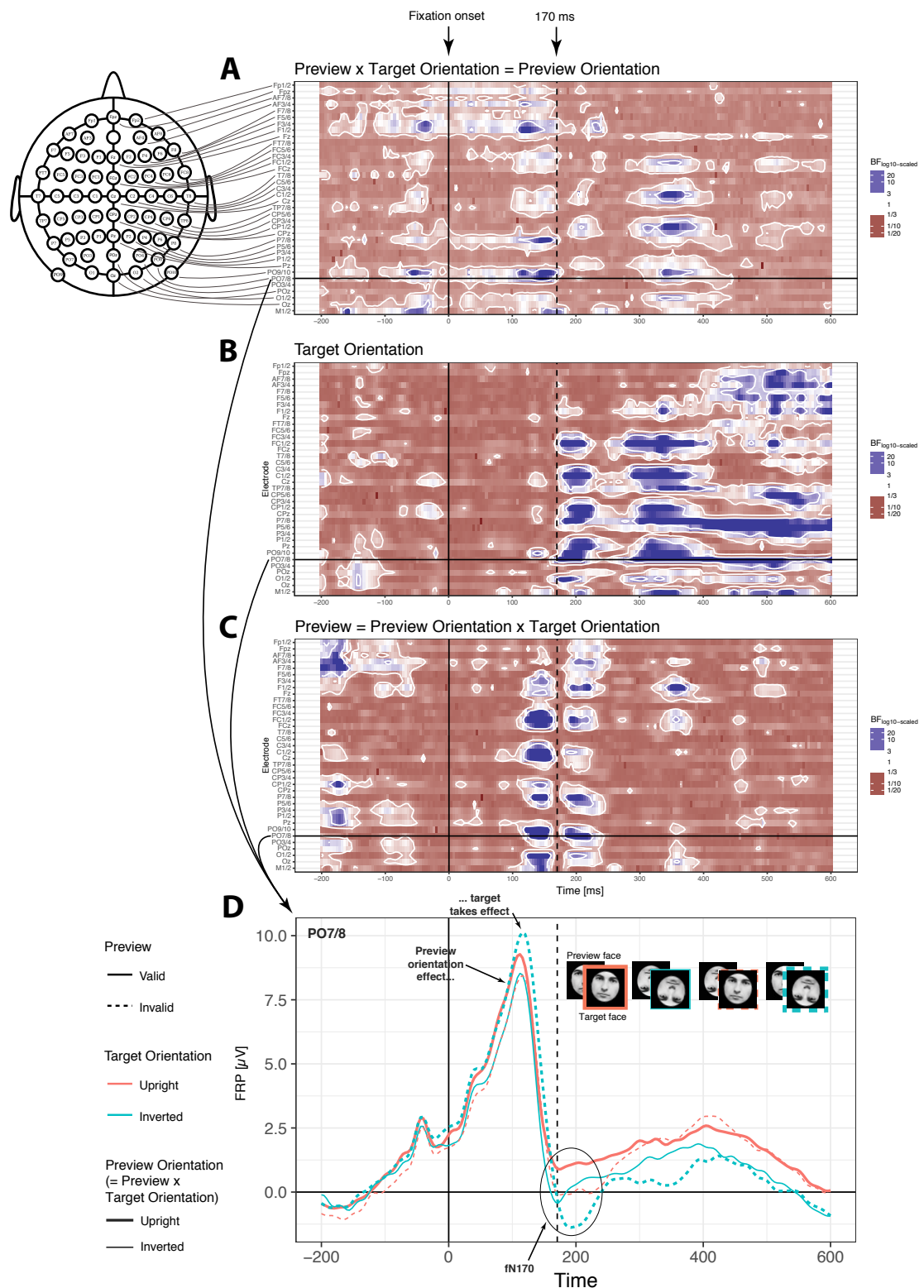
1254 also affected the response: Participants responded faster (panel A) and made fewer errors

1255 (panel B) in trials with upright (Up) compare to with inverted (In) target faces.

1256



1257 Figure 5



1258

1259 Whole-scalp Bayes factor (BF) analysis of the fixation-related potentials (FRP) to the target  
 1260 face (panels A-C). Panel D illustrates the corresponding ERPs at electrode pair PO7/8. Each  
 1261 horizontal row of panel A-C] represents the time-course of the BF for one contra-ipsilateral

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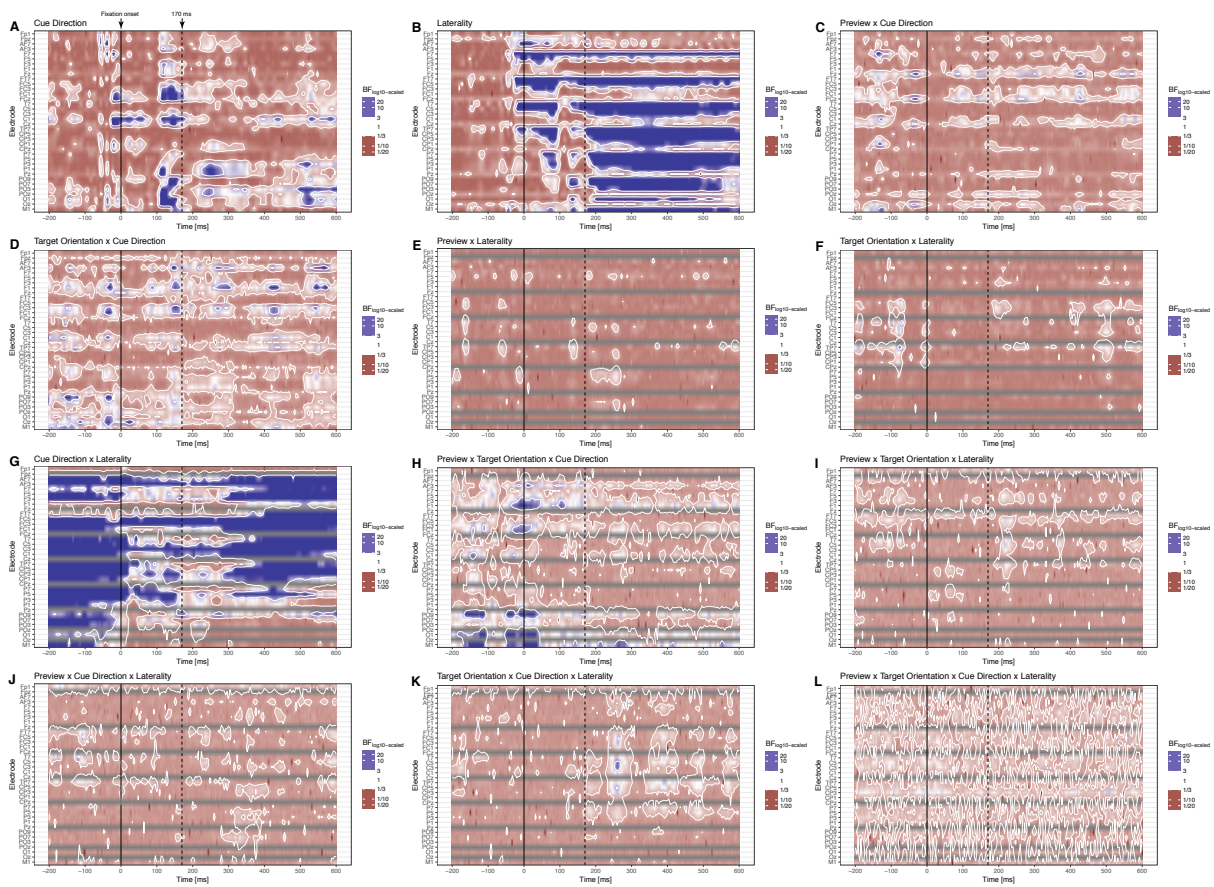
1262 electrode pair, sorted from frontal (top) to posterior (bottom) sites and within this order  
1263 further from lateral (top) to medial (bottom) sites. Values greater than 3 (blue) denote  
1264 positive evidence, values less than 1/3 (red) negative evidence. Values in-between are  
1265 indecisive (white). The thresholds 3 and 1/3 are indicated by two-dimensional white contour  
1266 lines. The vertical dashed line at 170 ms only serves as visual guide and does not indicate any  
1267 event in the experiment.

1268 Panel A shows the *Preview* × *Target Orientation* interaction, aka *Preview Orientation* main  
1269 effect. From ca. 100 ms post fixation onset to 170 ms the orientation of the preview face  
1270 dominated the posterior lateral EEG signal (see also panel D). Evidence for this effect  
1271 became positive again between ca. 300 to 400 ms primarily at central-parietal sites. Panel B  
1272 illustrates the main effect of *Target Orientation*. Evidence for this effect became positive  
1273 from ca. 170 ms post fixation-onset at lateral posterior and some central sites and, after  
1274 some decrease in evidence from ca. 250 to 300 ms extended throughout the post-saccadic  
1275 time-window. The corresponding face inversion effect in the fN170 is illustrated in panel D.  
1276 Panel C shows evidence for the crucial *Preview* effect, aka *Preview Orientation* × *Target*  
1277 *Orientation* interaction. In time windows of ca. 50 ms before and after 170 ms the EEG  
1278 response was more pronounced in valid (preview orientation and target orientation  
1279 matched) compared to invalid (no match) conditions. The ERPs in panel D show this effect in  
1280 the fN170 component at electrode pair PO7/8.

1281 Note that baseline correction was conducted with respect to the time window -200 to 0 ms  
1282 before preview display onset which is outside the plotted time period (cf. Figure 1).

1283

1284 Figure 6

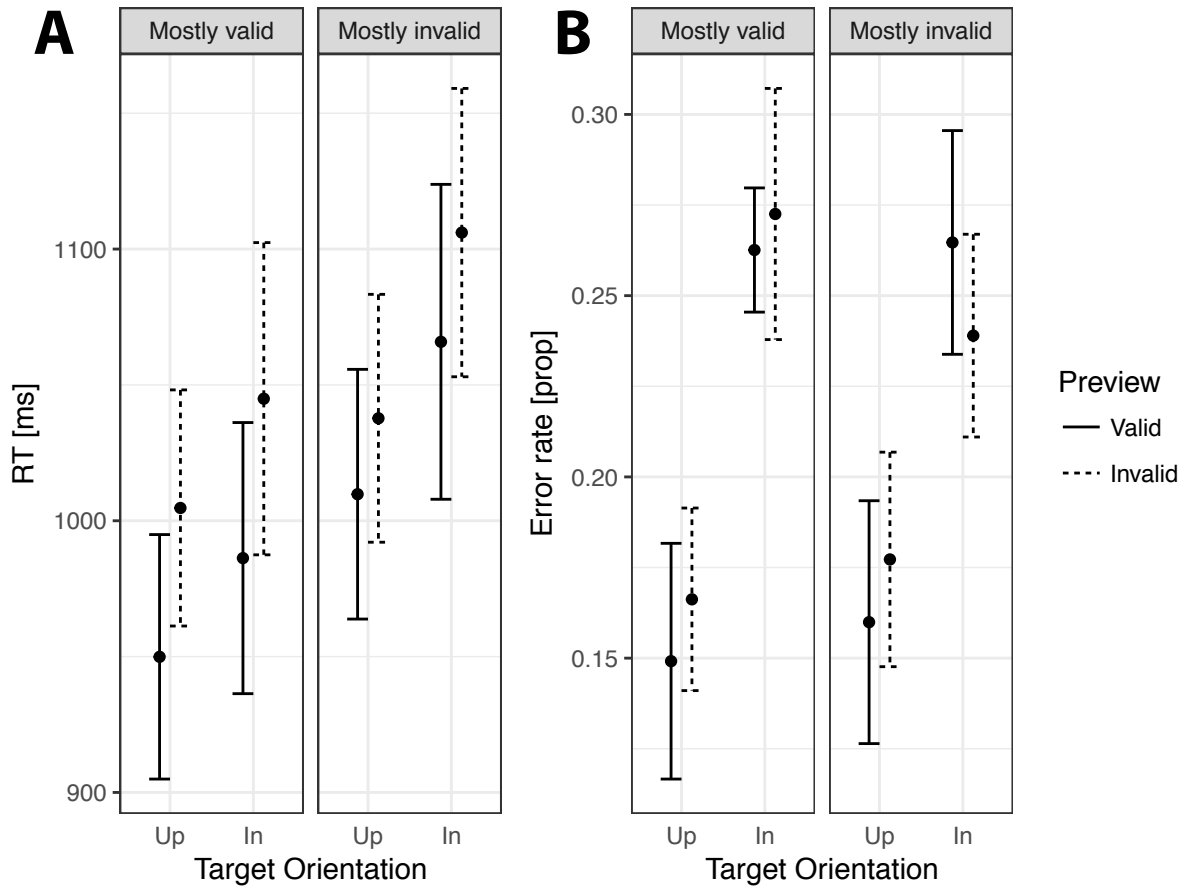


1285

1286 Whole-scalp Bayes factor (BF) for all the remaining main and interaction effects of  
 1287 Experiment 1 not illustrated in Figure 5. Importantly, the *Preview* and *Target Orientation*  
 1288 effects did not interact with other factors in particular not in the spatio-temporal window of  
 1289 the fN170 preview effect at lateral posterior electrodes ca. 50 ms before and after the  
 1290 170 ms time stamp.

1291

1292 Figure 7

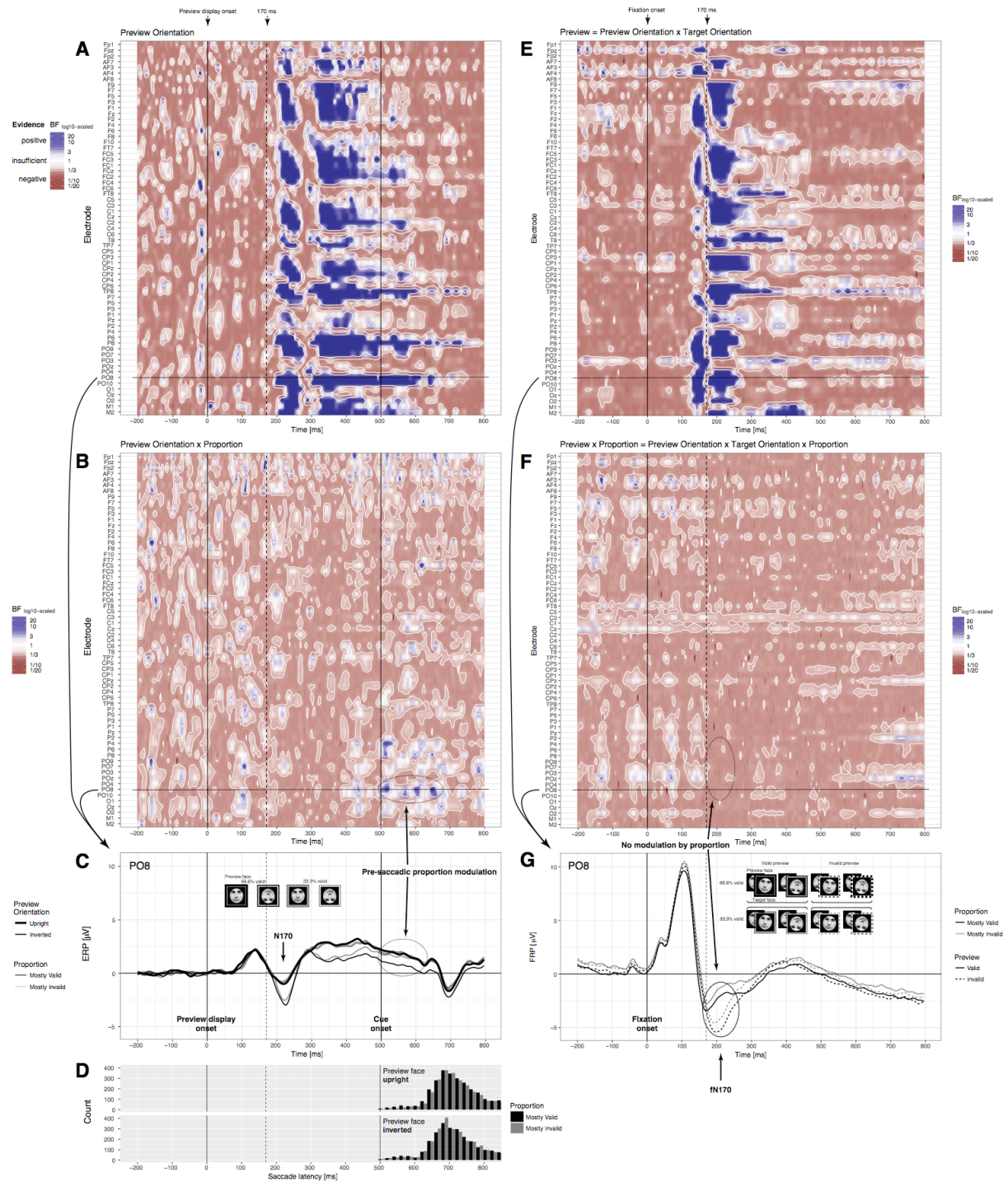


1293

1294 Behavioral results of Experiment 2. Response times (panel A) were faster in valid than in  
 1295 invalid trials, and faster for upright (Up) than for inverted (In) targets. The evidence for the  
 1296 *Preview* (valid, invalid) by *Proportion* (mostly valid, mostly invalid) interaction was unclear  
 1297 (see text). Error rate (panel B) was lower for upright than for inverted targets.

1298

1299 Figure 8



1300

1301 Whole-scalp Bayes factor, ERPs, FRPs, and saccade latencies of the most important effects of

1302 Experiment 2 time-locked to preview display onset (ERP, panels A-D) and time-locked to

1303 fixation onset (FRP, panels E-G). The preview period (panel A) showed positive evidence for a

1304 *Preview Orientation* effect in the N170 and in a later component from ca. 300 ms. Both

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1305 effects showed more negative deflections for inverted than for upright preview faces (panel  
1306 C). With cue onset and before onset of most of the saccades (pane D) this face inversion  
1307 effect at posterior lateral electrodes disappeared earlier in the mostly invalid than in the  
1308 mostly valid block (panel C), evidenced by a *Preview Orientation*  $\times$  *Proportion* interaction  
1309 (panel B).

1310 The preview effect in the fN170 established in Experiment 1 was replicated in Experiment 2  
1311 (panel E). Crucially, the fN170 preview effect was the same in mostly valid and mostly invalid  
1312 blocks (panel G) as evidenced by a BF clearly lower than 1/3 for the *Preview*  $\times$  *Proportion*  
1313 interaction (panel F). Note that panel G contains ERPs averaged across both target  
1314 orientations (upright, inverted). For effects of target orientation see Figure 9.

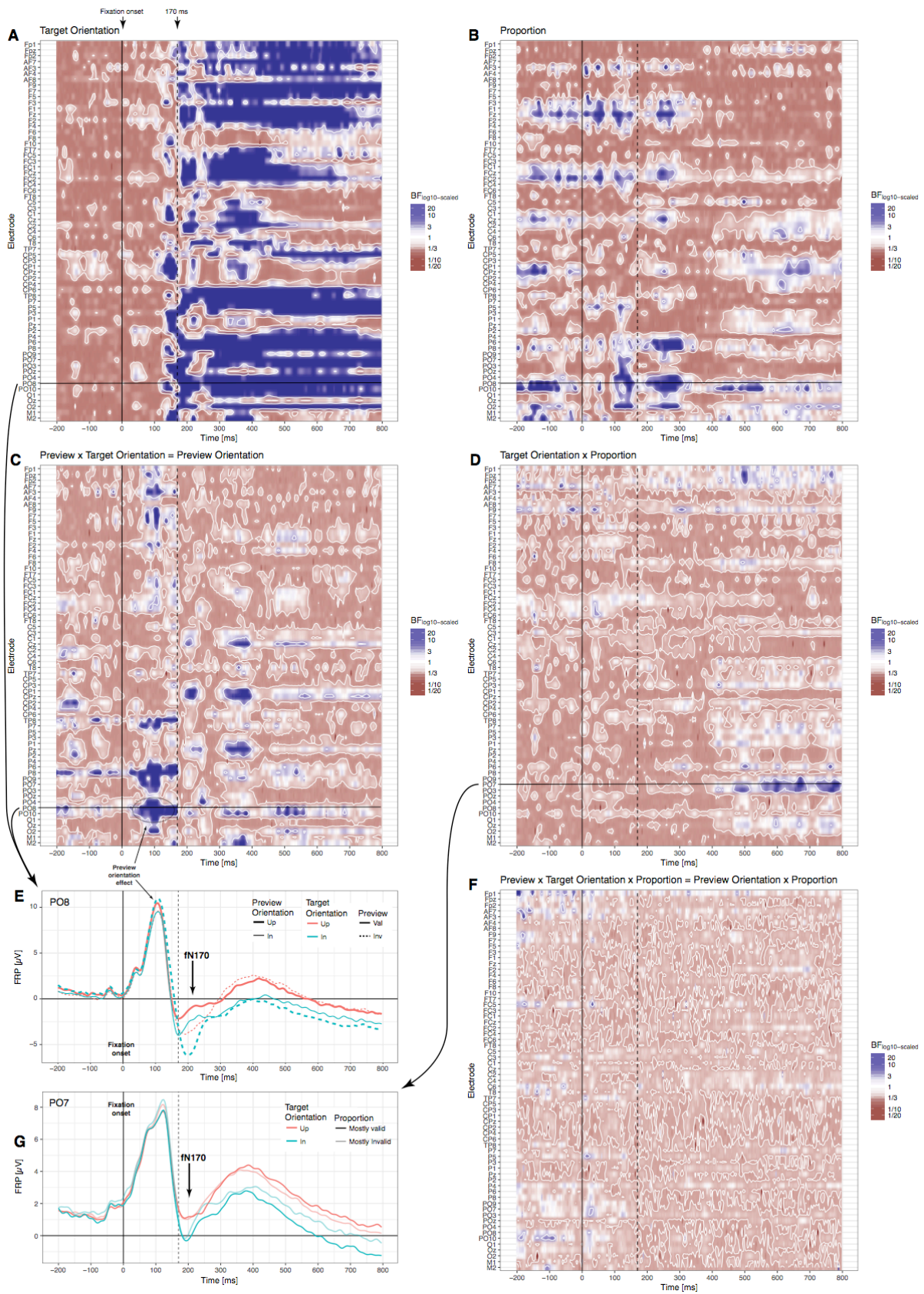
1315 Baseline correction was conducted for the -200 to 0 ms time window before preview display  
1316 onset (panel C).

1317



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1318 Figure 9



1319

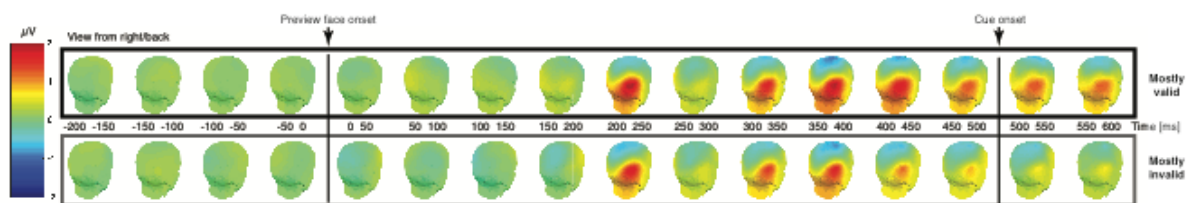
1320 Fixation-locked whole-scalp Bayes factor (BF) for the remaining main and interaction effects

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1321 of Experiment 2 not illustrated in Figure 8. The effects of Experiment 1 were replicated.  
1322 *Target Orientation* elicited again a pronounced face inversion effect in the fN170 and a later  
1323 component commencing at ca. 300 ms post-fixation onset (panel A, panel E). *Preview*  
1324 *Orientation* showed again a face inversion effect in the initial phase of post-saccadic  
1325 processing before 170 ms after fixation onset (panel C, panel E). In addition, the evidence for  
1326 a more negative fN170 in mostly valid compared to mostly invalid blocks was clearly positive  
1327 (*Proportion* main effect, panel B, corresponding ERPs in Figure 8G). Finally, the *Target*  
1328 *Orientation* effect was more sustained in the mostly valid compared to the mostly invalid  
1329 blocks in a very late time window and surprisingly at ipsilateral sites (panel D). Evidence for  
1330 the three-way interaction was largely indecisive (panel F).

1331

1332 Figure 10



1333

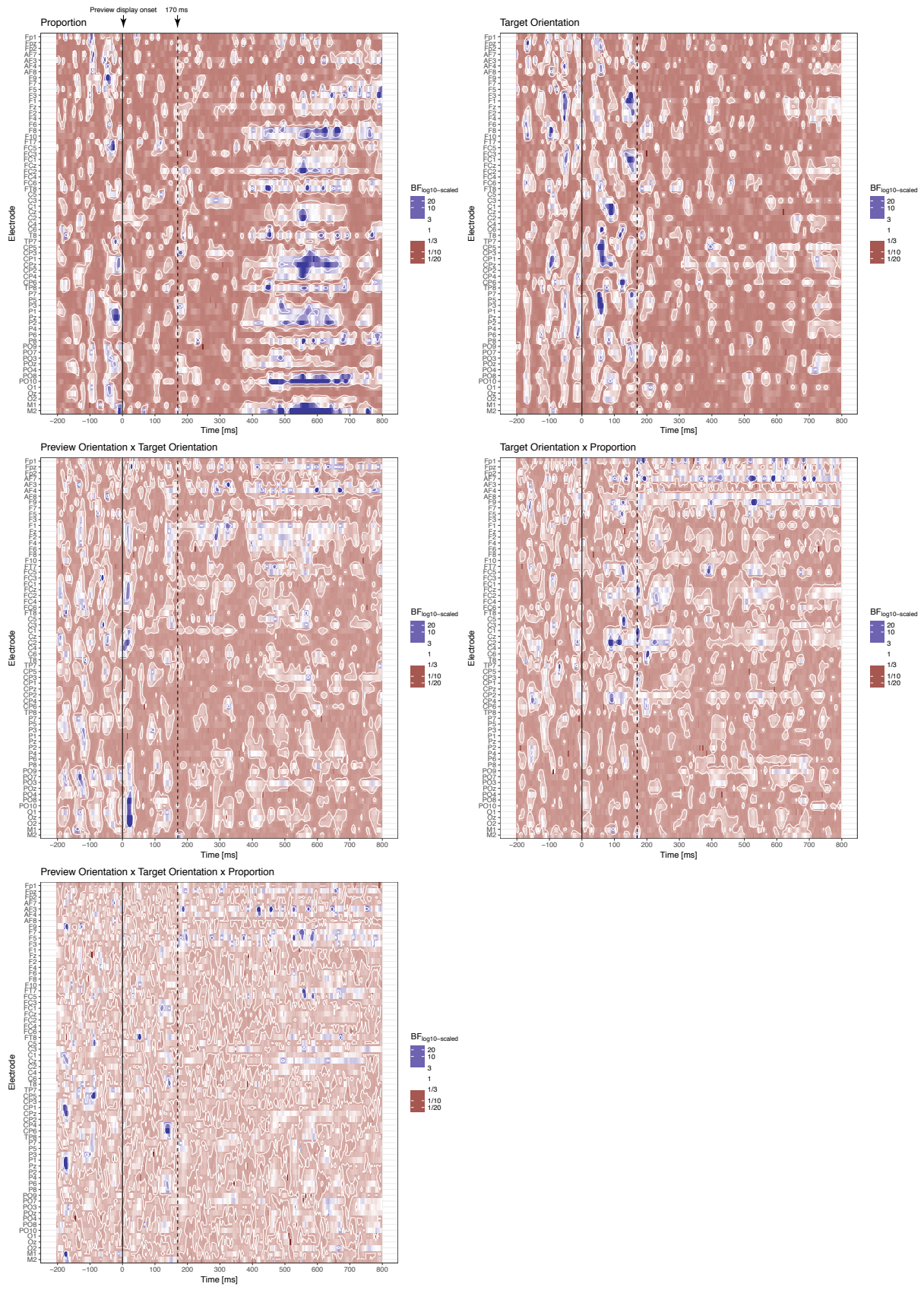
1334 Scalp map of the preview-display-onset locked face inversion effect at lateral posterior sites  
1335 (upright minus inverted). In the mostly valid block (upper row) the late face inversion effect  
1336 remained, whereas it declined before cue onset and disappeared with cue onset in the  
1337 mostly invalid block (lower row). Evidence for the corresponding *Preview Orientation* ×  
1338 *Proportion* interaction in Figure 8B.

1339



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1340 Figure 11



1341

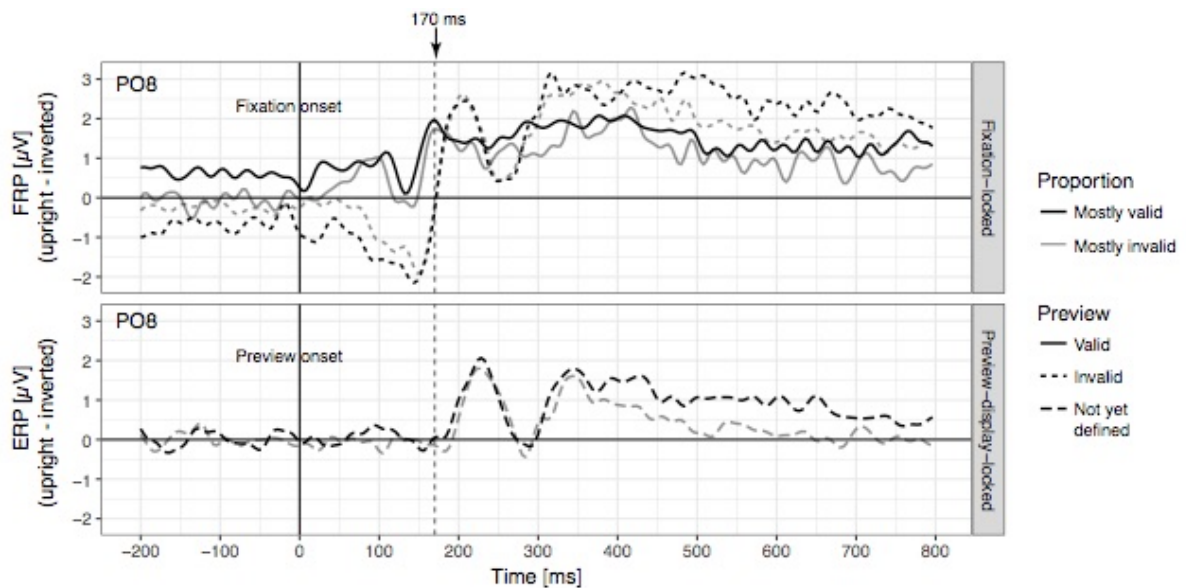
1342 Preview onset-locked whole-scalp Bayes factor (BF) for the remaining main and interaction

## PERIPHERAL FACE-PREVIEW

1343 effects of Experiment 2 not illustrated in Figure 8. Some positive evidence for a main effect  
1344 of proportion was present primarily at PO10 and some central-parietal electrodes (panel A).  
1345 The other effects involving *Target Orientation* (panel B-E) showed spatio-temporally  
1346 extremely limited and unsystematic patterns of occasional positive evidence.

1347

1348 Figure 12

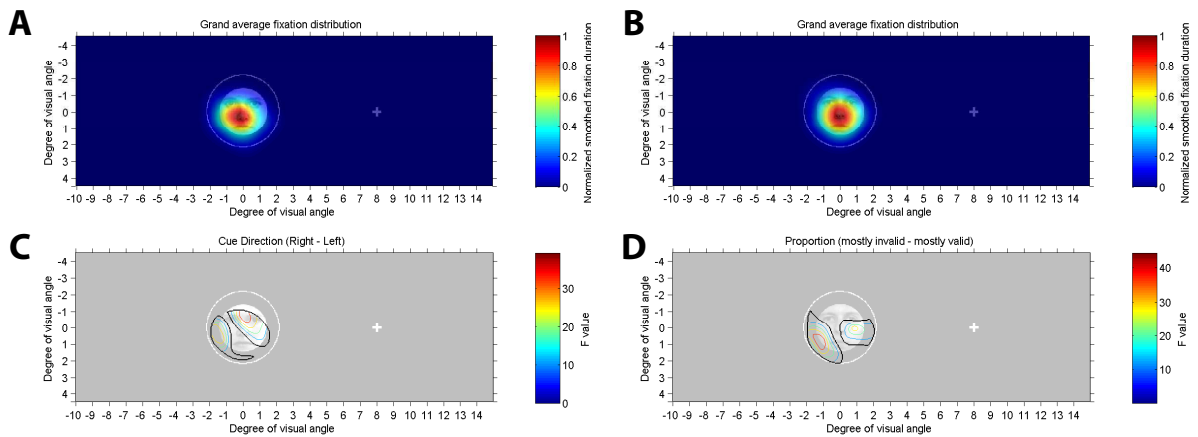


1349

1350 Time course of the face inversion effect calculated as difference between ERPs/FRPs to  
1351 upright faces minus ERPs to inverted faces separately for fixation-locked data (FRP, upper  
1352 panel) and preview-display onset locked data (ERP, lower panel) averaged across both target  
1353 face orientations. The onset of the face inversion effect was earliest in the post-fixation  
1354 period with a valid preview peaking at 170 ms (solid lines, upper panel). In contrast, an  
1355 invalid preview delayed the face inversion effect (dashed lines upper panel). The latest face  
1356 inversion effect occurred in response to the preview display, that is, before any eye  
1357 movement was made (lower panel). The Proportion factor did not affect face inversion  
1358 effect latency.

1359

1360 Figure 13



1361

1362 Grand average fixation distribution in Experiment 1 (panel A) and 2 (panel B). Significant

1363 differences in fixations emerged in Experiment 1 only for the factor *Cue Direction* (panel C)

1364 and in Experiment 2 only for the factor Proportion (panel D). For Experiment 1, right target

1365 fixations were mapped to the left by subtracting the distance between left and right target

1366 faces from the x-axis fixation location data. The white circles around the face stimuli only

1367 illustrate the spatial threshold that determined correct target fixations during the

1368 experiment and in the analysis; they were not present in the actual display. The black

1369 contour line in panels C and D enclose areas of significant differences.