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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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18

19 Abstract

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

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- 42 Keywords
- 43 Trans-saccadic perception; preview effect; prediction; EEG; eye tracking, fixation-related
- 44 potentials (FRP)

45

46 1. Introduction

47 Visual perception is surprisingly stable despite being interrupted by saccadic eye movements
48 about three times per second. One source of visual stability may be the integration of pre-
49 and post-saccadic visual information (Helmholtz, 1867; Melcher, 2011; Wurtz, 2008). Recent
50 gaze-contingent experimental designs have revealed that orientation (Ganmor et al., 2015;
51 Wolf and Schütz, 2015; Zimmermann et al., 2017), object size (Valsecchi and Gegenfurtner,
52 2016), visual motion (Fabius et al., 2016), and even whole-object information (Castelhano
53 and Pereira, 2017; Schut et al., 2016) are integrated across saccades in a statistically optimal
54 fashion that takes into account the relative reliability of pre-saccadic and post-saccadic input
55 (Ganmor et al., 2015; Herwig, 2015; Wolf and Schütz, 2015). Nonetheless, the time-course of
56 trans-saccadic perception and, in particular, the content of perception immediately after
57 fixation-onset remain controversial (for review, Melcher and Morrone, 2015).

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

66 Here we investigated whether the preview positivity known from reading research is also
67 elicited by non-word stimuli, namely by faces. One advantage of using face stimuli is that the
68 time course of face processing has been extensively studied (e.g. Bentin et al., 1996). In

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69 Experiment 1, participants made saccades to peripheral face stimuli. During the saccade, the
70 orientation of the face (upright, inverted) could change (invalid preview) or remain the same
71 (valid preview). After the saccade, participants reported by button press whether the post-
72 saccadic target face was slightly tilted to the left or right. If the preview positivity observed
73 in reading reflects a general trans-saccadic integration mechanism, a change in the FRP
74 component around 200 ms, as found with reading, should be elicited by a valid preview of
75 the target face. However, we hypothesized that faces might show an earlier preview effect
76 than words (Edwards et al., 2018), possibly influencing the N170 ERP index of face
77 processing (Buonocore et al., 2019).

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

88 Trans-saccadic preview effects are usually expressed as more pronounced neural responses
89 in invalid compared to valid conditions (Dimigen et al., 2012; Näätänen and Kreegipuu,
90 2011). As such they can be interpreted in terms of prediction errors in predictive coding
91 frameworks (Friston, 2010, 2005; Friston and Kiebel, 2009; Garrido et al., 2008; Stefanics et
92 al., 2014) and in current frameworks of predictive perception (De Lange et al., 2018). With

93 respect to trans-saccadic perception, the interpretation of the preview effect as a predictive
94 process is particularly intriguing, because one explanation for visual stability is that
95 upcoming foveal visual input is predicted based on pre-saccadic peripheral information and a
96 copy of the motor command (Cavanaugh et al., 2016; Friston et al., 2012; Melcher and
97 Colby, 2008; Wurtz, 2008). Finding predictive preview effects would therefore foster the
98 prediction hypothesis of visual stability.

99 Setting out to test the predictive nature of the trans-saccadic preview effect, in Experiment
100 2, we asked whether the trans-saccadic preview effect reflected a rather long-term
101 predictive process that extends across multiple trials. We manipulated the proportion of
102 valid and invalid trials to generate blocks with mostly valid (66.6% valid) and mostly invalid
103 (33.3% valid) previews. Proportion manipulations have successfully demonstrated the
104 predictive nature of sensory processing (Grotheer et al., 2014; Kovács et al., 2012;
105 Mayrhauser et al., 2014; Summerfield et al., 2011, 2008), with the rationale that a more
106 frequent event is more expected than a less frequent event and, therefore, elicits a reduced
107 neural response. Thus, if the preview effect reflects a predictive process that is sensitive to
108 the task context, it should become smaller in the mostly invalid and larger in the mostly valid
109 block.

110 2. Materials & Methods

111 2.1. Participants

112 Twenty volunteers participated in each experiment in return for a monetary reimbursement,
113 with no overlap in participants between the two experiments. All participants provided
114 written informed consent and reported normal or corrected-to-normal visual acuity that was
115 additionally confirmed by an eyesight test using a Snellen chart. In Experiment 1, two

116 participants had to be excluded due to poor performance in the tilt discrimination task. Of
117 the remaining 18 participants, 16 were right-handed, 7 were male, and their mean age was
118 24.3 years (range: 19-30 years). In Experiment 2, one participant had to be excluded because
119 of a technical problem during EEG data collection. Of the 19 remaining participants, 16 were
120 right-handed, 6 were male, and their mean age was 25.0 years (range 20-40 years). The
121 procedures of both experiments were approved by the local ethics committee.

122

123 2.2. Stimuli

124 Stimuli were presented on a VIEWPixx/EEG monitor (VPixx Technologies Inc., Canada) at
125 120 Hz screen refresh rate and 1920 × 1080 display resolution. The experiment was
126 programmed in Matlab (version 2014b, The Mathworks Inc.) using the Psychophysics
127 toolbox (Brainard, 1997; Pelli, 1997). For Experiment 1, 42 face images were taken from the
128 Nottingham face database (<http://pics.stir.ac.uk/zips/nottingham.zip>) as well as from the
129 Faces 1999 (Front) dataset (<http://www.vision.caltech.edu/archive.html>), with half of the
130 images being female faces and the other half male faces. For Experiment 2, we selected a set
131 of 16 face images only from the Nottingham face database, with half of the images showing
132 female faces and half male faces. The face images in this reduced set were more uniform
133 concerning the distribution of facial features like eyes, nose, and mouth across images.
134 For the face images of both experiments, a circular mask with a diameter of 2.88° was
135 centered at the tip of the nose and the image was sized to contain the internal facial
136 features. Face images were centered bilaterally at $\pm 8^\circ$ eccentricity from the screen center.
137 For each original face image, we generated a phase-scrambled counterpart that was
138 presented as a transient (for the duration of 2 display frames, i.e. 16.7 ms) during the
139 saccade to match the level of intrasaccadic visual change of the display between the valid

140 and invalid preview conditions. In order to equate low-level image features that could
141 otherwise confound the EEG signal, stimuli were matched with the SHINE toolbox
142 (Willenbockel et al., 2010). Specifically, we used the function *histMatch* with the mask
143 option to match the luminance histogram of all face cut-outs and their scrambled
144 counterparts to the average histogram of all face cut-outs within each of the two
145 experiments.

146

147 2.3. Procedure

148 Each trial started with a placeholder display consisting of a fixation cross ($0.5^\circ \times 0.5^\circ$) at the
149 screen center and two white rings (width 1 pixel) framing the position of the upcoming faces
150 (Figure 1A). In Experiment 1, one white ring appeared on either side of the fixation cross (as
151 illustrated in Figure 1A), in Experiment 2, only one ring appeared to the left of fixation (not
152 illustrated). Stable fixation within an area of 2° around the screen center for 1 s triggered the
153 preview display. In Experiment 1, the preview display contained two faces, one at either side
154 from fixation; in Experiment 2, there was only one face to the left of fixation. The face
155 images replaced the placeholder rings. Once the eye tracker detected a stable fixation at the
156 center of the preview display for 500 ms, the color cue was presented. In Experiment 1, the
157 fixation cross turned either blue or green indicating the saccade direction (color-to-direction
158 assignment counterbalanced across participants). In Experiment 2, the fixation cross turned
159 grey, prompting for a saccade to the single face on the left. Participants were instructed to
160 respond as quickly and accurately as possible to the cue by making one single eye-
161 movement to the corresponding face stimulus. Saccade onsets were detected online (see
162 section *EEG and eye-tracking data recording* for details), and upon detection, a scrambled
163 version of the preview face was presented for two frames (16.7 ms); in Experiment 1, the

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164 faces on both sides were scrambled. The transient occurred no more than 3.5 frames (~30
165 ms) after saccade onset, with the delay reflecting the computational requirements of
166 saccade detection and the screen refresh rate (Figure 1C). Given a total saccade duration of
167 around 40-60 ms, the target face was presented before fixation onset in most trials (Figure
168 1D). The purpose of this transient was to roughly equalize the amount of change in the
169 display across all conditions.

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

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

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188 85 invalid trials with target inverted. Importantly, the proportion manipulation was not
189 mentioned to the participants at any point.

190 In addition to its main orientation (upright or inverted), each target face was slightly tilted
191 (1.8°) either to the left or right, counterbalanced across trials. The non-target face in
192 Experiment 1 had the same amount of tilt as the target face (on the other side of fixation),
193 but its direction (left or right) was random. The target face tilt direction had to be reported
194 by the participants via a computer keyboard with the left and right index finger after they
195 had made an eye-movement to the target face. Figure 1B shows the true-to-scale tilt of 1.8°
196 which was hard to see even in the fovea but sufficient for above-chance performance (mean
197 error rates per condition between 15% and 20%, cf. section 3.1.). The purpose of the tilt
198 discrimination task was to ensure that participants paid attention to the target face and gave
199 a response that was orthogonal to all experimental manipulations. In fact, the preview
200 images were not tilted, making them task-irrelevant for the perceptual tilt discrimination
201 response. Correct saccades (end point at least within 2.16° of the target face center) were
202 detected online, and participants received feedback in case of incorrect response or if the
203 recorded gaze position was too far from the expected saccade start or end locations. Before
204 data collection, the eye-tracker was calibrated with a default 5-point rectangular grid. The
205 eye-tracker was manually recalibrated when it failed to correctly track gaze position, that is,
206 when the gaze position suggested that the participant was not following the instructed gaze
207 procedure anymore.

208

209 2.4. EEG and eye-tracking data recording

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

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

232

233 2.5. EEG and eye-tracking data analysis

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

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236 synchronized with the EEG by means of the EYE-EEG toolbox (version 0.81, Dimigen et al.,
237 2011). After synchronization, the synchronized signals were down-sampled to 250 Hz. The
238 EEG was then low-pass filtered (Hamming windowed sinc FIR filter, edge of the passband
239 40 Hz, transition band width 10 Hz, -6dB cutoff frequency 45 Hz), and re-referenced to
240 average reference (Hinojosa et al., 2015). The EEG data was then visually inspected for major
241 artifacts. Portions of data with severe artifacts were removed and bad channels were
242 spherical-spline interpolated.

243 In order to correct for eye movement artifacts in the EEG, we applied independent
244 component analysis (ICA; Makeig, Bell, Jung, & Sejnowski, 1996). Eye-movement related
245 components were determined based on the variance ratio of component activation during
246 periods of eye-movements (blinks and saccades) versus periods of fixations (Plöchl et al.,
247 2012). ICA was conducted in a separate processing pipeline containing an additional high-
248 pass filter (Hamming windowed sinc FIR, edge of the passband: 1 Hz, -6 dB cutoff frequency:
249 0.5 Hz) that was applied after down-sampling and before low-pass filtering (Dimigen, 2018;
250 Winkler et al., 2011). The ICA algorithm was Infomax (Bell and Sejnowski, 1995) with the
251 “pca” option activated to account for the reduced rank of some of the datasets that
252 contained interpolated channels. The ICA results (sphere and weights) were transferred to
253 the corresponding datasets in the original processing pipeline, which lacked a high-pass filter
254 (cf. Acunzo et al., 2012). Components were then rejected if the mean variance of their
255 activity time course during eye-movement periods was 10% greater than the mean variance
256 during fixation periods (Plöchl et al., 2012; Dimigen, 2018).

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

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

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

279 In Experiment 1, these strict criteria led to acceptance of a median number of 104 trials
280 (range 58 to 139 across participants) per cells of the experimental design (*Preview × Target*
281 *Orientation*). In the FRP analysis of Experiment 2, the median number of accepted trials was
282 78 (range 32 to 165) per cell of the design (*Preview × Target Orientation × Proportion*). For
283 the preview-locked analysis of Experiment 2, the median number was 79, and the range was

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

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

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

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

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

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

324

325 2.6. Whole-scalp analysis

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

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

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

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

348 3. Results

349 3.1. Experiment 1: Valid peripheral preview improves post-saccadic tilt 350 discrimination performance

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

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355 *Orientation* (upright, inverted), *Preview* (valid, invalid), and *Cue Direction* (left, right;
356 equivalent with saccade direction). Response time was measured from cue onset, which
357 means that it included saccade latency. Saccade latency was on average 414 ms and did not
358 differ across conditions, all $F_s < 1.55$, all $p_s > .232$, all $BFs < 0.33$, except for the *Preview* x
359 *Target Orientation* x *Cue Direction* interaction which had a Bayes factor slightly above the
360 0.33 threshold but still below 1, $F(1,17) = 2.25$, $p = .152$, $BF = 0.42$.

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

370 The ANOVA also showed an interaction of *Preview* and *Cue Direction* in the error rates,
371 $F(1,17) = 8.80$, $p = .009$. This interaction suggested a larger preview effect for left side targets
372 than for right side targets. However, a BF of 0.66 prevented us from drawing strong
373 conclusions.

374

375 3.2. Experiment 1: Valid peripheral preview reduces the N170 amplitude in the FRP
376 Results of the FRP whole-scalp Bayes factor analysis are illustrated in Figures 5 and 6. Figure
377 5 shows the BF for the theoretically most relevant effects of *Preview Orientation* (panel A,
378 aka *Preview* x *Target Orientation* interaction), *Target Orientation* (panel B), and the *Preview*

379 effect (panel C, aka *Preview Orientation* × *Target Orientation* interaction). The ERPs
380 corresponding to these effects are illustrated in panel D. Note that the *Preview Orientation*
381 (upright, inverted) main effect is expressed as a *Preview* × *Target Orientation* interaction.¹
382 Figure 6 shows the remaining and less theoretically important effects.

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

389 Nevertheless, an inverted preview face led to a more negative EEG response than an upright
390 preview face at posterior-lateral electrodes (see panel D). This effect could reflect a
391 mechanism relevant for the experience of visual stability, since it indicates that information
392 about the pre-saccadic preview influenced neural processing in this time period of around
393 110-170 ms. In other words, immediately after the fixation, the EEG signal initially reflected
394 what was perceived before the saccade and would be expected to be perceived after the
395 saccade, until new post-saccadic information was incorporated (Mirpour and Bisley, 2016).

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

¹ 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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398 Almost exactly at 170 ms the main influence on the EEG signal switched from the preview
399 face to the target face (cf. Figures 5A and 5B) which elicited a more negative response when
400 inverted compared to when it was upright (Figure 5D). This modulation perfectly matches
401 the classic N170 face inversion effect (Bentin et al., 1996; Eimer, 2000; Eimer et al., 2010;
402 Itier and Taylor, 2004a, 2004b; Rossion et al., 2000; Towler et al., 2012; Watanabe et al.,
403 2003). We therefore consider this target orientation effect around 170-220 ms post fixation
404 as a modulation of the fixation-locked N170 component, the fN170.

405 Most importantly, for a period of about 80 ms before and after the crucial time point of
406 170 ms, the preview orientation and target orientation factors interacted (Figure 5C),
407 showing a more pronounced neural response when the preview face and target face
408 orientations matched (valid preview) compared to when they did not match (invalid
409 preview) (Figure 5D). This finding is consistent with theories of trans-saccadic integration
410 that posit that information about the saccadic target influences post-saccadic processing of
411 that target in the new fixation (for review see Melcher, 2011). As can be seen from Figure
412 5D, the fN170 component in particular was more pronounced in invalid (dashed lines) than
413 in valid preview (solid lines) conditions, which is consistent with the idea of a trans-saccadic
414 prediction error. The role of prediction was further explored in Experiment 2.

415 As can be seen in Figure 5, panels A and D, the factors *Preview* and *Target Orientation*
416 interacted again from around 320 ms post fixation for a duration of about 80 ms in particular
417 at central parietal electrodes. The target orientation effect here consisted in a more negative
418 deflection for inverted compared to upright target faces and this face inversion effect was
419 larger for invalid than for valid preview conditions. This interaction likely reflects increased
420 processing of the target face orientation in invalid than in valid preview conditions – after an
421 invalid preview, the target face requires more in-depth processing of the critical features

422 related to face processing – which appears intuitively plausible given the literature on the
423 P300 component (e.g. Polich, 2011).

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

426 The interaction with *Cue Direction* showed sufficient positive evidence before and around
427 the time of the saccade and suggested that the *Preview* × *Target Orientation* interaction –
428 which is the statistical reflection of the *Preview Orientation* effect – consisted of more
429 negative EEG for inverted compared to upright preview faces, which was more pronounced
430 for saccade-right trials than for saccade-left trials (direction of effects not illustrated here).

431 Given the posterior lateral distribution of this effect (electrodes O1/2, PO9/10), and the time
432 periods before and around the time of the saccade, this effect might be attributed to
433 saccade-related perceptual processes.

434 Additional effects of less theoretical significance were identified in our analyses, including a
435 main effect of *Cue Direction* (Figure 6A), and the substantial effects of *Laterality* (Figure 6B)
436 as well as the *Laterality* × *Cue Direction* interaction (Figure 6G). The *Cue Direction* effect
437 indicated evidence for differences between right side and left side saccade trials at posterior
438 lateral electrodes from ca. 100 to 160 ms and at central electrodes from during the saccade
439 to 170 ms post fixation (Figure 6A). The *Laterality* effect showed strong evidence for
440 widespread effects across the whole post-saccadic time period (Figure 6B). Finally, *Laterality*
441 and *Cue Direction* showed a pronounced interaction across several electrode sites and across
442 the whole analysis time window (Figure 6G). Such laterality effects might be related to face
443 processing differences between hemispheres (Frässle et al., 2016; Schweinberger et al.,
444 2004), specifically, a stronger involvement of right posterior parietal cortex in oculomotor
445 control or remapping processes (for review see Pisella et al., 2011; Prime et al., 2011), or

446 some other factor beyond the scope of the current study. These factors were modeled in the
447 analysis in order to control for potential interactions with the preview and target orientation
448 effects, which were of central theoretical interest here.

449

450 3.3. Experiment 1: ANOVA results in the fN170 time window in line with the whole-
451 scalp analysis

452 To provide a statistical assessment of the main results from a frequentist perspective, we
453 computed repeated measures ANOVAs on average ERPs at electrode pair PO7/8, which
454 typically shows the most pronounced N170 effects (Hinojosa et al., 2015), in the time
455 window from 165 to 250 ms. This time window is later than the one usually adopted in ERP
456 studies of the N170 (Bentin et al., 1996), but is appropriate given the extended N170
457 observed in the invalid preview conditions of our experiment (cf. Figure 5). To assess the
458 later central-parietal *Preview* × *Target Orientation* interaction, we additionally computed a
459 repeated measures ANOVA at electrode CPz for the later time window of 320 to 400 ms.
460 The ANOVA results were in line with the evidence from the whole-scalp BF analysis. The
461 ANOVA showed clear main effects of *Preview*, $F(1,17) = 36.55, p < .001$, and *Target*
462 *Orientation*, $F(1,17) = 8.50, p = .010$, which corroborated the more pronounced N170 in
463 invalid compared to valid preview conditions and the more pronounced N170 for inverted
464 compared to upright target faces. The *Target Orientation* × *Cue Direction* interaction
465 approached marginal significance, $F(1,17) = 4.01, p = .062$, but the corresponding $BF = 0.30$
466 suggested that the evidence for this effect is negative. We do not consider this effect any
467 further. There was also a clear effect of *Laterality*, $F(1,17) = 20.16, p < .001$, indicating a
468 more negative ERP contralateral to the side of the target face.

469 One effect differed markedly between the ANOVA on average ERPs and the whole-scalp BF
470 analysis: The ANOVA showed a highly significant *Preview* × *Laterality* interaction, $F(1,17) =$
471 $21.53, p < .001$, though a low BF = 0.33 emerged from Bayesian analysis of the same values
472 (see also Figure 6E). This discrepancy between frequentist and Bayesian results suggests that
473 the effect is not reliable, although it would have been theoretically meaningful. The direction
474 of the interaction suggested a larger preview effect – expressed in the difference between
475 valid and invalid trials – at electrodes contralateral versus ipsilateral to target/saccade
476 direction. Though the target was foveated, any preview-face-related activity was possibly
477 lateralized, since the preview face was presented in the periphery and, therefore, projected
478 primarily to the contralateral hemisphere. Pre-saccadic preview-related activity might have
479 remained to some degree lateralized across the saccade, and therefore it is plausible that
480 also the preview effect was larger in the hemisphere contralateral to saccade/cue direction.
481 The ANOVA at electrode CPz on average amplitudes for the 320 to 400 ms time window
482 confirmed the *Preview* × *Target Orientation* interaction, $F(1,17) = 10.68, p = .005$, and
483 corroborated the more pronounced target face inversion effect (upright minus inverted)
484 with an invalid (-1.19 μV) compared to with a valid (-0.07 μV) preview. This ANOVA also
485 showed a main effect of *Target Orientation*, $F(1,18) = 5.90, p = .027$. No other effects were
486 statistically significant.

487

488 3.4. Experiment 2 replicates the effects from Experiment 1 in tilt discrimination
489 performance and in the FRP

490 In contrast to Experiment 1, Experiment 2 contained a more restrictive selection of face
491 stimuli, which were only presented to the left of fixation, and the proportion of valid and
492 invalid trials was manipulated to achieve a mostly-valid (66.6% valid, 33.3% invalid) block

493 and a mostly-invalid (33.3% valid, 66.6% invalid) block. Overall, Experiment 2 replicated the
494 preview effects in both behavior (Figure 7) and FRP data (Figure 8). Response times in the tilt
495 discrimination task were faster in valid than in invalid preview conditions, $F(1,18) = 31.58$, p
496 $< .001$, $BF = 4.89$ (Figure 7A). There was no preview effect in error rates $F(1,18) < 1$, $BF = 0.19$
497 (Figure 7B). The FRP again exhibited a pronounced preview effect in the fN170 component
498 (Figure 8E), which was corroborated by a repeated measures ANOVA on average ERPs at
499 right hemisphere electrode PO8 in the time window 165 to 250 ms, $F(1,22) = 41.46$, $p < .001$.
500 Note that, since preview face stimuli were only presented in the left visual field in this
501 experiment, we focused the ERP analysis on the right hemisphere (i.e. electrode PO8). The
502 evidence for the preview effect was, however, similar at the corresponding electrodes on
503 the left hemisphere, as can be seen in Figure 8E.

504 Like the preview effect, also the clear target orientation effect from Experiment 1 was
505 replicated in Experiment 2. Responses in the tilt discrimination task were faster, $F(1,18) =$
506 14.23 , $p = .001$, $BF = 10.00$, and clearly more accurate, $F(1,18) = 36.94$, $p < .001$, $BF > 100$, for
507 upright than inverted target faces. Furthermore, the FRP showed again a clear target face
508 inversion effect from about 150 ms onwards that further extended across the whole post-
509 fixation period. Importantly, the target orientation effect was present in the fN170
510 component consisting in a more negative deflection for inverted compared to upright target
511 faces (BF evidence in Figure 9A, ERPs in Figure 9E). This effect was confirmed by an ANOVA
512 at PO8, time window 165 to 250 ms, with $F(1,18) = 14.54$, $p = .001$.

513 Additionally, error rates indicated an interaction of *Preview* and *Target Orientation* factors,
514 $F(1,18) = 7.00$, $p = .016$, which can be interpreted as a *Preview Orientation* main effect. This
515 effect indicated slightly higher error rate with inverted (21.8%) compared to upright (20.5%)

516 preview faces. The BF for this effect was, however, indecisive and, if anything, suggested the
517 absence an effect, BF = 0.47. We do not further consider this effect.

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

524 Again, as in Experiment 1, evidence for the *Preview × Target Orientation* interaction became
525 positive again around 350 ms over central-parietal cortex (Figure 9C). When evaluated at
526 electrodes CPz in the time window 320 to 400 ms, the target orientation effect - consisting
527 of a stronger negativity for inverted compared to upright targets, $F(1,18) = 5.59$, $p = .030$ -
528 was more pronounced with an invalid (-1.20 μV) rather than valid preview (0.13 μV), $F(1,18)$
529 = 11.49, $p = .003$. As in Experiment 1, this likely reflects increased processing of the target
530 face orientation if the target presents information that conflicts with the preview. Overall,
531 the results of Experiment 2 reproduced the results observed in Experiment 1.

532

533 3.5. Experiment 2: The proportion manipulation affected tilt discrimination
534 performance and the FRP, but it did not modulate the magnitude of the
535 preview effect in the fN170

536 Experiment 2 tested whether the preview effect found in Experiment 1 was the result of a
537 contextual prediction mechanism across trials, in the sense that it is influenced by
538 expectations based on the frequency of events over an extended period of time rather than
539 a single saccade. If the preview effect results from such a context-specific prediction

540 mechanism, then it should be larger in blocks with mostly valid trials compared to blocks
541 with mostly invalid trials (Figure 3). We therefore expected to find a *Preview × Proportion*
542 interaction in the behavioral data of the tilt discrimination task and in the N170 component
543 of the FRP.

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

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

554 In contrast to these equivocal behavioral results, the EEG data provided compelling evidence
555 for the same fN170 preview effect in both mostly-valid and mostly-invalid blocks. BF values
556 less than 0.33 at posterior lateral electrodes, where the fN170 preview effect is located,
557 indicated the clear absence of a *Preview × Proportion* interaction (Figure 8F), and this was
558 supported in repeated measures ANOVA analysis on ERPs at PO8 from 165 to 250 ms,
559 $F(1,18) = 0.32$, $p = .581$, at PO7, $F(1,18) = 0.57$, $p = .462$. As can be seen from the ERPs in
560 Figure 8G, the difference in the amplitude between valid (solid line) and invalid trials
561 (dashed line) was the same in mostly-valid and in mostly-invalid blocks. This crucial result
562 suggests that the magnitude of the trans-saccadic preview effect in the fN170 component is

563 not the result of context-sensitive predictions, which contrasts ideas about the predictive
564 nature of the N170 (Johnston et al., 2017).

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

580 Apart from these *Proportion* effects of main interest, the factor *Proportion* interacted with
581 *Target Orientation* later in the FRP and, surprisingly, in ipsilateral electrodes (Figure 9D, 9G).
582 The effect was significant in an ANOVA on average ERPs at PO7, time window 550 to 800 ms,
583 $F(1,18) = 6.34, p = .021$, suggesting that the late target face orientation effect was larger in
584 the mostly valid than in the mostly invalid block. This effect possibly indicates some variation
585 in higher-level processing of the target face depending on the long-run frequency of valid
586 and invalid trials. The reasons for its direction and for its ipsilateral location are, however,

587 unclear. In any case, this finding does not influence our conclusions about the preview effect
588 and its modulation by proportion.

589

590 3.6. Experiment 2: Evidence for pre-saccadic expectations in the preview-locked
591 EEG response

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

602 First, we found a classical N170 face inversion effect in response to preview face orientation
603 as expected from an EEG study using face stimuli. Strong evidence from a whole-scalp BF
604 (Figure 8A) demonstrated a more pronounced N170 for inverted compared to upright
605 preview faces (Figure 8C). This effect was corroborated by an ANOVA on ERPs at PO8, from
606 200 to 260 ms, $F(1,18) = 29.63$, $p < .001$. Compared to previous EEG studies on face
607 perception showing an onset of the N170 largely around 150 to 200 ms (Bentin et al., 1996;
608 Eimer, 2000; Eimer et al., 2010; Itier and Taylor, 2004a, 2004b; Rossion et al., 2000; Towler
609 et al., 2012; Watanabe et al., 2003), our N170 appeared rather late at 200 ms (Figure 8A).
610 This discrepancy might be explained by a difference in stimulus position. Previous studies on

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611 the N170 usually presented faces at the fovea (for an exception see Pajani et al., 2017),
612 whereas our stimuli occurred further from fixation (cf. Buonocore et al., 2019, for a similar
613 result in this respect).

614 Instead of impacting early stages of post-saccadic processing, the proportion manipulation
615 influenced later stages of the face inversion effect. Specifically, in the second half of the
616 preview period, an inverted preview face led to a more negative deflection than an upright
617 preview face (Figure 8A, 8C), corroborated by an ANOVA on average ERPs at PO8, from 300
618 to 450 ms, $F(1,18) = 21.70$, $p < .001$. This effect possibly reflects a modulation of the N250 or
619 N400 face processing components (Schweinberger and Neumann, 2015). Interestingly, as
620 can be seen from Figure 8C, this late preview face orientation effect declined earlier in the
621 mostly invalid than in the mostly valid block. In particular, between cue onset (at 500 ms)
622 and saccade onset (see the histogram of saccade latencies in Figure 8D) the preview face
623 orientation effect had disappeared in the mostly invalid block but was still present in the
624 mostly valid block. This earlier reduction of the preview face orientation effect in the mostly
625 invalid compared to the mostly valid blocks around the time of cue onset is further
626 illustrated in the scalp maps in Figure 10. BF evidence for the corresponding *Preview*
627 *Orientation* \times *Proportion* interaction is presented in Figure 8B. An ANOVA on average ERPs at
628 PO8, 450 to 600 ms post preview onset, corroborated this interaction, $F(1,18) = 16.99$, $p =$
629 $.001$. Critically, this effect could not simply be explained by a difference in saccade latencies
630 between mostly valid and mostly invalid blocks, because saccade latencies did not differ
631 between *Preview Orientation* and *Proportion* conditions: *Proportion* main effect, $F(1,18) =$
632 0.63 , $p = .439$, $BF = 1.14$, *Preview Orientation* main effect, $F(1,18) = 0.14$, $p = .714$, $BF = 0.17$,
633 *Preview Orientation* \times *Proportion*, $F(1,18) = 0.00$, $p = .997$, $BF = 0.24$. As expected, also the
634 factor *Target Orientation* did not affect saccade latencies, all $ps > .089$, all $BFs < 0.29$. The

635 more sustained preview orientation effect in the mostly valid compared to the mostly invalid
636 block might therefore reflect the degree to which the target image was processed or the
637 degree of expectations about the upcoming target orientation based on the pre-saccadic
638 input.

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

649

650 3.7. Experiment 2: The onset of the N170 face inversion effect in the preview

651 period was later than the onset of the FRP N170 face inversion effect

652 As can be seen from Figure 8, the N170 in the event-related potential (ERP) elicited by the
653 onset of the preview display appeared a bit later than the N170 in the FRP (see in particular
654 Figure 8C and 8G). To determine the statistical evidence for this effect, we computed onset
655 latencies of the face inversion effect expressed as difference waveform between trials with
656 upright and inverted faces at electrode PO8. Specifically, we computed upright-minus-
657 inverted preview orientation ERPs separately for mostly valid and mostly invalid blocks for
658 the ERP aligned to the preview display. For the FRP, we computed upright-minus-inverted

659 target orientation ERPs separately for mostly valid and mostly invalid blocks and also
660 separately for trials with valid and invalid preview. The design for the latency onset analysis
661 was, thus, a 2 (*Proportion*: mostly valid, mostly invalid) \times 3 (*Preview*: valid/FRP, invalid/FRP,
662 undefined/ERP) design. Onset latencies of the face inversion effect were defined via a 50%
663 peak amplitude criterion based on jack-knifed subsamples. In other words, the onset latency
664 was the time stamp of the sample at which the leave-one-participant-out averaged
665 difference waves between upright-minus-inverted face ERPs reached the value closest to
666 50% of its maximum activation within 100 to 250 ms after preview-display-onset/fixation-
667 onset (Miller et al., 1998; Ulrich and Miller, 2001). These latency onset values were
668 subjected to a repeated measures ANOVA with the factors *Preview* (valid/FRP, invalid/FRP,
669 undefined/ERP) and *Proportion* (mostly valid, mostly invalid). The resulting *F* and *p*-values
670 were corrected for the reduced error introduced by jack-knifing (Ulrich and Miller, 2001). It
671 is at present unclear how a Bayes factor would have to be corrected for the reduced error
672 due to jack-knifing. To avoid this issue, we applied the correction factor that counteracts the
673 reduction in error, $(n-1)^2$ (Ulrich and Miller, 2001, see in particular Appendix), to the error
674 sum of squares term obtained from the ANOVA, which allows Bayes factor approximations
675 (Huber-Huber, 2016; Masson, 2011; Nathoo and Masson, 2016; Wagenmakers, 2007).
676 This latency onset analysis of the preview-locked and the fixation-locked face inversion
677 difference waves showed a main effect of *Preview* (valid/ERP, invalid/ERP, undefined/FRP),
678 $F(2,36) = 27.18, p < .001, BF_{\text{approx}} > 100$. Post-hoc tests based on Scheffe's interval as critical
679 difference (Ulrich and Miller, 2001) revealed a significantly (at alpha-level .05) shorter
680 latency of the face inversion effect in the valid/FRP than in both the invalid/FRP and the
681 undefined/ERP condition, but not between the invalid/FRP and the undefined/ERP condition
682 (Figure 12). Both the factor *Proportion*, $F(1,18) = 0.70, p = .413, BF_{\text{approx}} = 0.330$, and the

683 *Preview* × *Proportion* interaction, $F(2,36) = 0.15$, $p = .863$, $BF_{\text{approx}} = 0.031$, were not
684 significant.

685

686 3.8. Experiments 1 and 2: Gaze characteristics

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

691 We first checked whether the fN170 preview effect could have been confounded to some
692 extent by *saccadic amplitudes*. The effect occurred at the time of the first post-saccadic
693 positive deflection, which is also known as the lambda response, and this component is
694 certainly influenced by saccade amplitude (e.g. Dimigen et al., 2011, Kaunitz et al., 2014;
695 Ries et al., 2018). In Experiment 1, no significant effects in saccade amplitude were found;
696 only Bayes factors provided strong evidence for a difference in saccade amplitude between
697 saccades to the left (8.07°) and right (8.28°), $F(1,17) = 2.76$, $p = .115$, $BF > 100$. This piece of
698 evidence might provide some weak explanation for the saccade/cue direction effect in the
699 FRP signal (cf. Figure 6A), however, because of the lack of any interaction effects with
700 preview and face orientation, it cannot fully account for the fN170 preview effect and does,
701 thus, not present a confound. Saccadic reaction times in Experiment 2 did not differ
702 significantly across conditions and Bayes factor provided evidence for absence of all effects.
703 Differences in saccade size across conditions can therefore not account for the face
704 orientation effects in the EEG.

705 We then checked whether differences in *fixation durations* across conditions could have
706 affected the FRP, in particular at later stages, despite ocular artefact correction (see section

707 2. *Materials & Methods*). Surprisingly, in both Experiments 1 and 2, target fixation durations
708 differed depending on the orientation of the preview face. In Experiment 1, upright preview
709 faces led to longer subsequent target fixations (538 ms) than inverted preview faces
710 (487 ms), $F(1,17) = 18.24$, $p = .001$, $BF = 30.54$. This effect further appeared to be modulated
711 by *Cue Direction*, $F(1,17) = 16.19$, $p = .001$, however with a weak $BF = 1.43$, which suggested
712 an influence of preview face orientation primarily for saccades to the right, $F(1,17) = 29.95$,
713 $p < .001$, $BF > 100$, and not for saccade to the left, $F(1,17) = 2.40$, $p = .139$, $BF = 0.38$. The
714 same preview orientation effect was present in Experiment 2, $F(1,18) = 7.53$, $p = .013$, $BF =$
715 20.75 (upright 637 ms, inverted 595 ms), which featured only saccades to the left per design
716 and therefore contrasts Experiment 1. In addition, in Experiment 2, *Preview Orientation*
717 interacted with *Target Orientation* presenting a *Preview* effect, $F(1,18) = 5.52$, $p = .030$, $BF =$
718 1.50 , providing weak evidence for somewhat longer fixations with valid (629 ms) than with
719 invalid previews (603 ms). These mixed results demonstrate an influence of the preview face
720 orientation on post-saccadic processing. We can, however, only speculate about the reasons
721 for this effect. In general, inverted faces are uncommon in our everyday lives. Thus, inverted
722 preview faces might elicit shorter primary fixations in order to more quickly gain additional
723 information about this surprising (inverted) visual input by a secondary fixation.
724 Importantly, the difference in fixation durations between upright and inverted preview faces
725 in Experiment 1 and 2 and in particular the statistically weak difference between valid and
726 invalid trials in Experiment 2 are unlikely to have confounded the preview and face
727 orientation effects in the FRP. The early effects (around 100 ms), the $fN170$ effect, and the
728 later more central *Preview* \times *Target Orientation* interaction occurred in Experiment 1 more
729 than 100 ms before the average fixation end in the condition with the shorter fixation
730 duration (inverted preview face, 487 ms, cf. Figure 5), and in Experiment 2 more than

731 200 ms before (inverted preview face, 595 ms, cf. Figure 9). In other words, the fixation
732 durations were too long for artifacts from the secondary saccades to influence such early
733 components. Given this temporal sequence, it seems more likely that the effects in the EEG
734 were actually precursors for the differences in fixation durations, rather than the other way
735 around.

736 In theory, a difference in *fixation location* might also have influenced the FRP, because
737 differences in fixation locations imply differences in low-level visual input that affect visual
738 ERP responses (De Lissa et al., 2014). To rule out this confound, we analyzed the distribution
739 of target fixations with *iMap4* (Lao et al., 2017). This toolbox models fixation location and
740 duration by creating a heat map and by fitting a linear mixed model with predictors
741 according the experimental design to each pixel of the heat map. As suggested by Lao and
742 colleagues (2017), we used a Gaussian kernel with full width at half maximum (FWHM) of 1°
743 visual angle to smooth the pixel-resolved fixation data, thereby accounting for residual
744 spatial uncertainty and to approximate the span of foveal input. A random intercept for
745 participants was included in the model, but we omitted random slopes because of
746 convergence errors. Note that omitting random slopes usually overestimates associated
747 fixed effects (Barr et al., 2013; Matuschek et al., 2017) and should therefore be avoided.
748 Since we were interested in ruling out potential confounds, such a less conservative
749 approach was, however, appropriate. Further, we used bootstrapping with $n=1000$
750 resamples and the default clustering approach with cluster mass. In order to compare
751 fixation distributions for both target faces left and right in Experiment 1, we mapped the
752 fixation locations for right side targets to the left side without mirroring them, that is, by
753 subtracting the x-axis distance between the centers of the two target faces from the x-axis
754 coordinates of right target face fixations.

755 Figure 13 shows grand-average heat maps and significant effects for Experiments 1 and 2.
756 Target fixations accumulated around the nose in both Experiments (Figures 13A and 13B). In
757 Experiment 1, fixation patterns differed only between saccades to the left and saccades to
758 the right (Figure 13C). Similar to the saccade amplitude difference mentioned above, this
759 pattern could be related to the cue direction effects in the FRP (cf. Figure 6A). In Experiment
760 2, fixation patterns differed only between the mostly valid and mostly invalid proportion
761 blocks (Figure 13D). This difference in gaze behavior might be related to the proportion main
762 effect in the FRP signal (Figure 9B). It is possible that the proportion effect in the EEG
763 resulted from a low-level difference in visual input caused by differences in fixation
764 distributions between blocks. This result provides further evidence that the proportion
765 manipulation was in general strong enough to affect the participants' behavior. All other
766 effects were not significant, which suggests that differences in the distribution of fixations
767 on the target face cannot explain the preview and target orientation effects of main interest.
768

769 4. Discussion

770 We investigated the time course of trans-saccadic perception in a combined EEG and eye-
771 tracking study. In Experiment 1, we found a peripheral preview effect both in behavior and
772 in the lateralized posterior fN170 component. Behaviorally, participants were more efficient
773 in discriminating target-face tilt after a valid peripheral preview than after an invalid
774 preview. In line with this result, the fN170 component was clearly more pronounced with an
775 invalid than with a valid preview, which is the same effect direction as the preview positivity
776 known from reading research (Dimigen et al., 2012, in particular their Figure 3B). Our
777 preview effect with faces emerged, however, much earlier than the preview positivity for
778 reading (ca. 120 ms versus ca. 180 ms post fixation). We also found a later centroparietal

779 effect similar to the later and more central preview component in reading research (Dimigen
780 et al., 2012, their Figure 3B). Again, our late effect started earlier and consisted of a *Preview*
781 \times *Target Orientation* interaction rather than a *Preview* main effect, suggesting more in-depth
782 processing of the target face orientation after an invalid compared to with valid preview.
783 These results suggest that trans-saccadic integration effects can be found at different
784 temporal scales for different types of stimuli, possibly related to the different time course
785 for processing these stimuli at the level of categorization and meaning (e.g. Herrmann et al.,
786 2005; Sereno and Rayner, 2003).

787 In addition to the trans-saccadic preview effect in the fN170, we found a clear face inversion
788 effect (Bentin et al., 1996; Eimer, 2000; Eimer et al., 2010; Itier and Taylor, 2004a, 2004b;
789 Rossion et al., 2000; Towler et al., 2012; Watanabe et al., 2003). This effect was also present
790 as expected in response times and error rates, with better performance with upright than
791 with inverted target faces. Importantly, the target orientation and preview effects were
792 additive, suggesting that they reflect two independent processes, one for the structural
793 processing of faces (e.g. Bentin et al., 1996) and one for trans-saccadic integration. The
794 additive nature of these two effects is particularly apparent when comparing the waveforms
795 for an inverted preview face followed by an upright target face to the waveforms for an
796 inverted preview face followed by inverted target face (Figure 5D). These two waveforms do
797 not differ much from each other, very likely because the preview and the face inversion
798 effects cancelled each other out. An inverted target is expected to elicit a more negative
799 fN170 than an upright target. Here, the inverted target was preceded by an upright preview
800 rendering this condition invalid. The upright target was also preceded by an upright preview
801 rendering this condition in turn valid. If both upright and inverted targets were preceded by

802 an inverted preview face, the N170 preview effect, with a larger N170 in invalid than in valid
803 trials, cancelled what would otherwise have appeared as a target face inversion effect.
804 In addition to increasing the amplitude of the fN170 in general, an invalid preview also
805 delayed the face inversion effect. This result suggests that EEG studies in controlled
806 experimental settings without eye movements underestimate the latency of visual EEG
807 components during natural, unconstrained viewing situations, because real-world
808 perception usually affords a pre-saccadic preview, resembling the valid condition here.
809 In Experiment 2, we asked whether the beneficial effect of the preview for post-saccadic
810 processing, in particular on the fN170 component, was the result of a context-sensitive
811 prediction process that takes into account validity across multiple events. In other words,
812 does the trans-saccadic effect across a single eye movement take into account the overall
813 frequency of valid and invalid trials? The direction of the fN170 preview effect, with a larger
814 fN170 for invalid than for valid conditions, is consistent with a prediction error signal
815 (Friston, 2010, 2005; Friston et al., 2012; Summerfield and Egner, 2009; see also Kornrumpf
816 et al., 2016). If the fN170 preview effect reflected a context-sensitive predictive process, we
817 reasoned that it should adapt to the frequency of events such that it would become larger in
818 a block with more valid trials and smaller in a block with more invalid trials (Summerfield et
819 al., 2008). In Experiment 2, however, the same preview effect was found in both blocks and
820 confirmed by strong statistical evidence from a Bayes factor analysis. Our results therefore
821 indicate that the fN170 preview effect occurs regardless of context or recent experience,
822 making it different from many classical prediction effects (at least in the case of 66.6%
823 versus 33.3% valid blocks). At the same time, we do observe effects of the proportion
824 manipulation. The N170 preview face inversion effect differed in the mostly valid compared
825 to the mostly invalid block and there was also a corresponding difference in fixation

826 distributions between mostly valid and mostly invalid blocks. In sum, this pattern suggests
827 that the proportion manipulation with 33.3% versus 66.6% was strong enough to influence
828 gaze behavior and resulting EEG correlates of face processing, but not to impact the
829 magnitude of the post-saccadic preview effect.

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

836 The overall pattern of results provides a complex picture of how the N170 is related to visual
837 predictions. In an elegant study, Johnston and colleagues (2017) showed that violating visual
838 predictions derived from a sequences of image changes elicited an N170 even in the absence
839 of eye movements. These authors suggested this component as a potential tool for the study
840 of sensory predictions across saccadic eye-movements. Moreover, the source of visual
841 prediction errors signals has been localized in the fusiform face area (de Gardelle et al.,
842 2013a, 2013b) which has also been identified as one of the neural generators of the N170
843 component (e.g. Corrigan et al., 2009). Our results seem to contrast these findings.

844 One possibility to resolve this theoretical puzzle is that predictions across saccadic eye
845 movements (Buonocore et al., 2019; Edwards et al., 2017; Ehinger et al., 2015) might not
846 obey the same principles as concurrent sensory predictions in the visual system without
847 saccades (Alink et al., 2010; Johnston et al., 2017). This conjecture implies that the N170 and
848 the fN170 respond differently to the same type of prediction manipulation, which has not
849 yet been tested.

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

859 Finally, although proportion manipulations of 25% versus 75% have been successful in the
860 past (Summerfield et al., 2008) and our proportion manipulation was of similar magnitude
861 with 33.3% versus 66.6%, it might still not have been strong enough to trigger an adaptation
862 of trans-saccadic predictions (Kovács and Vogels, 2014; Mayrhauser et al., 2014). It is well-
863 known that effects of expectation scale with validity of the prediction just like endogenous
864 attention scales with cue validity (Giordano et al., 2009; Kok et al., 2012). Hence, more
865 extensive training with trans-saccadic changes than the one realized in the present design
866 (e.g. Herwig et al., 2015; Valsecchi and Gegenfurtner, 2016) might modulate the magnitude
867 or timing of the fN170 preview effect.

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

874 Second, at the beginning of the new fixation, we found evidence that neural activity
875 reflected the preview rather than the image actually present at the fovea, with some
876 interaction between the preview and post-saccadic stimulus up to the time of the fN170.
877 Third, at the time of the fN170, there was a preview effect consistent with the preview
878 positivity found previously in studies with visual words but at an earlier latency than in
879 reading. Interestingly, the trans-saccadic preview effect in the fN170 was independent of the
880 proportion manipulation. This suggests that some aspects of trans-saccadic integration
881 might be relatively automatic and resistant to change over the time period of one
882 experimental session.

883 In any case, the preview effect in the fN170 can still be interpreted as a prediction error in
884 terms of predictive coding (Grotheer and Kovács, 2016). In a computational sense, predictive
885 coding only means that, instead of transmitting the complete bottom-up signal from lower
886 to higher processing levels, only the prediction error is propagated in a feed-forward fashion
887 (Friston, 2010; Spratling, 2017). Predictive coding therefore does not imply anything about
888 the critical rate of occurrence of events required for adjusting top-down predictions. Thus,
889 even though the proportion manipulation did not influence the fN170 preview effect, the
890 preview effect itself might still have resulted from predictive coding circuits (Bastos et al.,
891 2012), with these circuits not influenced by our proportion manipulation.

892 In conclusion, the current results show a strong effect of a task-irrelevant preview face on
893 post-saccadic face processing, confirming that perception does not start anew with each
894 new fixation. We make about three saccades every second, and it takes about 100 - 150 ms
895 until visual information arrives at ventral-stream areas involved in object recognition (Foxe
896 and Simpson, 2002). If there was no perception during that time we would miss what is
897 going on around us for about four hours each day (Melcher and Colby, 2008). In contrast,

898 the *preview face* orientation effect that we found in the early stage of *post-saccadic*
899 processing (cf. Mirpour and Bisley, 2016) suggests that, instead of waiting for new visual
900 input after fixation onset, we perceive what was expected at that location before the eye
901 movement began.

902

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1200

1201

1202 Figure legends

1203 Figure 1

1204 Panel A. Procedure in Experiment 1. A stable fixation for 1000 ms triggered the *Preview*
1205 display. Further fixation for 500 ms then triggered the color cue (e.g. green left/blue right,
1206 counterbalanced across participants) indicating the required saccade direction and, thus, the
1207 target face. Both the target (cued) face and non-target face (opposite side) could be either

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1208 upright or inverted, and could both either change orientation or remain the same across the
1209 saccade. During the saccade, scrambled versions of the faces were presented as transients.
1210 The transient was replaced by the target display after two frames. The target display
1211 contained both target and distractor faces with additional slight tilt (left/right, amount of tilt
1212 is exaggerated in panel A). Panel B shows the true to scale target face tilt of 1.8°. The
1213 direction of this tilt had to be reported by button press upon fixation onset. Panel C
1214 illustrates the speed of the online saccade detection. In most trials, the transient was
1215 presented less than 25-30 ms after saccade onset. The timing of target onset and fixation
1216 onset is illustrated in panel D. Fixation onset was most of the time after target onset.
1217 Timeline, stimulus size, and target face tilt in panel A are not drawn to scale.

1218

1219 Figure 2

1220 Panel A shows the four possible preview and target face orientation conditions. Both
1221 *Preview orientation* and *Target orientation* could be upright or inverted leading to in total
1222 four conditions, two of which contained a valid preview (preview orientation and target
1223 orientation matched) and two an invalid one (preview orientation and target orientation did
1224 not match). Panel B shows the proportion of valid and invalid trials in Experiment 1 and 2. In
1225 Experiment 1, valid and invalid trials occurred at a frequency of 50% throughout the
1226 experiment. Experiment 2 consisted of two blocks, one with mostly valid (66.6% valid, 33.3%
1227 invalid) and one with mostly invalid trials (33.3% valid, 66.6% invalid). Block order was
1228 counterbalanced across participants.

1229

1230 Figure 3

1231 Illustration of the logic of the proportion manipulation to determine the predictive nature of
1232 the preview effect (difference on the y-axis between valid, solid, and invalid, dashed,
1233 conditions). If the preview effect is predictive, a block with more valid trials is expected to
1234 increase the preview effect, and a block with more invalid trials is expected to decrease the
1235 preview effect.

1236

1237 Figure 4

1238 Mean response times (panel A) and error rates (panel B) in the tilt discrimination task in
1239 Experiment 1, split by the factors *Cue Direction*, *Target Orientation*, and *Preview*.

1240 Participants were faster in valid (solid) than in invalid preview conditions. Target orientation
1241 also affected the response: Participants responded faster (panel A) and made fewer errors
1242 (panel B) in trials with upright (Up) compare to with inverted (In) target faces.

1243

1244 Figure 5

1245 Whole-scalp Bayes factor (BF) analysis of the fixation-related potentials (FRP) to the target
1246 face (panels A-C). Panel D illustrates the corresponding ERPs at electrode pair PO7/8. Each
1247 horizontal row of panel A-C represents the time-course of the BF for one contra-ipsilateral
1248 electrode pair, sorted from frontal (top) to posterior (bottom) sites and within this order
1249 further from lateral (top) to medial (bottom) sites. Values greater than 3 (blue) denote
1250 positive evidence, values less than 1/3 (red) negative evidence. Values in-between are
1251 indecisive (white). The thresholds 3 and 1/3 are indicated by two-dimensional white contour
1252 lines. The vertical dashed line at 170 ms only serves as visual guide and does not indicate any
1253 event in the experiment.

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1254 Panel A shows the *Preview* × *Target Orientation* interaction, aka *Preview Orientation* main
1255 effect. From ca. 100 ms post fixation onset to 170 ms the orientation of the preview face
1256 dominated the posterior lateral EEG signal (see also panel D). Evidence for this effect
1257 became positive again between ca. 300 to 400 ms primarily at central-parietal sites. Panel B
1258 illustrates the main effect of *Target Orientation*. Evidence for this effect became positive
1259 from ca. 170 ms post fixation-onset at lateral posterior and some central sites and, after
1260 some decrease in evidence from ca. 250 to 300 ms extended throughout the post-saccadic
1261 time-window. The corresponding face inversion effect in the fN170 is illustrated in panel D.
1262 Panel C shows evidence for the crucial *Preview* effect, aka *Preview Orientation* × *Target*
1263 *Orientation* interaction. In time windows of ca. 50 ms before and after 170 ms the EEG
1264 response was more pronounced in valid (preview orientation and target orientation
1265 matched) compared to invalid (no match) conditions. The ERPs in panel D show this effect in
1266 the fN170 component at electrode pair PO7/8.
1267 Note that baseline correction was conducted with respect to the time window -200 to 0 ms
1268 before preview display onset which is outside the plotted time period (cf. Figure 1).

1269

1270 Figure 6

1271 Whole-scalp Bayes factor (BF) for all the remaining main and interaction effects of
1272 Experiment 1 not illustrated in Figure 5. Importantly, the *Preview* and *Target Orientation*
1273 effects did not interact with other factors in particular not in the spatio-temporal window of
1274 the fN170 preview effect at lateral posterior electrodes ca. 50 ms before and after the
1275 170 ms time stamp.

1276

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1277 Figure 7

1278 Behavioral results of Experiment 2. Response times (panel A) were faster in valid than in
1279 invalid trials, and faster for upright (Up) than for inverted (In) targets. The evidence for the
1280 *Preview* (valid, invalid) by *Proportion* (mostly valid, mostly invalid) interaction was unclear
1281 (see text). Error rate (panel B) was lower for upright than for inverted targets.

1282

1283 Figure 8

1284 Whole-scalp Bayes factor, ERPs, FRPs, and saccade latencies of the most important effects of
1285 Experiment 2 time-locked to preview display onset (ERP, panels A-D) and time-locked to
1286 fixation onset (FRP, panels E-G). The preview period (panel A) showed positive evidence for a
1287 *Preview Orientation* effect in the N170 and in a later component from ca. 300 ms. Both
1288 effects showed more negative deflections for inverted than for upright preview faces (panel
1289 C). With cue onset and before onset of most of the saccades (pane D) this face inversion
1290 effect at posterior lateral electrodes disappeared earlier in the mostly invalid than in the
1291 mostly valid block (panel C), evidenced by a *Preview Orientation* × *Proportion* interaction
1292 (panel B).

1293 The preview effect in the fN170 established in Experiment 1 was replicated in Experiment 2
1294 (panel E). Crucially, the fN170 preview effect was the same in mostly valid and mostly invalid
1295 blocks (panel G) as evidenced by a BF clearly lower than 1/3 for the *Preview* × *Proportion*
1296 interaction (panel F). Note that panel G contains ERPs averaged across both target
1297 orientations (upright, inverted). For effects of target orientation see Figure 9.

1298 Baseline correction was conducted for the -200 to 0 ms time window before preview display
1299 onset (panel C).

1300

1301 Figure 9

1302 Fixation-locked whole-scalp Bayes factor (BF) for the remaining main and interaction effects
1303 of Experiment 2 not illustrated in Figure 8. The effects of Experiment 1 were replicated.
1304 *Target Orientation* elicited again a pronounced face inversion effect in the fN170 and a later
1305 component commencing at ca. 300 ms post-fixation onset (panel A, panel E). *Preview*
1306 *Orientation* showed again a face inversion effect in the initial phase of post-saccadic
1307 processing before 170 ms after fixation onset (panel C, panel E). In addition, the evidence for
1308 a more negative fN170 in mostly valid compared to mostly invalid blocks was clearly positive
1309 (*Proportion* main effect, panel B, corresponding ERPs in Figure 8G). Finally, the *Target*
1310 *Orientation* effect was more sustained in the mostly valid compared to the mostly invalid
1311 blocks in a very late time window and surprisingly at ipsilateral sites (panel D). Evidence for
1312 the three-way interaction was largely indecisive (panel F).

1313

1314 Figure 10

1315 Scalp map of the preview-display-onset locked face inversion effect at lateral posterior sites
1316 (upright minus inverted). In the mostly valid block (upper row) the late face inversion effect
1317 remained, whereas it declined before cue onset and disappeared with cue onset in the
1318 mostly invalid block (lower row). Evidence for the corresponding *Preview Orientation* ×
1319 *Proportion* interaction in Figure 8B.

1320

1321 Figure 11

1322 Preview onset-locked whole-scalp Bayes factor (BF) for the remaining main and interaction
1323 effects of Experiment 2 not illustrated in Figure 8. Some positive evidence for a main effect
1324 of proportion was present primarily at PO10 and some central-parietal electrodes (panel A).

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1325 The other effects involving *Target Orientation* (panel B-E) showed spatio-temporally
1326 extremely limited and unsystematic patterns of occasional positive evidence.

1327

1328 Figure 12

1329 Time course of the face inversion effect calculated as difference between ERPs/FRPs to
1330 upright faces minus ERPs to inverted faces separately for fixation-locked data (FRP, upper
1331 panel) and preview-display onset locked data (ERP, lower panel) averaged across both target
1332 face orientations. The onset of the face inversion effect was earliest in the post-fixation
1333 period with a valid preview peaking at 170 ms (solid lines, upper panel). In contrast, an
1334 invalid preview delayed the face inversion effect (dashed lines upper panel). The latest face
1335 inversion effect occurred in response to the preview display, that is, before any eye
1336 movement was made (lower panel). The Proportion factor did not affect face inversion
1337 effect latency.

1338

1339 Figure 13

1340 Grand average fixation distribution in Experiment 1 (panel A) and 2 (panel B). Significant
1341 differences in fixations emerged in Experiment 1 only for the factor *Cue Direction* (panel C)
1342 and in Experiment 2 only for the factor Proportion (panel D). For Experiment 1, right target
1343 fixations were mapped to the left by subtracting the distance between left and right target
1344 faces from the x-axis fixation location data. The white circles around the face stimuli only
1345 illustrate the spatial threshold that determined correct target fixations during the
1346 experiment and in the analysis; they were not present in the actual display. The black
1347 contour line in panels C and D enclose areas of significant differences.