1   Gaze Strategies in Skateboard Trick Jumps: Spatio-Temporal Constraints in Complex Loco-

2   motion

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25   Abstract

26   *Purpose*. This study aimed to further the knowledge on gaze behavior in locomotion by stud-

27   ying gaze strategies in skateboard jumps of different difficulty that had to be performed either

28   with or without an obstacle. *Method*. Nine experienced skateboarders performed "Ollie" and

29   "Kickflip" jumps over either an obstacle or over plane surface. The stable gaze at five differ-

30   ent areas of interest was calculated regarding its relative duration as well as its temporal or-

31   der. *Results*. Over the approach phase, an interaction between area of interest and obstacle

32   condition, $F(3, 24) = 12.91$, $p < .05$, $\eta_p^2 = .62$, was found with longer stable-gaze locations at

33   the take-off area in attempts with an obstacle ($p < .05$, $\eta_p^2 = .47$). In contrast, in attempts over

34   plane surface longer stable gaze locations at the skateboard were revealed ($p < .05$, $\eta_p^2 = .73$).

35   Regarding the trick-difficulty factor, the skateboarders descriptively showed longer stable

36   gaze locations at the skateboard for the "Kickflip" than for the "Ollie" in the no-obstacle

37   condition only ($p > .05$, $d = 0.74$). Finally, over the jump phase, neither obstacle condition

38   nor trick difficulty affected gaze behavior differentially. *Conclusions*. This study underlines

39   the functional adaptability of the visuomotor system to changing demands in highly dynamic

40   situations. As a function of certain constraints, different gaze strategies were observed that

41   can be considered as being highly relevant for successfully performing skateboard jumps.

42   Keywords: locomotion, perception-action-coupling, eye tracking, anticipatory behavior

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45   motion

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47   In the context of sports, the functional role of visual information processing for solving motor

48   tasks has been extensively studied (e.g., Mann, Williams, Ward, & Janelle, 2007). In this re-

49   gard, direct and indirect methods were applied to assess the link between gaze and sport per-

50   formance, referring to the application of either gaze-registration systems (e.g., Kredel,

51   Klostermann, & Hossner, 2015) or occlusions paradigms (e.g., Müller, Brenton, Dempsey,

52   Harbaugh, & Reid, 2015). However, most of these studies investigated gaze behavior of par-

53   ticipants in a more or less stable postural position like Vickers (1996) in her seminal study in

54   which expert basketball players had to score baskets while standing at the free-throw line.

55   In contrast, gaze strategies for locomotor behavior were only investigated during walking. In

56   this line of research, it was shown that natural gaze behavior should favorably be assessed in-

57   situ as participants showed substantially different gaze strategies when walking a path com-

58   pared to watching the exact same path from a first-person perspective (Foulsham, Walker, &

59   Kingstone, 2011; see also Droll & Eckstein, 2009). Furthermore, Pelz and Rothkopf (2007)

60   found that humans tend to visually focus the walking path more often in situations of uneven,

61   wooded surfaces. This finding could be replicated by t'Hart and Einhäuser (2012) by addi-

62   tionally controlling for possible visual and context biases.

63   With regard to more complex locomotion, Patla and Vickers (1997) investigated participants'

64   gaze behavior while stepping over obstacles of different heights. The results suggest that the

65   processing of obstacle information is particularly linked to the pre-planning of the stepping

66   movement since the participants did not fixate the obstacle during the stepping-over period

67   (see also Mohagheghi, Moraes, & Patla, 2004). In addition, only the duration of last fixations

68   at the obstacle was affected by the different obstacle heights elucidating the use of late infor-

69   mation for regulating locomotion. This look-ahead gaze strategy was quantified by Patla and

70   Vickers (2003) who showed that participants while walking over foot prints directed their

71   gaze in the majority of cases two footprints ahead. This means that the visuo-motor system

72   uses distal visual information to coordinate movements in a feedforward manner (Sailer,

73   Flanagan, & Johansson, 2005).

74   When it comes to sports, it must be stated that these results can claim relevance for the multi-

75   tude of sport tasks in which locomotion is required. In this domain, for instance, Vickers

76   (2006) was able to reveal a look-ahead strategy also for expert ice-skaters who regularly an-

77   chor their gaze at the inside line and the tangent point of the ice oval. However, the particular

78   requirement that has been previously sketched with respect to walking and that also is charac-

79   teristic for sports has not been investigated so far, namely the spatial-temporal adaptation of

80   the visuo-motor behavior to overcoming obstacles. Therefore, the current study aimed on the

81   gaze behavior of experienced skateboarders performing two jump tricks of different difficulty

82   either over plane surface or over an obstacle. On the one hand, this task is comparable to the

83   locomotion tasks sketched above since an obstacle has to be passed so that the location of the

84   take-off needs to be processed when planning details of the movement execution. On the oth-

85   er hand – and different from earlier investigations –, the handling of an additional object has

86   to be taken into account so that the current feet position on the skateboard needs to be consid-

87   ered to be able to kick the skateboard at the respective position in order to lift it into the air.

88   Furthermore, over the flight phase, continued visual information regarding the feet in relation

89   to the skateboard might be required to prepare the complex landing.

90   Hence, for the experimental comparison, it was expected to find differences in gaze behavior

91   as a function of jump difficulty as well as obstacle condition. In more detail, over the ap-

92 proach phase, skateboarders should show anticipatory gaze behavior at the take-off area to a

93 higher degree in the obstacle than in the no-obstacle condition (cf., Patla & Vickers, 1997).

94 Drawing on the empirical evidence on fixation durations as a function of task demands (e.g.,

95 Patla & Vickers, 1997), we further predicted longer stable-gaze locations at the board for the

96 more difficult than for the easier technique. Finally, referring to the research on passing ob-

97 stacles (cf., Mohagheghi et al., 2004; Patla & Vickers, 1997), one should not expect differ-

98 ences in gaze behavior over the flight phase.

99

100   Method

101 Participants

102 Twelve male skateboarders volunteered for the study and received individual analysis of their

103 own gaze behavior in return. The raw data of three participants had to be excluded from fur-

104 ther processing due to technical problems with the eye tracker in two cases and because one

105 participant was not able to finish all four conditions. The remaining nine participants (age:

106 28.5 ± 4.7 years) had self-reported normal or corrected to normal vision. They were skilled

107 skateboarders with on average 14.3 years (± 3.6 years) of experience. The approval of the

108 ethics committee of the University Faculty and written informed consent from the partici-

109 pants were obtained in advance. The experiment was thus undertaken in accordance with the

110 Declaration of Helsinki.

111

112 Apparatus

113 The skateboarders' gaze behavior over two movement phases ("approach" from start to take-

114 off and "jump" from take-off to landing) were recorded with a mobile binocular eye-tracking

115   system that was attached to custom-build swim goggles to minimize camera shifts (Eye-

116   SeeCam, EyeSeeTec GmbH, Fürstenfeldbruck, Germany). The EyeSeeCam (ESC, 60 Hz) is

117   connected to a MacBook Pro via FireWire cable that is stored in a rucksack so that the skate-

118   boarders could move freely (see Figure 1). Via infrared reflection from the pupil and the cor-

119   nea the ESC assesses the vertical and horizontal rotations of both eyes which are depicted as

120   fixations cross in the footage of a scene camera that films the direction the head is aligned to.

121   The accuracy of the ESC amounts to 0.5° of visual angle with a resolution of 0.01° root mean

122   squared error. The video data from the ESC scene camera were also taken to subdivide a sin-

123   gle trial into movement phases. The video data were cut with a self-written MATLAB script

124   (Mathworks, Natick, MA, USA) and analyzed frame-by-frame using Kinovea 0.8.15 video

125   chronometer and motion-analysis software (Boston, MA, USA). Finally, IBM SPSS Statistics

126   23 (New York, NY, USA) was used to conduct statistical analyses.

127

128   Insert Figure 1 about here

129

130   Procedure

131   The study was conducted on an outdoor, traffic-calmed part of a car-parking area. The ground

132   was flat with refurbished pavement. The skateboarders always started at the same position

133   marked by a cross from where they had to drive 12 m in a straight line into the jump zone

134   which was 4 m long and 3 m wide. The jump zone was visually highlighted by alternating red

135   and white stripes to the right and to the left. All skateboarders used their own skateboard.

136   Participants' task was to perform two common skateboard tricks, either an "Ollie" or a

137   "Kickflip". The "Ollie" is a no-handed aerial jump in which the skateboarder and the skate-

138   board leap into the air without the use of the rider's hand. Likewise, the "Kickflip" is a no-

139 handed aerial jump with an additional 360° twist of the skateboard around its longitudinal

140 axis. Consequently, the "Ollie" is the easier technique than the "Kickflip". In the obstacle

141 condition, an obstacle was placed at a distance of 14 m from the start position, that means,

142 exactly in the mid of the jump zone (see Figure 1). Due to safety reasons, the respective ob-

143 stacle differed for the two jump techniques. Whereas for the "Ollie" jump a laterally posi-

144 tioned customary skateboard was used (obstacle height 20 cm), for the more difficult

145 "Kickflip" jump the skateboard was replaced by a pipe which was slightly lower in height

146 (obstacle height 12.5 cm). Pilot testing showed that using the pipe also for the easier "Ollie"

147 might fail the manipulation since the skateboarder reported no relevant difference in compari-

148 son to jumping without an obstacle. However, as pilot skateboarder at the same time denied

149 to jump over the skateboard with the more difficult "Kickflip" technique, the experimental

150 setup had to be slightly adapted as sketched before.

151 The skateboarders attended individual sessions. After having read the instructions, a warm up

152 was performed before as well as after fitting the ESC system. Subsequently, the ESC was

153 calibrated by consecutively fixating five dots that were displayed by means of a laser pattern

154 in a regular grid with a distance of 8.5° of visual angle between the dots. Measurement accu-

155 racy of the ESC was verified after every jump by controlling the position of the fixation cross

156 while the participant was fixating several objects and the system was recalibrated if neces-

157 sary.

158 After the calibration, the skateboarders started with their first trial. In sum, four successful

159 attempts, that means, jumps according to the technique guidelines, had to be performed in 2

160 (technique) times 2 (obstacle) conditions, each. The order of the conditions was counterbal-

161 anced with the restriction that both obstacle conditions were consecutively tested for the same

162 jump. At the end of the session, the participants were thanked and debriefed about the objec-

163 tives of the study. The data collection for each participant lasted about 60 minutes.

164

165   Data Analyses

166   All analyses were conducted with the video data files recorded by the ESC system. First,

167   movement phases were manually identified by coding the moments of start of the trial (first

168   frame the skateboard moved into the direction of the jump zone), take-off (first frame the

169   skateboard's tail was touching the ground) and landing (first frame one of the skateboard's

170   wheels touched the ground). Participants' gaze behavior was also analyses manually resulting

171   in durations of stable-gaze locations of the fixation cross, defined as periods of time over

172   which the gaze vector remained within the same area of interest for at least 6 video frames

173   (i.e., 100 ms). For the allocation of the gaze to a certain location, five areas of interest had

174   been defined a priori: (a) the skateboard, (b) the take-off area, (c) the jump zone, (d) the land-

175   ing area, and (e) the obstacle (for the obstacle conditions only). For the areas of interest (b)

176   and (d), whose location could vary from trial to trial due to the actual performance of the

177   jump, the boundaries of the respective area were identified as a circle with the skateboard's

178   length as diameter and the resulting spots were marked in the video footage as patches allow-

179   ing for the allocation of the gaze vector. Further potential cues (e.g., the approach route) were

180   not expected to be relevant for the task at hand and thus not coded.

181

182   *Movement phases*. For the movement phases, the average duration of the approach

183   (from start until take-off), the average duration of the jump (from take-off until landing) and

184   the average total duration (from start until landing) were calculated out of 4 attempts for each

185   of the 2 (technique) x 2 (obstacle) conditions. The movement phases were analyzed with a 2

186   (phase) x 2 (technique) x 2 (obstacle) ANOVA with repeated measures on all factors.

187

188   *Gaze behavior*. The relative gaze duration (% of overall phase duration) at the five

189   different areas of interest was calculated out of 4 trials for each of the 2 (technique) x 2 (ob-

190   stacle) conditions for the approach and the jump phase separately. Relative values were pre-

191   ferred over absolute values in order to compensate for different overall phase durations be-

192   tween the two techniques ("Ollie", approach: min = 3085.4 ms, max = 5104.2 ms; jump: min

193   = 418.8 ms, max = 543.8 ms; ("Kickflip", approach: min = 3247.9 ms, max = 6233.3 ms;

194   jump: min = 406.3 ms, max = 628.5 ms). In addition, the percentage of stable gaze behavior

195   (% of trials) was further analyzed over (absolute) time by triggering all trials onto the mo-

196   ment of take-off and calculating the percentage score for average stable gaze locations at the

197   five areas of interest for each time step (of 16.7 ms) before and after this event, separately for

198   both techniques and obstacle conditions, respectively. This basically means that, for example,

199   if all participants in half of the trials would show a stable gaze at the jump zone at the mo-

200   ment of take-off, the respective value for jump zone would be 50 %. Finally, out of values for

201   each participant, a running Cohen's *d* was calculated for the respective comparison to assess

202   the relevance of differences in the area-of-interest-related percentage scores. Separately for

203   the approach and jump phase, the relative gaze duration was subjected to a 4 (area of interest)

204   x 2 (technique) x 2 (obstacle) ANOVA with repeated measures on all factors. Due to the

205   standardization, it was not possible to add "phase" as third factor in this calculation. Finally,

206   for the obstacle conditions, the relative duration of gaze located at the obstacle was analyzed

207   with dependent t-tests.

208   For all ANOVAs, significant main and interaction effects were further analyzed with planned

209   t-tests. In cases of sphericity assumption violations Greenhouse-Geisser corrections were

210   applied. A posteriori effect sizes were computed as partial eta squares (η_P^2) and Cohen's *d*.

211   The level of significance was set at $\alpha = .05$.

212

213   Results

214   Movement Phases

215   For movement phases, a significant main effect for phase, $F(1, 8) = 157.38$, $p < .05$, $\eta_p^2 = .95$,

216   was found with longer durations for the approach ($M = 4543.9$ ms, $SD = 884.2$ ms) than for

217   the jump ($M = 483.9$ ms, $SD = 71.8$ ms) phase. In addition, a significant main effect for tech-

218   nique, $F(1, 8) = 23.83$, $p < .05$, $\eta_p^2 = .75$, and a significant phase x technique interaction, $F(1,$

219    $8) = 21.44$, $p < .05$, $\eta_p^2 = .73$, was revealed, elucidating significant technique differences in

220   the approach phase, $t(8) = 4.75$, $p < .05$, $d = 0.85$, but not in the jump phase, $t(8) = 1.68$, $p >$

221    $.05$, $d = 0.31$, $1\text{-}\beta = .13$. The skateboarders approached the jump zone faster in the "Ollie"

222   condition ($M = 4165.3$ ms, $SD = 810.9$ ms) than in the "Kickflip" condition ($M = 4920.7$ ms,

223    $SD = 957.4$ms). No further significant main and interaction effects were revealed (all $ps >$

224    $.05$, all $\eta_p^2 < .05$, all $1\text{-}\beta > .12$) highlighting that the skateboarders performed the respective

225   jump in both obstacle conditions in a similar way.

226

227   Gaze Behavior

228   *Relative gaze duration: Approach phase*. The ANOVA for relative gaze duration re-

229   vealed a significant main effect for area of interest, $F(3, 24) = 10.67$, $p < .05$, $\eta_p^2 = .57$, as

230   well as significant area of interest x obstacle, $F(3, 24) = 12.91$, $p < .05$, $\eta_p^2 = .62$, and area of

231   interest x technique x obstacle interactions, $F(3, 24) = 3.37$, $p < .05$, $\eta_p^2 = .29$. Independent of

232   technique and obstacle the skateboarders stabilized their gaze longest at the skateboard ($M =$

233   25.6%, $SD = 18.6\%$), followed by the take-off area ($M = 14.1\%$, $SD = 10.6\%$) and jump zone

234   ($M = 10.3\%$, $SD = 6.1\%$), and shortest at the landing area ($M = 0.4\%$, $SD = 6.2\%$).

235   For skateboard as an area of interest, a significant main effect for obstacle, $F(1, 8) = 21.67$, p

236    $< .05$, $\eta_p^2 = .73$, and a significant technique x obstacle interaction, $F(1, 8) = 5.98$, $p < .05$, η_p^2

237 = .43, was found with shorter gaze durations in the obstacle ($M = 16.8\%$, $SD = 13.6\%$) than in

238 the no-obstacle conditions ($M = 34.4\%$, $SD = 23.6\%$) and descriptively longer stable-gaze

239 durations for the "Kickflip" ($M = 39.5\%$, $SD = 27.4\%$) than for the "Ollie" ($M = 29.4\%$, $SD =$

240 19.7%) in the condition without obstacle, $t(8) = 2.21$, $p > .05$, $d = 0.74$. For the take-off area,

241 longer stable-gaze durations ($M = 21.4\%$, $SD = 15.0\%$ vs. $M = 6.9\%$, $SD = 6.2\%$), $F(1, 8) =$

242 7.11, $p < .05$, $\eta_p^2 = .47$, and for the jump zone ($M = 7.75\%$, $SD = 6.1\%$ vs. $M = 12.8\%$, $SD =$

243 6.2%) shorter stable-gaze durations, $F(1, 8) = 8.39$, $p < .05$, $\eta_p^2 = .51$, were found for the ob-

244 stacle than for the no-obstacle condition. No further significant main and interaction effects

245 were revealed (all ps $> .05$, all $\eta_p^2 < .19$, 1-$\beta > .07$). For obstacle as area of interest in the tri-

246 als with an obstacle – that could not be included in the ANOVA –, no significant difference

247 was found between "Ollie" ($M = 12.9\%$, $SD = 19.1\%$) and "Kickflip" ($M = 4.1\%$, $SD =$

248 7.2%), $t(8) = 1.62$, $p > .05$, $d = 0.53$, 1-$\beta = .29$. Summing up, in terms of effect sizes, the most

249 important effect was revealed not with respect to the technique but with respect to the obsta-

250 cle factor with longer stable-gaze durations on the skateboard in the obstacle than in the no-

251 obstacle conditions and longer stable-gaze durations on the take-off area in the no-obstacle

252 than in the obstacle conditions.

253   *Relative gaze duration: Jump phase*. For the relative gaze duration in the jump phase

254 a significant main effect for area of interest was found, $F(3, 24) = 39.01$, $p < .05$, $\eta_p^2 = .83$,

255 with the longest gaze duration at the skateboard ($M = 77.1\%$, $SD = 35.6\%$) followed by the

256 remaining three areas of interest that did not significantly differ from each other (all ps $> .05$,

257 all 1-$\beta > .79$). No further significant main effects and interactions were found (all ps $> .05$, all

258 $\eta_p^2 < .11$, all 1-$\beta > .09$). Likewise, no significant difference for technique ("Ollie": $M = 1.8\%$,

259 $SD = 3.9\%$; "Kickflip": $M = 0.0\%$, $SD = 0.0\%$) was revealed for the obstacle as specific area

260 of interest in the obstacle conditions, $t(8) = 1.29$, $p > .05$. This means that under all condi-

261   tions, directing the gaze to the skateboard was found to be most important over the jump

262   phase.

263   *Percentage of stable gaze*. The percentage of stable gaze at the areas of interest skate-

264   board, take-off area and jump zone for the two obstacle conditions are depicted in the upper

265   panel of Figure 2 as a function of (absolute) time using the moment of take-off as a trigger (=

266   0 ms). As the previous descriptions revealed no relevant percentage of gaze allocations to the

267   landing area as fourth a-priori defined area of interest, these data have been excluded from

268   the illustration for the sake of clarity. In the lower panel, running Cohen's *d* values are dis-

269   played for the area-of-interest-related comparisons between the two obstacle conditions. In

270   both panels, the two black vertical lines denote the average jump phase.

271   Insert Figure 2 about here

272   For skateboard as an area of interest, the percentage of stable gaze increases over time for

273   both conditions with the highest value at 300 ms after the take-off. However, in the no-

274   obstacle condition, the percentage starts to increase at around 2000 ms before take-off with a

275   first peak at around 200 ms before take-off whereas, in the obstacle condition, virtually no

276   stable gaze can be observed until 250 ms before take-off with a rapid increase from this mo-

277   ment and catching up with the no-obstacle condition shortly after the moment of take-off.

278   This spread between the two obstacle conditions can also be seen in the running Cohen's *d*

279   graph with almost linearly increasing values until about 250 ms before take-off, peaking at a

280   value of $d = 4.94$, and a rapid decrease after that point in time.

281   In contrast, for the take-off area as an area of interest, the opposite was observed with in-

282   creasing percentage scores for the obstacle condition in the early phase until 450 ms before

283   the moment of take-off whereas virtually no stable-gaze on the take-off area was found for

284   the no-obstacle conditions. This difference is represented in the running Cohen`s *d* illustra-

285   tion by a maximum value of $d = 4.14$ at about 450 ms before take-off. Over the jump phase,

286   the skateboarders did not stabilize their gaze at the take-off area.

287   Finally, the percentage scores for a stable-gaze location at the jump zone was overall smaller

288   than for the two other areas of interest. Between about 2500 ms and 1500 ms before take-off

289   the skateboarders showed slightly higher values for a stable gaze at the jump zone in the no-

290   obstacle condition than in the obstacle condition. The relevance of this difference is repre-

291   sented in the Cohen's d values peaking about 2200ms before take-off at $d = 2.96$.

292

293   Discussion

294   In the current study, the gaze behavior of experienced skateboarders was investigated when

295   performing trick jumps of different difficulty over an obstacle on the one hand and over a

296   plane surface on the other hand. Whilst the expected difference in gaze behavior as a function

297   of trick difficulty was not empirically found, the obstacle-related hypothesis could be con-

298   firmed since the analyses of the gaze behavior revealed an interaction between obstacle and

299   area of interest. This interaction illustrates that over the approach phase the skateboarders

300   apply different gaze strategies if they have to perform the jumps either over an obstacle or

301   over a plane surface. Over plane surface, predominantly visual information regarding the

302   skateboard is processed whereas, if the jumps must be performed over an obstacle, infor-

303   mation about the take-off area are continuously updated over the approach phase until shortly

304   before the moment of take-off (for the predictive function of visual perception, see also, e.g.,

305   Sailer et al., 2005).

306   With regard to underlying motor-control processes, it should be particularly noted that it is

307   not the stable gaze at the obstacle that characterizes gaze behavior in the obstacle condition

308   (with a maximum score of 21.9 % about 700 ms before take-off). Instead, the gaze is stabi-

309 lized at the take-off area, that means, at a visual cue that is available in both obstacle condi-

310 tions. These findings imply that the skateboarders apply two different strategies when prepar-

311 ing the jump movement. In the case of an obstacle, the exact timing of the take-off needs to

312 be planned to avoid a collision such that it is crucial to continuously update information about

313 the distance to this point (cf. optical-flow from a psycho-ecological perspective, Gibson,

314 1950). In contrast, in the case of a plane surface, the skateboarders were only instructed to

315 perform the jump within a certain jump zone such that motor planning could be predominant-

316 ly directed to the mere execution of the jump which is reflected in the preferred stable-gaze

317 location at the feet on the skateboard. In sum, these findings highlight the close link between

318 action and perception such that differing demands for the motor-control systems directly af-

319 fected the timing of the processing and the selection of visual information. The bi-

320 directionality between these two domains was, for example, shown by Amazeen, Amazeen,

321 Post, & Beek (1999) who found that constraining visual information processing with liquid

322 crystal googles results in adaptations within the timing of a throw and catch cycle (for an

323 overview, e.g., Schütz-Bosbach & Prinz, 2007).

324 Regarding effects of trick difficulty, the only found tendency refers to the stable-gaze loca-

325 tion at the skateboard as a function of jump difficulty which was revealed solely for the ob-

326 stacle condition over the approach phase. Nevertheless, this result corroborates earlier find-

327 ings on the relation between task demands and foveal information processing (e.g., Patla &

328 Vickers, 1997) hypothesizing that longer intervals for visual information processing are re-

329 quired as a function of fine-tuning demands over movement planning (e.g., Vickers, 1996) as

330 well as over online-control of the movement execution (e.g., Klostermann, Kredel, & Hoss-

331 ner, 2014). However, since the respective inferential test (marginally) missed the predeter-

332 mined level of significance, this interpretation has to be treated with care.

333   Finally, the gaze data on the jump phase clearly showed that, after the moment of take-off,

334   neither trick difficulty nor the presence or absence of an obstacle affected gaze behavior. This

335   finding suggests that difficulty- or obstacle-related visual information – although having been

336   definitive, as shown before, for the planning of the jump movement – is not further used for

337   the online-control of the jump phase. Instead, the direction of the gaze to the skateboard un-

338   der each condition implies that for the preparation of a save landing information on the rela-

339   tion between the own body and the skateboard becomes crucial. This interpretation would be

340   perfectly in-line with the above-suggested conclusion that locomotion control in complex

341   sports environments is mainly affected by the question whether the current movement needs

342   to be spatio-temporally adapted to relevant obstacles or not.

343   As for the majority of eye-tracking studies the mobile measuring devices need to be consid-

344   ered as limiting factor which might have affected the skateboarders' natural movement and

345   gaze behavior. The rather long warm-up phase in which the skateboarders had as much time

346   as required to accustom themselves with the setup definitely minimized possible negative

347   effects. Nevertheless, the results have to be treated with caution.

348

What Does This Article Add?

350   To the best of our knowledge, this is the first study to investigate gaze behavior in a complex

351   and highly dynamic locomotion task like performing skateboard tricks. In sum, the results

352   illustrate a strong link between specific task demands and visual information processing,

353   thereby further underlining a close coupling between action and perception in motor perfor-

354   mance: As a function of specific constraints for the motor-control system, different gaze

355   strategies were observed to successfully perform the jump tricks. With regard to surface plau-

356   sibility, the revealed strategies can claim to reflect functional characteristics of perceptual-

357   action coupling. However, as the gaze behavior was not manipulated in the study at hand,

358   further research would be needed in which the actual functionality of these strategies is ex-

359   perimentally addressed.

360

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362

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