

1 **Does Framing The Hot Hand Belief Change Decision-Making Behavior In Volleyball?**

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### Abstract

Purpose: Previous discussions of the hot hand belief, wherein athletes believe that they have a greater chance of scoring after two or three hits (successes) compared to two or three misses, have focused on whether this is the case within game statistics. Researchers have argued that the perception of the hot hand in random sequences is a bias of the cognitive system. Yet most have failed to explore the impact of framing on the stability of the belief and the behavior based on it. Method: The authors conducted two studies that manipulated the frame of a judgment task. In Study 1, framing was manipulated via instructions in a playmaker allocation paradigm in volleyball. In Study 2, the frame was manipulated by presenting videos for allocation decisions from either the actor or observer perspective. Results: Both manipulations changed the hot hand belief and sequential choices. We found in both studies that the belief in continuation of positive or negative streaks is non-linear and allocations to the same player after three successive hits are reduced. Conclusions: The authors argue that neither the hot hand belief nor hot hand behavior is stable but rather both are sensitive to decision frames. The results can inform coaches on the importance of how to provide information to athletes.

**Keywords:** *streak, fallacy, cognitive bias, choice*

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50 People perceive streaks every day: A scientific paper is rejected three times in one year;  
51 there are three days of sunny weather; black comes up three times in a row in a game of roulette.  
52 People might believe such streaks are based on bad luck in the case of rejections, on base rates in  
53 the case of sunny weather when living in Florida, and on chance when playing roulette. Even in  
54 cases of independence of sequentially observed outcomes, people tend to behave as if there is a  
55 greater chance of one outcome occurring after the other outcome has occurred three times, such  
56 as believing red will come up in roulette after black has come up three times—a belief known as  
57 the gambler’s fallacy (Ayton & Fischer, 2004). Yet in roulette, winning on red or black has the  
58 same probability and thus the belief does not harm the gambler’s chances of winning. In sport,  
59 however, such beliefs could harm or benefit a team when they drive strategic decisions such as to  
60 whom to allocate the ball.

61 In sports, fans and players often believe in the opposite pattern to the gambler’s fallacy,  
62 called the hot hand, where streaks are expected to continue (Raab, Gula, & Gigerenzer, 2012).  
63 Whether the sequential outcome of basketball shots is independent has been hotly debated. The  
64 majority of studies have shown that the sequences are independent, among them a study by  
65 Gilovich, Vallone, and Tversky (1985), a narrative review by Bar-Eli, Avugos, and Raab (2006),  
66 and a meta-analysis (Avugos, Köppen, Czienkowski, Raab, & Bar-Eli, 2012).

67 Regardless of whether it reflects reality, belief in the hot hand can nevertheless influence  
68 the success of a behavior (Burns, 2004). In sports, a positive relationship between the hot hand  
69 belief and the success of a behavior was recently found in conditions in which the base rates of  
70 players were highly variable, not known, or correlated positively with the number of streaks  
71 (Raab et al., 2012). The study used a computer experiment in which participants viewed videos  
72 of successful or unsuccessful attacks from the perspective of a playmaker in volleyball and had  
73 to decide to whom they would allocate the next ball. Results indicated that the belief that either

74 Player A or Player B was “hot” changed over natural breaks such as sets, as did the behavior of  
75 favouring one of the players. Thus, the hot hand belief and a behavior associated with it were  
76 changeable. Could these changes have been produced by different frames?

77 A frame refers to a mental model that is used to perceive a task and influence a judgment  
78 (Soman, 2004). Stability and framing in the hot hand belief and hot hand behavior have not been  
79 extensively studied, and most explanations of the belief have been general in nature. For  
80 instance, in their original study, Gilovich et al. (1985) explained the hot hand belief of basketball  
81 fans and players as a fallacy originating from the law of small numbers. This law describes how  
82 an observer of small samples of hits and misses such as three hits or three misses believes that  
83 the sequence is representative (e.g., Kahneman, 2012). Representativeness ignores the base rate  
84 of the player or how often in a given sequence three hits or misses can come about by chance.  
85 Another account of the hot hand belief that does not consider framing has been recently  
86 introduced in a review of how individual success can breed success by modelling duration,  
87 intensity and frequency of streaks (Iso-Ahola & Dotson, 2014). Although this argument seems to  
88 explain individual behavior when judging one’s own decisions it is unclear whether such effects  
89 easily transfer to observations of the behavior of others in sports.

90 Experimental evidence suggests that observers use streaks as a cue for an agent’s  
91 intentionality. For instance, if streaks such as basketball shots are performed by a player  
92 intentionally, participants predict that streaks may continue, whereas if a robot performs the  
93 same task, hot hand streaks are attributed to chance (Caruso, Waytz, & Epley, 2012). It seems,  
94 then, that humans are well equipped for understanding the goal-directed behaviors of others and,  
95 critically, also attuned to contextual factors.

96 A test to understand the effects of agency, given the arguments above, would be to  
97 instruct participants either to judge their own sequential decisions or to observe others. For  
98 instance, in athletes there is convincing evidence that the performance outcome in decision-

99 making or anticipation tasks is affected by whether the task requires independent choices as an  
100 actor or as an observer (Ward, Suss, Eccles, Williams, & Harris, 2011). Whether such effects  
101 generalize to sequentially (in)dependent choices in sports is unknown, but there is evidence in  
102 non-sports tasks that serves as a basis for predictions (Lyons, Weeks, & Elliot, 2013). For  
103 example, it has been argued that rolling dice or observing someone else rolling dice produces  
104 different predictions of the continuation of streaks (Langer & Roth, 1975). A manipulation of  
105 control (self vs. other) would allow us to determine if framing through agency (one's own or  
106 others' movements) has an impact on sequential judgments. This has yet to be explored in hot  
107 hand research and it could have an impact on how to frame sequential choices in sports.

108         Recent evidence suggests that the rather generic and stable beliefs and behaviors based on  
109 streak perception are also exposure-based and can be altered by the frequency of exposure. This  
110 can be explored by using different expertise groups (Köppen & Raab, 2012; MacMahon, Köppen  
111 & Raab, 2014; MacMahon & Starkes, 2008). Given all this literature, and acknowledging that  
112 agency and exposure are factors in decision frames, another potentially stronger way of  
113 investigating the stability of the hot hand belief and hot hand behaviors would be to manipulate  
114 the judgment frame via instructions.

115         One type of judgment frame is an outcome frame. A typical outcome frame manipulation  
116 would be to present a problem in terms of gains or losses. For example, Tversky and Kahneman  
117 (1981) presented participants with information about an Asian disease and framed the problem  
118 for participants by either asking them to focus on saving lives or on reducing deaths, which had  
119 an effect on choices.

120         Framing may have an effect on the perception of and behavior pertaining to streaks, as  
121 well. For instance, in a study on the hot hand belief, participants were asked to take the  
122 perspective of the playmaker and allocate balls to the best player. This produced more  
123 allocations to the hot hand player. In comparison, when asked to replace poor players, there were

124 fewer allocations to a weaker player (Köppen & Raab, 2012). Further, belief in both the hot and  
125 cold hand was reported by participants. If participants are instructed to focus on a cold hand  
126 (streaks of failures) they may be more likely to detect it and change their allocation to a stronger  
127 player, compared to participants who are instructed to focus on wins, who may focus on hot  
128 streaks that they believe will continue. A manipulation of this kind, using different sets of  
129 instructions, would allow a test of whether a generic focus on positive streaks is stable in  
130 different frames, as is suggested by Wilke and Barrett (2009), who propose that detection of  
131 streaks is adapted from the need to detect food sources.

132         In sum, current research on the hot hand belief and hot hand behavior focuses on stable  
133 behaviors that rely on stable hot hand beliefs. Evidence suggests, however, that both beliefs and  
134 behavior change and are adapted to the information they are exposed to during sequential  
135 choices. Although some individual and situational differences have been shown recently, a  
136 systematic manipulation of outcome framing has not been done. Therefore we conducted two  
137 studies that systematically manipulated outcome frames by presenting different instructions  
138 (Study 1) or different visual perspectives in video clips (Study 2).

139         If framing alters hot hand beliefs and behavior, participants should give different  
140 responses depending on the frame. Specifically, we predicted that outcome framing using a win  
141 frame would increase participants' hot hand belief and lead to more balls being allocated to a hot  
142 player than when a losing frame is used. We predicted that framing from the actor perspective  
143 would increase participants' sense of control and their belief in streak continuation and would  
144 result in a longer continued allocation to a hot player than when framing was from the observer  
145 perspective. Given that framing has not yet been tested in this context, we used two kinds of  
146 framing to explore the general effects of framing on the hot hand belief and the hot hand  
147 behavior. However, we tested the main effects of different kinds of framing independently and  
148 thus no interaction of these effects was assumed.

149 **Study 1**150 **Method**

151 Effects of outcome framing on the hot hand belief and allocation decisions were tested in  
152 a within-subjects design with the two factors agency frame (actor vs. observer) and goal frame  
153 (win or lose), resulting in four conditions (actor–win frame, actor–lose frame, observer–win  
154 frame, observer–lose frame). Hot hand belief was measured after each condition and framing  
155 effects on allocation decisions were described as mean allocation per condition as well as the  
156 length of allocations continuation to the hot hand player after sequences of one to four  
157 consecutive hits (and vice versa for cold players and sequences of one to four consecutive  
158 misses).

159 **Participants.** Twenty-nine students who majored in sport from a university ( $M = 23.5$   
160 years,  $SD = 3.8$ , 15 male and 14 female) participated in this study. We chose students who  
161 majored in sport, as they would be able to understand the displayed volleyball situations and  
162 have experience in both watching and playing volleyball during their physical education program  
163 at the university. We controlled for gender, age, and the number of years spent training ( $M =$   
164  $5.26$ ,  $SD = 3.48$ ) as well as for sport-specific experience (sport type: team or individual sport, see  
165 Köppen & Raab, 2012) that could alter choices in our study but found no significant moderators.  
166 Further, we checked comprehension of instructions and motivation levels on a six-point Likert  
167 scale (1 high, 6 low) asking explicitly whether they understood the instruction and whether they  
168 were motivated to perform the task. Results showed high motivation on average ( $M = 1.4$ ,  $SD =$   
169  $.6$ ) and good instruction comprehension ( $M = 1.2$ ,  $SD = .7$ ). Debriefing showed no specific  
170 answers from the participants other than acting as instructed. All participants in this study  
171 provided informed consent and the university's ethics board approved the study.

172 **Materials and Apparatus.**

173 Videos for decision making behavior: We used videos of sequential decision making in

174 volleyball to measure choice behavior presented on a computer screen (Raab et al., 2012).  
175 Participants were instructed that the game was the final of the volleyball World Cup. Winning  
176 was thus important. The video clips were filmed from the stands as is typical in television  
177 broadcasts and lasted around 3 seconds each. The videos displayed one volleyball team serving  
178 and the playmaker's team preparing its attack. At the moment of the freeze frame, the ball was  
179 on its way to the playmaker, thus neither the position of the playmaker nor his movements  
180 revealed any cues for allocation.

181       Experimental measures of the hot hand belief: We used questionnaires on the hot hand  
182 belief that were validated in previous research (Gilovich et al., 1985; Raab et al., 2012) to  
183 measure if participants believed in the hot hand and if they applied this belief to choice behavior.  
184 The predictive validity was shown in Gilovich et al.'s (1985) belief-behavior experiments, and  
185 Raab et al.'s (2012) studies showed that reliable results could be obtained using a modified paper  
186 and pencil version of the questionnaire. There were two Yes/No questions on current hot hand  
187 belief that were asked after each condition: (a) Do you believe that it is important to allocate the  
188 ball to a player who just successfully performed two or three hits? (b) Does a player who scored  
189 a hit in the last two or three attempts have a better chance of scoring on the next ball compared to  
190 when previously missing two or three balls?

191       Post-experimental measures of self-reported allocation strategy: There were six questions  
192 after the experiment about allocation strategies (c-g multiple choice questions or filling in a  
193 discrete number, question h is an open question that was labelled by two independent raters with  
194 .92 inter-rater reliability to higher order themes): (c) Which of the two players (A or B) was more  
195 successful, or were they equal? (d) Consider a game in which the last point in the last set will  
196 decide the game. You are the playmaker and allocate the ball. Do you allocate the ball to the  
197 player with the better average performance or to the player who scored the last three attempts?  
198 (e) For your choices in the experiment, how often did you shift your allocation from one player



199 who just made an error to the other player? (f) For your choices in the experiment, how often did  
200 you shift your allocation from one player who just made a hit to the other player/keep your  
201 allocation with the same player? (g) How often did you consider at least the last three attempts of  
202 the players for your next allocation? (h) When you considered the last one or more attempts,  
203 please describe your allocation strategy.

204       Decision making task: The basic task was to decide to which attacker - Player A or B - to  
205 pass the ball, via a keypress on the computer keypad. After participants had chosen to whom they  
206 would allocate the next ball (Player A or B) a clip was displayed in which the chosen player was  
207 either successful (spike) or not successful (spike hits outside the court or hits the net).

208       There were 176 trials, separated into four sets of 44 clips representing the four conditions  
209 of actor perspective with either a win or a lose frame and observer perspective with either a win  
210 or a lose frame. The number of hits and misses was identical for Players A and B. Within each  
211 set we twice showed three consecutive hits and twice three consecutive misses. These sequences  
212 are real game footage sequences selected from male volleyball games of the national Premier  
213 League.

214       There were two framing manipulations: agency and goal. In the agency manipulation,  
215 participants were instructed to imagine themselves as either the playmaker (actor) or an observer  
216 (observer perspective). Whether they followed the instruction to imagine themselves as an actor  
217 (actor frame) or an observer (observer frame) was checked in the debriefing. In the goal  
218 manipulation, participants were instructed to allocate the ball to the player who would likely  
219 score (win frame) or to indicate which of the two players would likely not score (lose frame). For  
220 the frame manipulation in which we manipulate the agency, participants were instructed either  
221 (a) to take the playmaker's perspective and make all the decisions in that role or (b) to observe  
222 the playmaker in the video and indicate from an observer's perspective how the playmaker  
223 should allocate the ball. For the outcome frame, we instructed participants either (a) to press the

224 key that represents the player to whom the playmaker should allocate the ball (seek to win) or (b)  
225 to press the key that represents the player to whom the playmaker should not allocate the ball  
226 (avoid loss).

227         After the first set and for all following sets of 44 trials a display asked the participants to  
228 indicate how many hits Player A and Player B just had as well as to type in their allocation  
229 strategy for the first 11 trials of the next set (“In how many of 11 trials would you allocate the  
230 ball to Player A” and “In how many of 11 trials would you allocate the ball to Player B”). The  
231 first question was asked to explore to what extent choice behavior was influenced by the memory  
232 of players’ base rates, that is, the number of hits out of the number of trials. The question about  
233 future allocation was used to analyse to what extent allocations change as a result of actual  
234 experienced hit and miss sequences. We used a small (11 out of 44) and unequal number of trials  
235 to evaluate choice behavior (i.e., the unequal number forced a greater number of allocations to  
236 one player).

237         **Procedures.** We tested each participant individually in a maximum of 90 minutes, using  
238 written instructions to inform them about the goal of the experiment, and collected personal data  
239 and informed consent. Then we provided participants with the video test of 176 trials. Using a  
240 within-subject design, we counterbalanced the four sets of 44 trials per condition to manipulate  
241 the win–lose and observer–actor framing with a break of about 2 minutes between conditions.  
242 After each trial the participants produced an allocation decision for the next trial. We asked  
243 Questions a and b after each block and Questions c–h only after the experiment. Finally,  
244 participants were debriefed.

245         **Data Analysis.** We tested whether framing has an affect on the hot hand behavior and the  
246 hot hand belief. For the hot hand behavior we expected differences in choice variables using  
247 ANOVAs or t-tests between framing conditions. For hot hand belief we asked questions during  
248 the video task and after the experiment.

249 For hot hand behavior we calculated (a) the average allocation to Player A and Player B  
250 for each condition; and (b) autocorrelation tests of participants' choices to provide sequential  
251 analyses of the choices following the autocorrelation claim by Hales (1999) and (c) participants  
252 allocation strategy.

253 For (b) we used autocorrelation to analyse the sequence of choices by correlating the  
254 original sequence of choices with a sequence shifted by one position (lag 1). An autocorrelation  
255 of 1 means a participant only ever chose one player (i.e., Player A or Player B), and a -1  
256 autocorrelation means a participant always alternated between Player A and Player B on  
257 consecutive trials. Because the base rates of Players A and B were equal and at .5 (5 out of 10  
258 trials are hits) and we had an equal number of positive and negative streaks in the trials, we could  
259 expect an autocorrelation of zero if sequential choices were independent of each other. However,  
260 if participants believed in the continuation of a streak we could expect a positive autocorrelation,  
261 and if they believed in the gambler's fallacy (after two or three hits a miss on the next trial is  
262 more likely) we could expect a negative correlation.

263 For (c) we calculated allocation strategy during the experiment, by comparing the number  
264 of trials that represented a win-stay, lose-shift strategy (where only the previous response is  
265 considered,  $n = -1$ ) to the number of trials in which other strategies were considered (including a  
266 strategy that considered more than the previous attempt,  $n = -2$  or more). A win-stay, lose-shift  
267 strategy counts the number of trials in which participants allocated the ball to the same player  
268 after a hit (win-stay) and changed to the other player after a miss (lose-shift). If the allocation  
269 did not follow a win-stay, lose-shift strategy it was marked as 'other'. The general tendency of  
270 following a win-stay lose-shift strategy can be assessed by  $t$  tests using one or zero as a criterion  
271 of a win-stay, lose-shift strategy (or the mirrored version, win-shift, lose-stay).

272 For hot hand belief we examined (a) whether the reported allocation strategy for the next  
273 11 trials (how many balls should be allocated to Player A or Player B) and responses to base rate

274 questions (how many hits Player A and Player B achieved the last ten trials) queried between  
275 each set of 44 trials, differed based on differences in framing conditions, using chi-square tests;  
276 and (b) answers on questions a,b indicating general beliefs in the hot hand, compared between  
277 framing conditions.

278         Alpha criterion was set to .05, with expected mean effect sizes given previous studies and  
279 sample size (Köppen & Raab, 2012). Effect sizes are not displayed for  $F$ ,  $t$  values lower than 1 as  
280 these findings may be unreliable.

## 281 **Results**

282 **Hot Hand Behavior.** Allocations were equally distributed to Player A and Player B (see Table  
283 1), averaged over all participants and conditions ( $t$  values from .11 to 2.7, effect sizes from .05 to  
284 .11,  $p > .05$ ) and thus reflect the equal base rates of the displayed players. We performed a two-  
285 way analysis of variance (ANOVA) on the number of allocations to the players using the  
286 framing conditions actor–observer and win–loss. We found neither statistically significant main  
287 effects,  $F(1,25) = 1.6$ ,  $p > .05$ , nor interaction effects,  $F(1,25) = .41$ ,  $p > .05$ , in participants’  
288 mean allocation behavior. To test our main hypothesis that agency (actor-observer) and goal  
289 (win-lose) framing will change sequential decisions we performed a number of tests. First, when  
290 we analysed the sequential choice strategies rather than average behavior, we found that choices  
291 based on a 1-back strategy—such as win–stay, lose–shift— differed depending on participants’  
292 condition. T-tests showed that participants differed significantly in all conditions from such pure  
293 strategy behavior ( $t$  values from .21 to 1.4, effect sizes from .04 to .52, all  $p_s < .05$ ) indicating  
294 that sequences of more than 1-back are used. This finding extends previous research on 1-back  
295 sequences in hot hand research (Attali, 2013). Yet contrasting the number of trials using a win–  
296 stay, lose–shift strategy with chance level (t-test with .5 as criterion) revealed that a win–stay,  
297 lose–shift strategy is used roughly about the same amount as predicted by chance (t values from  
298 2.27 to 14.4, effect sizes from .42 to 2.67,  $p_s < .05$ ).

299 In Table 1 the percentage of trials per condition in which participants followed a win-  
300 stay, lose-shift strategy are displayed for up to four sequential hits or misses. We set the  $x$  axis at  
301 50% as this percentage of trials using a win-stay, lose-shift strategy would be predicted by  
302 chance if participants ignored the previous hit or miss in consecutive choices. We used a  
303 sequence length of four hits or misses as sequences of three hits or three misses are preceded by  
304 a hit or miss. Participants in the actor condition tended to use a win-stay, lose-shift strategy  
305 more often ( $F(1,28) = 1.14, p = .07, \eta^2 = .21$ ) than participants in the observer condition,  
306 potentially reflecting a greater perception of control as argued in the introduction. No such effect  
307 was found for the win-lose goal frame manipulation. As we used the same number of hot and  
308 cold hands in the video clips, this finding partly confirms our expectations that framing can alter  
309 sequential choice behavior complementing previous research in basketball (Aharoni & Sarig,  
310 2012; Attali, 2013).

311 In a second approach to understanding sequential allocation behavior we performed two  
312 additional tests. We (a) compared the number of win-stay, lose-shift strategies between  
313 conditions of different streak length, streak direction, and actor-observer framing only for streak  
314 patterns within the trials. We (b) performed autocorrelations to allow for a general pattern of  
315 consecutive allocation behavior from one trial to another. Both tests should provide us with  
316 information on whether framing has short-term effects on allocation decisions.

317 First, we performed a three-way ANOVA with sequence length (one to four hits/misses),  
318 streak direction (positive streak of hits or negative streak of misses), and agency frame  
319 (actor/observer) as within-subject factors. The number of win-stay trials increased in positive  
320 streaks (hit streaks) and the number of lose-shift trials decreased over sequence length, non-  
321 significantly,  $F(3, 27) = .6, p > .05$ . The number of win-stay trials in positive streaks was non-  
322 significantly greater than the number of lose-shift trials in negative streaks, as indicated when  
323 we tested the main factor streak direction,  $F(1, 27) = 3.11, p = .08, \eta^2 = .10$ . There was no

324 significant actor–observer effect or any interaction effects of the number of win–stay, lose–shift  
325 strategies again confirming our argument that hot hand analyses beyond 1-back strategies such as  
326 three hits/misses in a row are a crucial component of the hot hand belief.

327         Second, we analysed lag-1 autocorrelations for each player over all allocation choices of  
328 176 trials. We found that of 29 participants, 7 had significant correlations in the range of .22 and  
329 .39 either positive (4 times,  $p < .05$ ) or negative (3 times,  $p < .05$ ). Thus, for all allocations the  
330 majority did not show a systematic dependence on consecutive allocations. Comparisons to  
331 previous studies indicate that the data are in the ball park of results: Gilovich et al. (1985) had a  
332 significant autocorrelation of 1 out of 12 players and Raab et al. (2012) 13 out of 26. Given that  
333 these autocorrelations are run within sequences of positive and negative streaks this measure  
334 may not be as sensitive as a measure of runs represented in win–stay, lose–shift strategies,  
335 described above. This adds further evidence to our tenet that 1-back strategies are limited in  
336 showing hot hand allocation behavior in contrast to sequences of longer runs as displayed in  
337 Table 1.

338         **Hot Hand Belief During Experiment.** The hot hand belief during the experiment was  
339 assessed after each condition when asking about the performance of the players and the future  
340 allocation strategies of the participants. Our results indicate that allocation strategies could not be  
341 explained by false representations of players’ base rates. Averaged over all conditions and  
342 participants, the base-rates of players were correctly recalled by about 1 more or less hit  
343 attributed to a player than the real base-rates (t-tests for each condition between real vs. recalled  
344 base-rates is non-significant, t values from .87 to 1.6, effect sizes from .16 to .30,  $p_s > .05$ ). This  
345 nearly exact recall confirms base-rate recall in previous studies (e.g., Raab et al., 2012). Further,  
346 when participants were asked about their allocation strategies before a next set of video clips  
347 they produced almost identical allocation strategies for Player A and Player B reflecting the  
348 absence of fixed mind sets and reflecting their equal allocation behavior to Player A and Player

349 B as reported above.

350           However, when we analyzed condition-specific beliefs, we found an actor–observer  
351 difference concerning the belief in playing more to a hot player. In actors (using only the  
352 responses to Question a) after the manipulation of an actor instruction), 11 of 14 participants  
353 were in favour of playing more to a hot player, whereas in observers (using only the responses to  
354 Question a) after the manipulation of an observer instruction), only 6 of 15 participants were in  
355 favour of doing so,  $\chi^2(1, n = 28) = 4.88, p < .05$ , Cramer’s  $V = .93$ . We found no significant  
356 interaction between the win–lose and actor–observer framing manipulations on playing more to a  
357 hot hand player ( $p > .05$ ).

358           **Hot Hand Belief After The Experiment.** After the experiment we asked participants if  
359 they believed in the hot hand, testing whether the sequential allocation behavior is correlated to a  
360 belief in the hot hand. Over all conditions, 57% indicated a belief in the hot hand. Participants  
361 indicated that both players were equally good and when participants allocated balls, 55% used  
362 information about the base rate and 45% the previous success indicated by a hot hand. We found  
363 no indication that hot hand behavior and hot hand belief significantly correlate, and thus even if  
364 beliefs about the hot hand change as a result of instructions, the average distribution between two  
365 players in allocation performance remained unaltered. However, as previously reported, framing  
366 does alter the sequential strategies participants use to decide whether Player A or Player B  
367 receives the next ball and confirms previous research (Raab et al., 2012).

## 368 **Discussion**

369           Does framing sequential choices from an actor versus observer perspective or framing a  
370 problem with the goal of winning or avoiding losing change either belief in the hot hand or hot  
371 hand allocation behavior? The answer is yes, but this effect is stronger for the belief system  
372 measured by the questionnaire than for the behavior measured by participants’ allocations. In  
373 contrast to a recent study (Raab et al., 2012), where 91% of the participants believed in the hot

374 hand, in the current study fewer participants (57%) held this belief after engaging in behavior  
375 related to the belief. This difference cannot be explained simply by the sport used, the task, or the  
376 sample, as these were the same in the two studies (volleyball, allocation decisions, and students  
377 majoring in sports with similar experience). One explanation that could be explored in future  
378 studies is the specific within-subject design. Asking the same two questions four times or using  
379 framing instructions may have reduced the hot hand belief.

380 Mechanisms discussed in general psychology may be candidates for further tests such as  
381 “explicit discounting” or the “mere exposure effect”. Frequently asking about the hot hand belief  
382 may cause explicit discounting of the degree of participants’ belief in the hot hand. Even without  
383 explicit discounting just the “mere exposure” to the belief questions may have changed the  
384 degree to which participants liked the hot hand belief. Up to half of the participants may have  
385 had their levels of liking lowered after the experiment due to too much “mere exposure”,  
386 resulting in less belief in the hot hand (Bornstein & Craver-Lemley, 2004). Further studies could  
387 test these effects by incorporating different between-subject designs and looking for changes in  
388 the belief before, during, and after the experiments. One limit may be the power of the presented  
389 studies. In comparison to Gilovich et al. (1985), who tested only 12 players, the recent papers  
390 have been using approximately 20 participants per group (Köppen & Raab, 2012) or analyzed  
391 streaks for 26 players (Raab et al., 2013) and thus using identical paradigms and sports we  
392 believe power is sufficient. Nevertheless, Arkes (2013) argued that the hot hand has been  
393 difficult to detect because it occurs very rarely and thus further research with larger data sets is  
394 warranted.

395 In summary, the actor–observer instructions changed the reliance on the 1-back strategy  
396 of win–stay, lose–shift. The actor–observer difference can be explained by framing having  
397 changed the decision problem. Whether such effects can be replicated and extended for similar  
398 choice behaviors may be a matter of design and sample size. Therefore, in a second study we



399 tested a larger sample and manipulated the agency (actor–observer) frame in a different way. In  
400 Study 2 we manipulated the visual perspective by making the observer perspective that of a fan;  
401 the actor perspective was that of watching a video as used, for instance, in tactical training or in  
402 scouting.

## 403 Study 2

### 404 Method

405 In Study 2 the effects of framing manipulations on the hot hand belief and allocation  
406 decisions were tested in a between-subject design manipulating the agency frame (actor vs.  
407 observer). Rather than using instruction as in Study 1, in Study 2 we changed the video  
408 perspective from which allocation decisions had to be made. Hot hand belief was measured after  
409 the experiment and framing manipulations using the video perspective effects on allocation  
410 decisions were measured as mean allocation per condition as well as the length of allocation  
411 continuation to the hot hand player after sequences of one to four consecutive hits (and vice  
412 versa for cold players and sequences of one to four consecutive misses).

413 **Participants.** Two hundred and two students ( $M = 24.9$  years,  $SD = 2.1$ , 129 male and 73  
414 female) from a university were tested. None had been involved in Study 1. We randomly  
415 assigned participants to either an actor visual perspective or an observer visual perspective  
416 (dividing the sample equally into groups of 101 participants each). Participants received course  
417 credit as the experiment was part of a lecture integrating theory and experimental studies. As in  
418 Study 1, we controlled for gender, age, and training age ( $M = 4.31$ ,  $SD = 2.67$ ) as well as for  
419 sport-specific experience that could alter choices in our study but found no significant  
420 moderators. When each group was asked how well they could imagine the perspective of the  
421 group to which they were assigned, most of the participants (> 70%) indicated good to very good  
422 role identification. Debriefing showed no specific answers from the participants other than acting  
423 as instructed. All participants in this study provided informed consent and the university's ethics

424 board approved the study.

425       **Materials and Apparatus.** We used the same paradigm as in Study 1 but manipulated  
426 the video perspective. Clips were identical in structure and hit and miss sequences to those of  
427 Study 1 but differed in their perspective: The observer perspective was from the visual angle of a  
428 fan sitting in the stands; the actor perspective showed the performance of the team from behind,  
429 at court level, as a player might experience while playing or in a team video feedback meeting.

430       **Procedure.** We used the same procedure in terms of instructions and questionnaires as in  
431 Study 1, but we asked the hot hand belief questions only once after the experiment. The video  
432 test was applied with the same procedure as in Study 1 (176 trials) with the only exception being  
433 we presented the videos from two perspectives and no win–lose framing in the instructions was  
434 applied.

435       **Data Analysis.** The dependent variables were average allocation to players and the  
436 autocorrelation score. Strategy description was identical to Study 1 as far as setting the alpha  
437 criterion to .05 and reporting effect sizes.

## 438 **Results**

439       We controlled for effects other than framing and asked about experience in observing or  
440 playing volleyball. In both the actor-frame and the observer-frame groups, approximately 85%  
441 indicated that they did not watch much volleyball (fewer than four times a year). Further, skill  
442 level in volleyball was nearly identical, as over 80% reported having no volleyball experience at  
443 the club level.

444       We found an equal distribution of allocations to Player A and Player B averaged over  
445 participants and conditions compared in a *t* test ( $t(201) = .72, p > .05$ , Table 1). We thus  
446 replicated the findings from Study 1 showing that, in average allocation behavior, there were no  
447 significant differences for an actor–observer manipulation. As in Study 1, we performed further  
448 tests.

449 First,  $t$  tests with a criterion of 1 (all trials based on a win-stay, lose-shift strategy) or 0  
450 (all trials based on the mirrored strategy) would not be significant if participants always allocated  
451 the ball to the same player in the case of a hit, and changed allocation in the case of a miss for  
452 the win-stay, lose-shift strategy. The opposite would also be the case if players always shifted  
453 their allocation after a hit, and stayed with the same allocation after a miss, the win-shift, lose-  
454 stay strategy). This was what we found. Participants clearly did not show a 100% win-stay, lose-  
455 shift or win-shift, lose-stay strategy. However, the number of win-stay, lose-shift trials was  
456 significantly different from chance if we used .5 as a criterion for the  $t$  tests ( $t$  values from 1.67  
457 to 14.39, effect sizes from .12 to 1,  $p_s < .05$ ), assuming that chance in a two-option choice task  
458 with equal base rates of the options at 50% would produce allocation that reflects a win-stay,  
459 lose-shift strategy. Indeed in all but one condition of actors in positive streaks with a streak  
460 length of 1, allocations were at chance levels.

461 Second, we compared sequential allocations by contrasting the number of trials in which  
462 a win-stay (in sequences of one to four consecutive hits) or lose-shift (in sequences of one to  
463 four consecutive misses) strategy was applied. For this we performed a three-way ANOVA with  
464 sequence length (one to four hits/misses) and streak direction (hit or miss streak) as within-  
465 subject factors and agency frame via visual perspective (actor/observer) as a between-subject  
466 factor. The number of win-stay trials increased in positive streaks and the number of lose-shift  
467 trials decreased over sequence length,  $F(3, 201) = 26.7, p < .01, \eta^2 = .31$ . Post hoc comparisons  
468 between streak lengths of one to four revealed that this difference was driven by meaningful  
469 contrasts between sequence lengths of 1, 2, and 4, whereas the number of win-stay strategies  
470 was almost identical between streak lengths of 2 and 3. In positive streaks the number of win-  
471 stay trials was higher than the number of lose-shift trials in negative streaks, as indicated by a  
472 main effect of streak direction,  $F(1, 201) = 89.58, p < .01, \eta^2 = .34$ . There was no significant  
473 actor-observer effect on number of win-stay, lose-shift strategies but we did find a three-way

474 interaction of Sequence Length  $\times$  Streak Direction  $\times$  Actor–Observer Frame,  $F(3, 600) = 4.96, p$   
475  $< .05, \eta^2 = .03$ . We refrained from further analysis of these effects as they were not predicted.

476 Thus when we compared sequential behavior between the conditions, we found for both  
477 the actor and the observer perspective that sensitivity to both the hot hand and the gambler’s  
478 fallacy depended on the streak length (Table 1). The number of times participants applied a win–  
479 stay, lose–shift strategy increased after a hit until three hits in a row and then decreased as  
480 confirming the rule of three (Hahn & Warren, 2009). This effect was more pronounced for  
481 observers than for actors, although this did not reach significance. The effect is reversed for  
482 sequences of misses, where the win–stay, lose–shift strategy decreased from the first miss to  
483 three misses in a row. This means participants believed that streaks would continue, that is, that  
484 hits would follow hits and misses would follow misses. However, in both cases this belief  
485 changed if participants had already seen three consecutive hits or misses, as streaks in sports may  
486 not be overly lengthy and will not run forever (MacMahon, Köppen & Raab, 2014).

487 >>>Table 1 about here<<<

488 Third, to test the dependencies of allocation choices, we performed autocorrelations as  
489 described above. If the video perspective changes the hot hand belief, we should find more  
490 participants in one of the conditions producing dependent sequential choices. When we  
491 performed all trials for each individual in an autocorrelation we found 22 participants (21.8%) in  
492 the observer condition produced significant and positive autocorrelations and 38 (37.6%) in the  
493 actor condition. It is possible that actors, as argued in the introduction and confirmed in Study 1,  
494 perceived a greater sense of control.

495 **Hot Hand Belief During The Experiment.** As in Study 1, we analysed if allocation  
496 strategies could be explained by false representations of players’ base rates. We found, averaged  
497 over all conditions and participants, that base-rates of players are correctly recalled by less than 1  
498 more or less hit attributed to a player than the real base-rates (t-test between real and recalled

499 base-rates,  $t(201) = 2.69$ ,  $p > .05$ ,  $\eta^2 = .38$ ). This confirms independent empirical evidence to  
500 Study 1 and previous research (Raab et al., 2012). Allocation strategies for Player A and Player  
501 B before a next set of video clips are almost identical and thus influences of fixed mind sets seem  
502 unlikely.

503 **Hot Hand Belief After The Experiment.** When asked about their hot hand belief after  
504 the experiment, fewer than half of the participants (47%) indicated that a player has the same  
505 chance of performing a hit after two or three hits as after two or three misses. Belief in the hot  
506 hand, that is, that a player has a greater chance of hitting after two or three previous hits, was  
507 indicated by 31% (actor frame) and 28% (observer frame) of the participants. When we asked  
508 participants after the experiment which of the two players they would like to allocate balls to—  
509 Player A with a hit (1)–miss (0) sequence of 1010101010101010 or Player B with a “streaky”  
510 sequence of 111000111000111010, 61% in the actor condition chose the streaky performance,  
511 whereas only 52% in the observer condition chose the streaky performance, nearly reflecting the  
512 equal base rates of the players.

### 513 **Discussion**

514 Did framing the video from different perspectives conceptually replicate the perspective  
515 framing effects from instructions in Study 1? The answer is yes, the effects of framing were  
516 present in both the belief and sequential behavior. We speculated in the discussion of Study 1  
517 that the reduced hot hand belief may be caused by the within-design of framing. However when  
518 we use a between subject design the general hot hand belief is smaller than in other studies  
519 before (31% and 28%, compared to previous belief between 60-91%). This seems hard to explain  
520 simply by differences in the questions (which were the same as in Gilovich et al., 1989, Raab et  
521 al., 2012) or the paradigm, type of sample or sports (same sport as in Raab et al., 2012).

522 A new finding of Study 2 is that framing effects can be subtly manipulated. Here we just  
523 changed the video perspective in which the same hit-miss sequences are presented. Further

524 research may focus on the impact of manipulating frames more or less explicitly and with that  
525 provide further data on when frames may influence choices in real environments. Finally, Study  
526 2 provided evidence that winning and losing streaks produce decisions that take the streak length  
527 into account. If streaks continue for a while participants believe that streaks may stop and they  
528 thus change their allocation behavior.

### 529 **General Discussion**

530 The studies used here asked whether framing sequential choices from an actor versus  
531 observer perspective change either belief in the hot hand or allocation behavior of the hot hand.  
532 The answer for both beliefs and behavior is yes. In Study 1, framing participants as observers  
533 seems to have reduced their hot hand beliefs compared to when they were asked to behave as  
534 actors. Observers relied more on a simple win–stay, lose–shift strategy than actors did. One  
535 important difference from previous studies (Gilovich et al., 1985; Raab et al., 2012) is the much  
536 lower number of participants who believed in the hot hand. This finding provides further  
537 evidence that the often-cited stability of the hot hand belief is not as high and stable as  
538 previously thought and this finding also extends notions about differences in the hot hand belief  
539 and behavior between groups with different levels of expertise (Köppen & Raab, 2012;  
540 MacMahon et al., 2014). Whether the difference in amount and stability of the belief is the result  
541 of design features or the samples used is a potential line of future research.

542 A new finding is that participants in the actor condition did not switch after they had  
543 chosen a player for allocation as often as participants in the observer condition did. When players  
544 exhibited streaks, participants tended to choose the hot player after streaks of hits and the not-  
545 cold player after streaks of misses up to about three hits or misses. Thereafter, it appears that all  
546 participants believed that neither a lucky nor an unlucky streak would continue and reversed their  
547 strategy. This inverted-U function of allocation behavior for hot players (or U function in the case

548 of cold hand allocations) is important for scouting and predicting the allocation behavior of  
549 opponent teams. The Study 1 finding that the longer the sequence the less likely the allocation to  
550 that player was replicated in Study 2 with a different frame manipulation, indicating that the  
551 video perspective from which participants perceive a situation can alter their belief and behavior.  
552 What is new is the finding that from the actor perspective, players who show sequences of hot  
553 hands are preferred for ball allocation, as indicated by positive autocorrelations in Study 2.

554         Why did framing influence the belief and the behavior as predicted? We can find  
555 explanations in general psychology. First, it seems likely that when confronted with this  
556 volleyball task, our participants—who were studying physical education or sports science—did  
557 use reference points from experience. Sports experience could produce reference points from  
558 which the perceived behavior of the players in the video can be compared. This comparison  
559 process may change the hot hand belief and the hot hand behavior conceptually replicating  
560 previous evidence (Köppen & Raab, 2012, MacMahon et al., 2014). Framing via instructions or  
561 video perspective may alter such reference points when the decision problem is encountered.  
562 Whether framing also has an influence on the mental representation or memory of previous trials  
563 has not been tested yet, but given the changes we saw in the average choice decisions in hot or  
564 cold streaks, some intermediary processes need to be considered to explain the differences.

565         Limitations of the current two studies could be overcome by differentiating the influence  
566 of frames at different stages of the decision-making process. As well, sophisticated measures of  
567 internal frames are needed—that is, participants' representations and memory of previous  
568 performance—which could have an additional effect on their beliefs and choices. For instance,  
569 framing research suggests that we judge winning two lotteries of \$50 and \$30 differently from  
570 winning \$80 in one lottery. Framing using aggregated or disaggregated quantities of hits and  
571 misses is unexplored and may help us understand under which situations playmakers aggregate  
572 performances of players for their allocation decisions. In addition, knowledge of such effects has

573 implications for how scouts should provide statistics for teams, as well as the opponent teams  
574 they are preparing to face. There are further limitations that come from the studies themselves:  
575 We were able to use frames successfully with participants, but we by no means know how they  
576 used the frames to produce a specific representation of the problem. Similarly, the actor  
577 perspective in the video clips is not fully identical to a first-person perspective and thus further  
578 study could use stimuli that present the environment from an actor's head-mounted camera.  
579 Previous research has convincingly demonstrated that the visual perspective in sports changes  
580 the responses in anticipation and decision-making tasks (Farrow, 2007; Williams, Ward, Ward &  
581 Smeeton, 2008). Therefore, future research should test the individual effects of such a  
582 manipulation in a Latin square design. Finally, carry-over effects between conditions cannot be  
583 fully controlled by simply counter-balancing conditions in our design. Similarly, explanations to  
584 account for why about 40% of the participants did not believe in the hot-hand in contrast to  
585 previous studies are beyond this study and need to be tested in varying designs and tests.

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### **What Does This Article Add?**

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This article adds to theory and the understanding of sequential decisions in sport by highlighting the influence of framing. We introduced outcome frames that affect the hot hand belief and hot hand behavior, indicating that neither the belief nor the behavior is a stable entity that can be explained by generic mechanisms. Rather, future research needs to understand how people adapt their strategies when exposed to ever-changing environments. Recent models of why success breeds success (Iso-Ahola & Dotson, 2014) propose that psychological components such as individual perceived momentum play a crucial mediating role in explaining behavior. This explanation cannot be applied to framing-observer effects, however. Future research may therefore focus on assumptions within these models that specify the likely role of influential dimensions of perceived streaks such as duration, intensity and frequency.



598           The framing perspective on the hot hand belief and hot hand behavior may have practical  
599 consequences in the long run, as well. For instance, coaches could use winning or losing frames  
600 in their game preparation or in time outs during a game that could alter the playmakers' belief in  
601 streaks as well as their behavior. For example, showing videos of the players or the opponents  
602 from the first-person or observer perspective could alter the belief and behavior evaluation.  
603 Furthermore, in time outs the orientation of a coach's flip-chart can determine if the perspective  
604 is that of an actor or observer. Whether these effects are positive or negative for performance is  
605 still hotly debated and has not yet been tested in the field by manipulating pregame routines or  
606 instructions in time outs, but it may be worth doing so.

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## 668 Author Note

669           We thank Anita Tood for English editing and the Performance Psychology group at the  
670 German Sport University Cologne for comments on an earlier version of the paper. We thank Dr.  
671 Avugos and one further anonymous reviewer for their insightful suggestions.  
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