Strategic Gaze: An Interactive Eye-Tracking Study[1]

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We present an interactive eye-tracking study that explores the strategic use of gaze. We analyze gaze behavior in an experiment with four simple games. The game can either be a competitive (hide & seek) game in which players want to be unpredictable, or a game of common interest in which players want to be predictable. Gaze is either transmitted in real time to another subject, or it is not transmitted and therefore non-strategic. We find that subjects are able to interpret non-strategic gaze, obtaining substantially higher payoffs than subjects who did not see gaze patterns. If gaze is transmitted in real time, eye movements become more informative in the common interest games and players predominantly succeed to coordinate on efficient outcomes. In contrast, eye movements become less informative in the competitive game.

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I. Introduction and Related Literature

More than 50 years ago, Nobel laureate Thomas Schelling described a hypothetical experimental setting to test his theories as follows: “The first stage in the experiment is to invent a machine, perhaps on the principle of the lie detector, that will record or measure a person’s recognition or the focus of his attention […]” (Schelling (1960): 109). Since then, eye-tracking has developed into an affordable and precise method to analyze decision-making processes (Duchowski 2007; Holmqvist et al. 2011). Both eye-tracking and mouse-tracking have proven useful to study how people play games and to infer players’ types from process data (Costa-Gomes et al. 2001; Knoepfle et al. 2009; Wang et al. 2010; Stewart et al. 2016; Polonio et al. 2015; Brocas et al. 2014). In contrast to this line of research we extend the use of eye-tracking technology to be an active component of the strategic interaction. Comparing strategic and non-strategic gaze allows us to explore how much communication—voluntary or involuntary—is possible with eye movements.

Since eyes are a very natural means of communication, observing a player’s eye movements should help to coordinate if the players share a common interest. There is ample evidence that individuals can learn from observing gaze in collaborative problem-solving tasks (Velichkovsky 1995; Stein and Brennan 2004; Litchfield et al. 2010; Litchfield and Ball 2011; Brennan et al. 2008; Neider et al. 2010).[5] At the same time, the beneficial effects of gaze transfer are limited: Gaze cannot transmit complex information and its dual use for visual search and for indicating a location creates ambiguities in the meaning of transmitted gaze (Müller et al. 2013; Müller et al. 2014).[6] While these studies analyze how the benefits of gaze transfer depend on the nature of the task environment, they do not consider the effects of varying incentives.

Observing gaze might not be helpful at all if players have an incentive to be unpredictable or even to deceive another player. The question is how difficult people find it to keep their gaze from revealing their intentions in such situations. It could be that “eyes don’t lie” and that gaze always conveys information even if this is not in the players’ interest. After all, professional poker players often wear sunglasses, eye movements of amateur blackjack players

[5] It has further been shown that people are generally better at interpreting dynamic rather than static representations of gaze in various types of tasks (Nalanagula et al. 2006; Gallagher-Mitchell et al. 2017; van Wermeskerken et al. 2018).

[6] The limits of eye-to-eye communication are nicely expressed in the science fiction novel “The Dark Forest” by Liu (2008), in which two of the characters try to convey a message through facial expressions: “They stared at each other, but held that pose for less than half a minute before they burst out laughing at practically the same instant. ‘My message was, `Tonight I'd like to invite you to have supper on the Champs-Elysees,'’ he said. She doubled over with laughter. ‘Mine was, `You ... need to shave!'’” (p. 179).

can reflect the numerical value of their hands (Holmes et al. 2016), and it is very difficult to prevent recognition of previously seen faces from being shown in the eyes (Schwedes and Wentura 2012). For sender-receiver games, it has been shown that there is substantial information about intentions contained in eye movements and pupil dilation of the senders, potentially helping receivers to obtain a larger payoff at the expense of senders (Wang et al. 2010).

In other contexts, the sincerity of eye movements is an illusion that might be exploited by liars. For example, many people, even professional interrogators, mistakenly believe that deception is associated with evasive eye movements (e.g., Vrij (2004)). In a recent study that systematically compares non-strategic gaze with deceptive gaze (Foulsham and Lock 2015), subjects were able to guess the choice made by a previously eye-tracked subject with a high success rate, but this was no longer true when the eye-tracked subjects were instructed to hide their true preferences with their eye movements. Success rates in the deceptive treatment were lower than in a baseline without any gaze transfer, but – although guessers were not aware of the instructions – not lower than chance.

The aim of our study is to analyze how gaze patterns and the interpretation of gaze patterns change with the strategic environment. In our setting, participants were placed in a truly interactive environment, and the incentive to convey meaning or mislead was created by the strategic situation. We used eye-trackers connected to the software z-tree (Fischbacher 2007) such that live gaze data could be displayed and integrated into the strategic interaction. In particular, in two of our treatments, one of the players sees a real-time representation of the other player's eye movements on her own screen before having to choose. This setting with a scanning device eliciting reactions is very close to what Schelling envisioned, and it opens new possibilities to study strategic interactions with gazes. By varying the incentives created by the situation and the way that gaze is transferred to the other player, we test Schelling's prediction that each player "knows that his own visible reaction is yielding information about his own expectations." (Schelling (1960): 110). If this is the case, then gaze patterns that are not transmitted should differ in predictable ways from gaze patterns that are transmitted.

More specifically, we ask whether subjects strategically signal and deceive other subjects with their eyes in four simple two-player games when their focus of attention is shown to the other player on screen. To assess the feasibility and limits of signaling one's intentions through gaze, we used three common interest games in which being predictable is in the interest of the eye-tracked player. Two of them are coordination games (one with and one without a focal option) in which subjects have to make the same choice in order to get a positive payoff. The third game is a focal discoordination game in which subjects earn money if they choose different options. Finally, we also explored if and how people utilize gaze transmission to conceal their true intentions in a hide & seek game in which being predictable can be exploited by the other player.

In order to investigate differences between strategic and non-strategic gaze, we used a treatment in which gaze was recorded but not transmitted to the other player as a benchmark. This non-strategic gaze was then shown to participants in another treatment when they played against the decisions of the subjects in the treatment without gaze transmission. We find strong evidence that people are able to correctly interpret non-strategic gaze patterns, both in the common interest games and in the competitive hide & seek game. However, because non-strategic gaze is less focused in the hide & seek game, the effect is less pronounced there.

When gaze is transmitted live to the other player, subjects can increase their success rates even further in the two coordination games but not in the discoordination game. It seems that the slightly more complex nature of this game makes it harder for the eye-tracked subject to commit to a clear gazing strategy. Finally, in the hide & seek game, we identify two general types of strategic gaze: Most people try to mask their intended choice with an uninformative gaze pattern while some try to actively mislead their counterparts into holding a wrong belief. Hiding intentions works almost perfectly in the sense that they are correctly detected at an average rate close to the random rate. Nevertheless, some strategies to actively mislead the other player are more successful: In our data, hiders tend to gain an advantage when they do not choose the option they emphasized with their gaze.

II. Methods

Games

All participants played four different two-player games: A coordination, a focal coordination, a focal discoordination, and a hide & seek game. Each game was played for five consecutive rounds with random re-matching of participants and no feedback between rounds. The order of games was counterbalanced within each session. In all 20 rounds, both players saw four large, gray rectangles arranged in a square on their computer screens and had to pick one of them. Subjects made their choices by pressing one of four keys which were marked with stickers (R, U, C, and N, approximately mirroring the positioning of the boxes on screen).

Participants' earnings were determined by whether or not the two players' actions matched: In the coordination and the focal coordination game, both participants only earned points when they chose the same box. In the focal discoordination game, both participants only earned points when their actions did *not* match. In the hide & seek game, the first-mover would earn points if the actions did not match whereas the second-mover would earn points if the actions did match.

The maximum number of points a player could earn by choosing a box was always displayed in the center of the box. In the coordination game, this number was always equal to 10 in all four boxes, i.e., both players earned 10 points if they managed to coordinate on one box and received 0 otherwise. In the focal coordination game, only the top-left box gave 10 points whereas the other three boxes gave 11 points if the players managed to coordinate on them. Similarly in the focal discoordination game, if the players managed to choose different boxes, any box apart from the top-left one, which yielded 10 points, earned the player who chose it 11 points. If they chose the same box in the focal discoordination game, both earned 0 points. Finally, in the hide & seek game, always one of the players earned 10 points: the second-mover if their actions matched and the first-mover if they did not. Figure 1 shows the four games in normal form.

	TL	TR	BL	BR
TL	10,10	0,0	0,0	0,0
TR	0,0	10,10	0,0	0,0
BL	0,0	0,0	10,10	0,0
BR	0,0	0,0	0,0	10,10

(a) Coordination Game

	TL	TR	BL	BR
TL	10,10	0,0	0,0	0,0
TR	0,0	11,11	0,0	0,0
BL	0,0	0,0	11,11	0,0
BR	0,0	0,0	0,0	11,11

(b) Focal Coordination Game

	TL	TR	BL	BR
TL	0,0	10,11	10,11	10,11
TR	11,10	0,0	11,11	11,11
BL	11,10	11,11	0,0	11,11
BR	11,10	11,11	11,11	0,0

(c) Focal Discoordination Game

	TL	TR	BL	BR
TL	0,10	10,0	10,0	10,0
TR	10,0	0,10	10,0	10,0
BL	10,0	10,0	0,10	10,0
BR	10,0	10,0	10,0	0,10

(d) Hide & Seek Game

FIGURE 1. THE FOUR GAMES IN NORMAL FORM.

Notes: The numbers in the cells correspond to the players' respective payoffs: The first number always shows the row-player's (hider's) payoff. The second number shows the column-player's (seeker's) payoff. The strategies' labels TL, TR, BL, and BR represent the top left, top right, bottom left, and bottom right box on the participants' computer screens, respectively.

Participants entered their decisions sequentially without observing the other player's choice. The eye-tracked player chose first. Once the first-mover had entered his decision, a green frame appeared around the boxes on the second-mover's screen indicating to her that she could now enter her decision. Before each round, subjects saw a brief reminder of the payoff consequences of matching and non-matching choices for both players for eight seconds, followed by a two second display announcing the start of the next round, and finally a fixation cross in the center of the screen for one second.

In all games, all possible individual choices are consistent with some Nash equilibrium. The coordination games have the very intuitive best response to choose the same strategy as the other player. There are four Nash equilibria in pure strategies in the coordination game, but strategies are isomorphic with no reason to choose one over the others except possibly the labeling of the strategies, which here corresponds to the boxes' locations. There is also a completely mixed equilibrium, in which every box is chosen with equal probability. Similar arguments apply to the focal coordination game but here the strategies are not entirely isomorphic, since coordination on TL yields a slightly lower payoff. Thus, the completely mixed Nash equilibrium involves playing TL with slightly larger probability.

Although the focal discoordination game is also symmetric, the only symmetric equilibrium involves completely mixed strategies which put slightly less probability on the less efficient focal option TL. Moreover, TL is never a best response for a player as long as the other plays a pure strategy. Finally, the hide & seek game is an asymmetric game which has a unique Nash equilibrium in mixed strategies with both players choosing all strategies with equal probability. If all players randomize as specified by the Nash equilibrium, then all strategy choices should occur with approximately the same frequency.

Treatments

We used four treatments to explore the role of gaze: *NoGaze*, *RecordedGaze*, *LiveGaze-FreeChoice*, and *LiveGaze-ForcedChoice*. In *NoGaze*, the gaze of the first-mover was recorded but it was not shown to the second-mover. With this benchmark treatment, we investigate the gaze patterns of non-strategic gaze. In *RecordedGaze*, we displayed this earlier recorded non-strategic gaze data to subjects who then also played against the corresponding old decisions. This allows us to infer whether and when subjects understand non-strategic gaze.

In the two remaining treatments, the first-mover's gaze was transmitted in real time to the second-mover which allows to study the communicative function of gaze. In *LiveGaze-FreeChoice*, the first-mover could freely choose any of the four boxes. To disentangle the effect of choices and gaze patterns on achieved payoffs, we introduced the *LiveGaze-ForcedChoice* treatment, in which first-movers only earned points if the chosen box coincided with the one that was randomly selected by the computer beforehand. This box was marked by an arrow which was only visible to him (not to the other player) for two seconds before the fixation cross appeared. In the *ForcedChoice* treatment, subjects do not have to think about strategic choices and can focus on the strategic use of gaze.

Procedures

Gaze data was visualized by changing the color of the box that was currently looked at by the first-mover from gray to red (see Figure 2). This was the case both on the screen of the first-mover and on that of the second-mover, i.e., the first-mover was fully aware of how his gaze data was displayed to the second-mover. Although no gaze data was transmitted between players in *NoGaze,* we nevertheless kept the treatment as symmetric as possible: For the first-movers, the boxes still changed color according to where they looked as in the *LiveGaze* treatments. Likewise, second-movers also had to wait for the first-mover to enter his decision before she could enter hers—she merely did not see any gaze data.

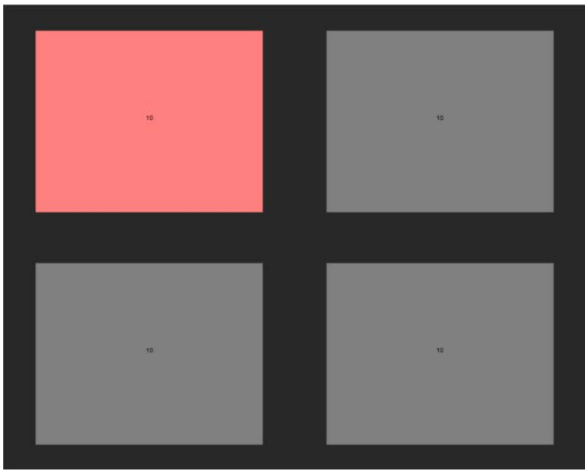

FIGURE 2. SCREENSHOT OF A SUBJECT CURRENTLY LOOKING AT THE TOP LEFT BOX.

To account for our method of gaze visualization in the analysis, we deviate from common fixation definitions which typically require that the position of gaze remains constant for some minimum amount of time (see, e.g., Salvucci and Goldberg (2000)). Instead, we consider everything a fixation that was actually displayed to the participants. A fixation thus starts the moment the respective box turns red and lasts until the box turns gray again.

We ran three sessions in each treatment with eye-tracking (*NoGaze, LiveGaze-FreeChoice,* and *LiveGaze-ForcedChoice*), each with 24 subjects of which the twelve first-movers were eye-tracked. Data acquisition for the *RecordedGaze* treatment was finished within one session with 30 second-movers who played against 30 randomly selected sequences of moves faced by second-movers in the *NoGaze* treatment.

We used Tobii EyeX eye trackers with a sampling rate of 60 Hz. Subjects were seated approximately 58 centimeters in front of their screens, all of which were of the same model and had a resolution of 1280×1024 pixels. To improve data quality, we used chin rests for all eye-tracked subjects. None of the subjects had issues with the eye-trackers. The experiment was programmed in z-Tree (Fischbacher 2007) and our subjects were recruited from the general student population of the University of Konstanz using the software ORSEE (Greiner 2015). Each session lasted around one hour, and subjects were paid €0.1 for each point they earned in the experiment such that they received an average of around €17. Our participants had an average age of about 21 years and about 40% were male.[7]

Hypotheses

With this design, we aimed at answering the following questions. First, how informative are gaze patterns about choices and to what extent are subjects able to exploit this information? Second, how do the answers to these questions depend on the strategic situation? Several studies have shown that decisions often follow eye movements, in the sense that the chosen option is both the one that was looked at last and for a longer time.[8] Gaze should therefore contain some information about choices also in strategic situations. Accordingly, Hypothesis 1 ("Interpreting gaze") states that it is possible to infer choices in strategic games from the observed gaze patterns of the choosing subject.

This hypothesis can be tested by comparing the success rates of the second movers in the *NoGaze* treatment with those in the *RecordedGaze* treatment. We further tested the limits of this ability along two dimensions. First, we varied the nature of the strategic interaction between the games (common interest vs competitive) and second, we varied whether subjects have an incentive to affect the informativeness of their gaze (recorded gaze vs live gaze transmission). Our second hypothesis is concerned with how the eye-tracked players react to this incentive. It is based on the assumption that eye-movements can be used as a communication device to announce a strategy choice, e.g., by focusing on one option for a long time. Hence, Hypothesis 2 ("Strategic gazing") states that subjects are aware that their gaze conveys information and are able to strategically adapt it.

If people are able to infer meaning from another person's eye movements, then there are obvious implications for strategic interactions. If being predictable is in a player's self-interest, then she should try to communicate as clearly as possible. This is the case in the three common interest games.[9] If, however, being predictable is not in the player's self-interest, she should try to remove all meaning from any signal she sends out. In the hide & seek game, all communication must be completely uninformative in equilibrium. We investigated two differ-

[7] A translation of the instructions given to the participants as well as further details on the experimental procedures can be found in the Appendix. Except for the different treatments, all features of the experiments were made common knowledge to the participants

[8] See, e.g., the gaze cascade effect as described by Shimojo et al. (2003), or the attentional drift diffusion model by Krajbich et al. (2010).

[9] In the language of game theory, communicating one's intended choice is "self-signaling" and "self-committing" in the common interest games: A player wants the other to think that she will choose a strategy if and only if she indeed intends to choose it, and if a player has persuaded the other player that she will play a certain strategy, she indeed wants to choose that strategy (see, e.g., Farrell and Rabin (1996)).

ent gazing strategies: Hiding all information from one's gaze (signal-jamming) and trying to actively mislead the opponent into holding a wrong belief.

III. Results

Average Choices

Table 1 shows the choice distribution of both first and second-movers in all treatments with free choice. The choice data from *NoGaze* can be used to explore whether there is some bias toward any of the four boxes. For instance, the top-left box could be perceived as salient since a western reading style is associated with a top-left bias (Abed 1991), and the top-right box might stand out as being located in the first (positive) quadrant. Despite the symmetric layout of the four boxes in a square, the choice data from the coordination game in *NoGaze* reveals a tendency of the first-movers to favor the top-right box and for second-movers to favor both top boxes, but not any of the two in particular. A χ^2-test rejects the null-hypothesis that the subjects were choosing randomly (χ^2=26.5 and p<0.001 for first-movers and χ^2=6.42 and p<0.1 for second-movers).

TABLE 1—AVERAGE BOX CHOICES IN TREATMENTS WITH FREE CHOICE.

NoGaze Treatment	Coordination	Focal Coordination	Focal Discoordination	Hide & Seek
Top Left	24% (31%)	35% (59%)	18% (27%)	22% (24%)
Top Right	47% (32%)	38% (18%)	23% (17%)	17% (29%)
Bottom Left	9% (21%)	9% (11%)	32% (28%)	32% (21%)
Bottom Right	19% (17%)	17% (12%)	27% (28%)	29% (26%)

RecordedGaze Treatment	Coordination	Focal Coordination	Focal Discoordination	Hide & Seek
Top Left	27% (27%)	35% (25%)	18% (17%)	23% (27%)
Top Right	44% (41%)	38% (42%)	23% (27%)	18% (19%)
Bottom Left	11% (13%)	9% (11%)	34% (27%)	31% (30%)
Bottom Right	19% (20%)	18% (21%)	25% (29%)	29% (25%)

LiveGaze-FreeChoice Treatment	Coordination	Focal Coordination	Focal Discoordination	Hide & Seek
Top Left	34% (36%)	1% (1%)	12% (10%)	26% (29%)
Top Right	37% (36%)	46% (46%)	34% (23%)	16% (27%)
Bottom Left	13% (12%)	17% (18%)	29% (35%)	34% (24%)
Bottom Right	17% (16%)	36% (36%)	24% (32%)	23% (20%)

Notes: The table shows the choice distributions of the eye-tracked participants and those of the second-movers in parentheses. There were 36 first and second-movers in the *NoGaze* and the *LiveGaze-FreeChoice* treatments, 30 second-movers in the *RecordedGaze* treatment. Data of first-movers in the *RecordedGaze* treatment stems from the 30 randomly selected first-movers from the *NoGaze* treatment. Each participant played each game five times. Totals unequal 100% are due to rounding.

Choices in the focal coordination game were similarly concentrated more on the top boxes. Such a focal coordination game was described by Schelling (1960) and later used by Bardsley et al. (2010) to study how focal points can foster coordination. Bardsley et al. (2010) report mixed evidence, with the amount of focal choices depending on the nature of the other choice questions participants saw. In our experiment, the inefficient focal option was readily adopted as a coordination device by second-movers who chose it in 59% of trials, but only to some extent by first-movers who only chose it in 35% of the trials.[10] In the focal discoordination game, the focal option was chosen least often by the first-movers as predicted by the symmetric Nash equilibrium, but not by second-movers.[11]

When second-movers could see the previously recorded gaze, their choice distribution is more in line with that of the first-movers in both coordination games. This effect is even stronger with live gaze transmission. Moreover, in *LiveGaze-FreeChoice*, the inefficient outcome in the focal coordination game was avoided almost completely by the players. In the focal discoordination game, the inefficient option was still chosen in *LiveGaze-FreeChoice*, but least often. These comparisons already suggest that gaze transfer helps to coordinate which will be explorer in detail later in this section.

Finally, in the hide & seek game, the first-mover's top (right) bias observed in the coordination game disappeared and instead the bottom boxes were chosen more frequently. This is in line with the finding by Rubinstein et al. (1997) that hiders choose the salient option less often than seekers. However, this observed bias towards the bottom boxes is not statistically significant. Interestingly, in *LiveGaze*, the first-movers again exhibit a slight bias favoring the bottom-left box (χ^2=6.31, $p < 0.1$) but the observed distribution of second-movers' choices is not statistically different from random selection, as in *NoGaze*.

Non-Strategic Gaze

We first investigate non-strategic gaze. Figure 3 depicts the average success rates of the second-movers across all four treatments and games. Participants in *RecordedGaze* were clearly able to correctly interpret the first-movers' non-strategic gaze patterns previously rec-

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[10] Regarding the theories of behavior that are compared in Bardsley et al. (2010), our results therefore point towards "team reasoning" as a plausible explanation. Nine subjects made the same predominant choice (at least 3 out of 5) in the coordination and the focal coordination game and nine subjects switched to a predominant choice of the top left box in the focal coordination game. There are, however, also six subjects who avoided the top left box in the focal coordination game.

[11] Since the second-movers did not see the choice of the other player when they had to make their choice, any differences in choices by first and second-movers in *NoGaze* can only be explained by the timing of the choices. In fact, there is some evidence in the literature that framing players in a simultaneous-move game as a first and a second-mover matters for how strategically players think about a game (e.g. Penczynski (2016)).

orded in *NoGaze*. Second-movers in *RecordedGaze* achieved significantly higher success rates in all four games (Wilcoxon rank-sum tests comparing individual average success rates in each game by treatment, all Bonferroni corrected p-values < 0.03). In the three common interest games, second-movers do remarkably well in interpreting the recorded gaze patterns. Though the success rate in the hide & seek game is also significantly higher when non-strategic gaze can be observed, the gained advantage is less pronounced.

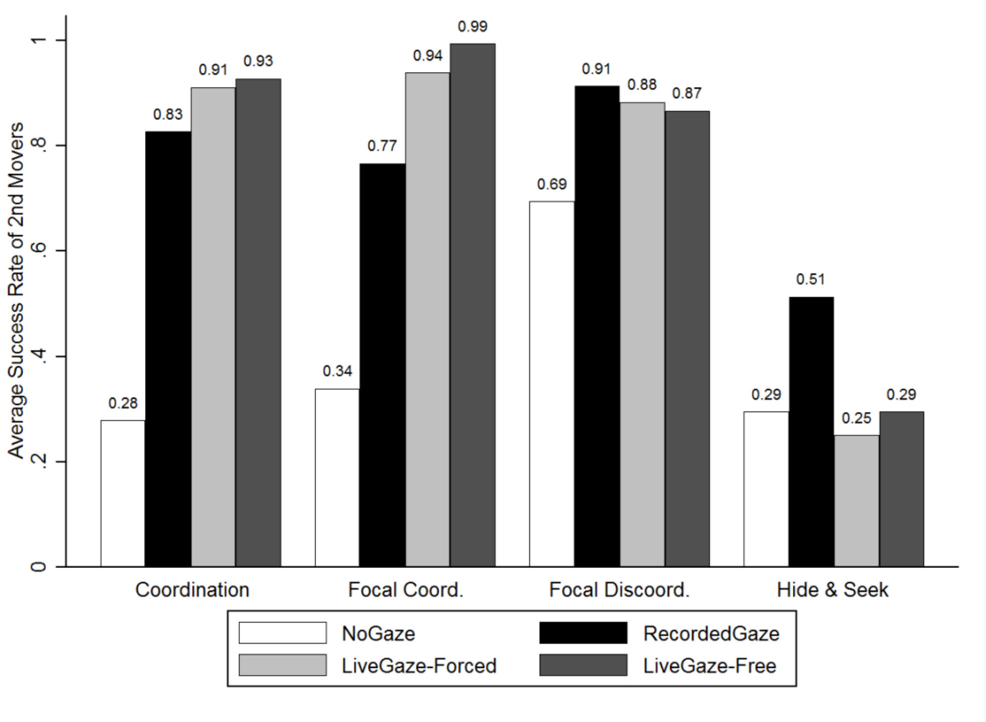

FIGURE 3. AVERAGE SUCCESS RATES OF SECOND-MOVERS ACROSS TREATMENTS AND GAMES.

Notes: A trial is counted as a success for the second-mover when she receives a positive payoff, i.e., when the two players choose the same box in the coordination, the focal coordination, and the hide & seek game and when they choose different boxes in the focal discoordination game.

The second-movers' smaller gain from seeing the first-movers' eye movements in the hide & seek game may be due to differences in the non-strategic gaze patterns between the games. For instance, gaze from the hide & seek game could be more difficult to interpret if the first-mover looks back and forth between boxes repeatedly or if fixations on individual boxes are particularly short. However, neither the average number of transitions nor the average fixation duration differed significantly between the games (Wilcoxon signed ranks tests, all Bonferroni corrected p-values > 0.8).

What else can make gaze patterns more difficult to interpret? To gain an advantage from seeing the first-mover's gaze, the second-mover must come up with a theory of how the first-mover's gaze translates into his choice. Motivated by the literature reviewed in the introduction, we compared the predictive success of three simple heuristics that second-movers might resort to in order to interpret gaze. The *Most Looked* heuristic predicts that the first-mover chooses the box that he looks at for the longest time. The *Last Looked* heuristic states that he chooses the box that he looks at last. Finally, we consider a *Frugal Tree* heuristic (see Raab and Gigerenzer (2015) for a recent discussion of frugal trees).

The frugal tree that we consider combines the two heuristics from above. It first checks the *Most Looked* heuristic but moves on to the *Last Looked* heuristic if the first criterion is not clear enough. This is the case when the inspection time on the most and second most looked at boxes are not sufficiently different from one another. We make the somewhat arbitrary requirement that the most looked at box was inspected at least twice as long as each of the other three boxes.[12]

Table 2 shows the average success rates the second-movers in the *RecordedGaze* treatment would have achieved if they all had followed the respective heuristics (Table 7 in Appendix shows the shares of second-movers choosing in line with each heuristic). Clearly, the heuristics perform much worse in the hide & seek game than in the other games. These differences also turn out to be significant in pairwise Wilcoxon rank-sum tests comparing the success rates between games for each of the three heuristics (all Bonferroni corrected p-values < 0.002 except for the predictive success of the *Last Looked* heuristic in the hide & seek vs the focal discoordination game with corrected $p = 0.072$). Hence, gaze indeed seems to be less informative about the actual choice in this game which can explain why the second-movers in the *RecordedGaze* treatment profited least from seeing the gaze patterns in the hide & seek game.

TABLE 2—SHARES OF CORRECT PREDICTIONS BY THE THREE HEURISTICS IN RECORDED GAZE TREATMENT.

	Coordination	Focal Coordination	Focal Discoord.	Hide & Seek
Most Looked	0.84	0.88	0.83	0.61
Last Looked	0.94	0.91	0.85	0.72
Frugal Tree	0.95	0.93	0.87	0.68

Notes: The table shows each heuristic's share of correct predictions in each game in the recorded gaze treatment. This also corresponds to the second-movers' success rate in the coordination games and the hide & seek game, which they would have achieved if they had all followed the predictions of the respective heuristic.

Although the success rates of the three heuristics are slightly lower in the focal discoordination game in *RecordedGaze*, only one of these differences is significant: The success rate of the *Last Looked* heuristic is significantly higher in the coordination game than in the focal

[12] In our sample, the highest predictive power across all games and treatments (80.5%) would be reached if we required that the most inspected box was inspected at least $\gamma = 3.64$ times as long as each of the other four. We nevertheless stick to this rule of thumb because of its simplicity and because the main increase in predictive power of the heuristic (from 76.1% to 80%) happens when γ is increased from 1 to 2. All further increases only improve the average success rate by very little.

discoordination game (corrected $p < 0.1$). Among all games, the coordination game is also the one in which participants benefited the most from seeing the recorded gaze patterns.

In summary, we find strong support for our first hypothesis: People are indeed able to correctly interpret gaze patterns, even when they are purely instrumental and not willingly controlled in order to influence their informativeness. The amount of information that can be extracted from the gaze data reflects the complexity of the strategic incentives in the games. Choice in the hide & seek game is harder to predict from non-strategic gaze patterns than in the other games, but subjects nevertheless significantly increased their success rates even there.

Strategic Gaze: Success Rates

We now turn to analyzing strategic gaze. When comparing *RecordedGaze* to the two *LiveGaze* treatments in Figure 3, we can see that subjects increased their success rate even further when the first-movers' gaze was live transmitted to their current partner in the two coordination games. In the coordination game, the success rate significantly increased from 83% in *RecordedGaze* to 91% and 93% in *LiveGaze-ForcedChoice* and *LiveGaze-FreeChoice* (pairwise Wilcoxon rank-sum tests comparing individual average success rates by treatment, both corrected *p*-values < 0.04). In the focal coordination game, the effect is even more extreme: The success rate of 77% in *RecordedGaze* is increased to 94% in *LiveGaze-ForcedChoice* and even to 99% in *LiveGaze-FreeChoice* (both corrected *p*-values < 0.04).

However, in the focal discoordination game, the success rates are slightly lower in *LiveGaze* than in *RecordedGaze*, but these differences are insignificant (both *un*corrected *p*-values > .4). Despite the slight decrease in the focal discoordination game, live gaze transmission nevertheless led to significantly higher success rates compared to *NoGaze* (both corrected *p*-values < 0.001). Thus, by using their gaze as a signaling device, first-movers were clearly able to make themselves more predictable than without gaze transmission in all three common interest games.

This pattern changes in the hide & seek game. The success rates in the two *LiveGaze* treatments (25% and 29%) are both significantly smaller than in *RecordedGaze* (51%, both corrected *p*-values < 0.01). Hence, first-movers were able to hide their intentions when it was in their interest to become less predictable. However, they were not able to increase their success rate compared to *NoGaze* by somehow misleading seekers with their gaze. Interestingly, the success rate in *LiveGaze* with free choice is exactly the same as in *NoGaze* and the success rate in *LiveGaze* with perfectly random forced choices is exactly the one that would result from perfect randomization. These are the predicted rates if gaze was completely uninformative. Of course, the difference between these two success rates is insignificant (both *un*corrected *p*-values > 0.3).[13]

Strategic Gaze: Characteristics

To get a first impression of how first-movers made use of the opportunity to gaze strategically, we again compared the average number of fixations and the average fixation durations across games (see Table 3). Unlike in *RecordedGaze*, the average number of fixations is significantly higher in the hide & seek game compared to the three common interest games in both *LiveGaze* treatments (pairwise Wilcoxon signed ranks tests, all corrected *p*-values < 0.02). Similarly, the average fixation duration is significantly shorter in the hide & seek game than in the other three games for both *LiveGaze* treatments (all corrected *p*-values < 0.01). In the hide & seek game, subjects thus moved their gaze more quickly from one box to the next and did so more often than in the common interest games, making their gaze more difficult to interpret.

Apart from one exception, the gaze characteristics did not differ significantly between the three common interest games in neither treatment (all corrected *p*-values > 0.15). The exception lies in *LiveGaze-ForcedChoice*: Here, the average number of fixations is greater, and the average fixation duration is shorter in the focal discoordination game than in the focal coordination game (both corrected *p*-values < 0.08). This could also explain why the success rate in the focal discoordination game in the *LiveGaze* treatments did not improve compared to *RecordedGaze*.

[13] The two different *LiveGaze* treatments allow to distinguish whether observed success rates are due to players being attracted to certain conspicuous or (seemingly) inconspicuous choices, or due to information content of gaze alone. Hence, in *LiveGaze-ForcedChoice*, we may expect second mover's success rates to be a bit lower in the hide & seek game and coordination games (where baseline success rates are typically somewhat higher than chance) and higher in the focal discoordination game. Although there is a tendency towards this effect, none of the comparisons are significant.

TABLE 3—AVERAGE FIXATION NUMBERS AND FIXATION DURATIONS ACROSS GAMES AND TREATMENTS.

	Average Number of Fixations			
	Coordination	Focal Coordination	Focal Discoord.	Hide & Seek
RecordedGaze	4.6	5.3	5.3	5.3
LiveGaze-Forced	2.8	2.6	5.3	9.3
LiveGaze-Free	4.7	3.4	4.8	13.8

	Average Fixation Duration in Seconds			
	Coordination	Focal Coordination	Focal Discoord.	Hide & Seek
RecordedGaze	1.05	.83	1.00	.66
LiveGaze-Forced	2.57	2.67	1.84	.73
LiveGaze-Free	1.85	2.43	1.95	.67

Notes: The top half of the table shows the average number of fixations between boxes per game for each treatment. The bottom half shows the according average fixation durations in seconds. We consider everything a fixation that was displayed to the participants as a red box, i.e., a fixation starts when the respective box turns red and ends when it turns gray again.

These effects also become apparent in the predictive success of the three heuristics we introduced earlier (the heuristics' respective shares of correct predictions in all four games are shown in Table 4 below). In both *LiveGaze* treatments, the success rates of all three heuristics in the hide & seek game drop to values of 30% and below. This again clearly shows that first-movers actively try to keep their gaze as uninformative about their intentions as possible. In contrast, in the coordination as well as the focal coordination game, the heuristics' hit rates lie between 94% and 100% indicating that in these games the first-movers succeed in being particularly predictable. Finally, first-movers seem to have more difficulties in sending clear signals in the focal discoordination game as the heuristics' success rates only lie between 74% and 81% there.[14]

The heuristics' hit rates in the focal coordination game in *LiveGaze-FreeChoice* are exceptionally high (99% for the *Last Looked* heuristic and even 100% for the other two). This indicates that the presence of the salient but inefficient outcome in the focal coordination game makes subjects exhibit the most extreme gaze patterns. This also becomes apparent in the sense that they clearly avoid looking at the focal option: Compared to the coordination game without a focal payoff in the top-left box, the share of first fixations on the top-left box drops from more than 50% to less than 15% in the focal coordination game. Similarly, the share of trials in which the top-left box is not even looked at once increases from 36% to 71%.

[14] The success rates of all heuristics are significantly smaller in the hide & seek game than in all other games (Wilcoxon rank-sum tests, all corrected p-values < 0.002). Further, success rates in the focal discoordination game are significantly smaller than in the (focal) coordination games (all corrected p-values < 0.002), and they do not significantly differ between the focal and the non-focal coordination game (all corrected p-values > 0.1).

TABLE 4—SHARES OF CORRECT PREDICTIONS BY THE THREE HEURISTICS IN LIVE GAZE TREATMENTS.

	LiveGaze-ForcedChoice			
	Coordination	Focal Coordination	Focal Discoord.	Hide & Seek
Most Looked	0.97	0.96	0.74	0.22
Last Looked	0.96	0.99	0.78	0.30
Frugal Tree	0.97	0.99	0.78	0.28

	LiveGaze-FreeChoice			
	Coordination	Focal Coordination	Focal Discoord.	Hide & Seek
Most Looked	0.96	1.00	0.79	0.26
Last Looked	0.94	0.99	0.79	0.30
Frugal Tree	0.97	1.00	0.81	0.30

Notes: The table shows each heuristic's share of correct predictions in each game for the *LiveGaze-ForcedChoice* (top) and the *LiveGaze-FreeChoice* treatment (bottom).

In the focal discoordination game, the heuristics' hit rates are significantly lower than in the other common interest games. This indicates that the ability to send clear signals also depends on the nature of the strategic situation at hand. A discoordination game adds complexity to the situation as the signal now becomes ambiguous: It could both be an announcement of the first-mover's own strategy but also a choice recommendation for the second-mover. This aspect could make it harder for the first-movers to commit to a particular gazing strategy such that their gaze patterns become more difficult to interpret. Also note that the share of second-movers deciding in line with a belief based on the respective heuristics never drops below 90% also in the focal discoordination game (see Table 7 in Appendix). This indicates that the failure to increase the success rate in the discoordination game with strategic compared to non-strategic gaze is due to first-movers not choosing the box that they emphasized with their eye movements.

In order to explore the effects of the strategic environment on the signal quality more closely, we also analyzed it in terms of the distribution of viewing time across the four boxes. To send a clear signal, one box should be emphasized as much as possible. This is achieved when the share of viewing time on all, but the most inspected box is minimized. Figure 4 shows the cumulative distribution of the share of viewing time which subjects allocated to all but the most inspected box (separately for all four games and the two *LiveGaze* treatments). The intercept with the *y*-axis indicates the share of games in which the respective first mover only looked at a single box. This share is largest in the focal coordination game in both *LiveGaze* treatments (86% and 67%, respectively). In *LiveGaze-FreeChoice*, the cumulative distribution of gaze time in the focal coordination game is always to the left of that in the coordination game, i.e., gaze in the focal coordination game is particularly clear also with respect to the allocation of viewing time (two-sided Kolmogorov-Smirnov test, corrected p-value < 0.001).

This is different for the focal discoordination game in which complexity is increased due to the ambiguity of the signal. In both treatments, the share of first-movers looking at only one box is lower in the focal discoordination game than in the focal coordination game. The cumulative distributions of gaze time in the focal discoordination game are also always to the right of their counterparts from the focal coordination game and these differences are highly significant (Kolmogorov-Smirnov tests, both corrected *p*-values < 0.001). Signal strength in terms of viewing time thus clearly suffers in the focal discoordination game.

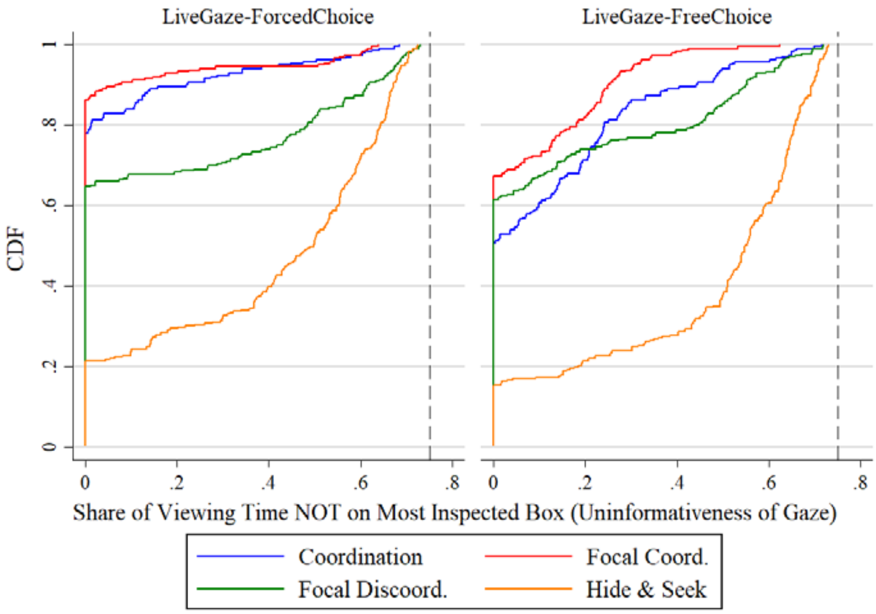

FIGURE 4. CUMULATIVE DISTRIBUTION OF SHARE OF VIEWING TIME ON ALL BOXES OTHER THAN THE MOST INSPECTED BOX ACROSS GAMES AND TREATMENTS.

Notes: The graphs show the distribution of the share of viewing time that subjects allocated to all boxes except the one they inspected the most. The intercept with the *y*-axis thus corresponds to the percentage of people that only looked at one single box in the respective game and treatment. The dashed lines mark the natural maximum of 75% viewing time on the non-most inspected boxes which would be reached if all four boxes were inspected for exactly 25% of the time.

Strategic Gaze in Hide & Seek: Signal-Jammers and Misleaders

In Figure 4, the CDFs of the share of viewing time of all but the most looked-at choice in the hide & seek games start out relatively low and with a flat slope which becomes steeper toward the dashed lines. This indicates that at least some first-movers tried to blur their intended choice by looking at each of the boxes for approximately the same amount of time.

Especially when the number of transitions between boxes increases, it becomes exceedingly difficult to mentally keep track of which is the most inspected box. Among the first-movers that look at all four boxes at least once, the mean number of fixations is in fact very high in both *LiveGaze* treatments (13.8 in *ForcedChoice* and 18.4 in *FreeChoice*), indicating that these first-movers are indeed trying to make themselves unpredictable. For our further analyses, we therefore categorize first-movers that looked at all four boxes at least once as signal-jammers that intend to hide all information from their gaze. Most first-movers in both *Live*-

Gaze treatments apply this method (56.7% in *ForcedChoice* and 66.1% in *FreeChoice*, see Table 5).

A second straightforward method to hide one's intended choice in our setting would be to simply not look at any boxes at all, e.g., by closing your eyes and blindly pressing a button. We did not mention this possibility in the instructions but we neither explicitly forbade it. Nevertheless, only 6.1% of first-movers applied this method in *LiveGaze-ForcedChoice* and only 8.9% in *LiveGaze-FreeChoice*.

Apart from trying to hide their intentions, first-movers could also try to actively mislead second-movers into holding a wrong belief. To achieve this, some participants tried to emphasize one or more boxes with their gaze and then choose either the emphasized or a different box. In the post-experimental questionnaire, participants using such techniques for instance described them like this: "[I] never looked at the chosen box", "[I looked] at the chosen box because I assumed that the respective other partner would not expect this", "I concentrated on a different box and switched to another box shortly before my choice but also did not choose that one", "I always looked at a different box first and then briefly at the one I chose and then at the first one again". We therefore classify all those first-movers as active misleaders who only looked at one, two, or three boxes in the hide & seek game. In *LiveGaze-ForcedChoice*, 20% of first-movers only looked at a single box and 17.2% looked at two or three boxes. Similarly, in *LiveGaze-FreeChoice*, 13.9% looked at one box and 11.1% looked at two or three. Table 5 summarizes which strategies have been applied in the two *LiveGaze* treatments and shows their respective success rates in parentheses.

TABLE 5—FIRST-MOVERS' GAZE STRATEGIES AND SUCCESS RATES (IN PARENTHESES) IN HIDE & SEEK GAME.

LiveGaze-ForcedChoice, First-movers					
	Applying	Share of which Choosing:			
Gaze Strategy	Strategy	Most = Last	Most Not Last	Last Not Most	Neither
Did Not Look	6.1% (63.6%)				
Looked At All	56.7% (79.4%)	9.8% (50.0%)	1.0% (100%)	14.7% (73.3%)	74.5% (84.2%)
Looked At One	20.0% (63.9%)	44.4% (31.3%)	-	-	55.6% (90.0%)
Other	17.2% (77.4%)	29.0% (77.8%)	3.2% (0%)	6.5% (50.0%)	61.3% (84.2%)
Mean	100% (75.0%)	19.4% (48.6%)	1.1% (50.0%)	9.4% (70.6%)	70.0% (83.3%)

LiveGaze-FreeChoice, First-movers					
	Applying	Share of which Choosing:			
Gaze Strategy	Strategy	Most = Last	Most Not Last	Last Not Most	Neither
Did Not Look	8.9% (75.0%)				
Looked At All	66.1% (68.9%)	16.0% (63.2%)	5.9% (57.1%)	10.9% (61.5%)	67.2% (72.5%)
Looked At One	13.9% (76.0%)	48.0% (75.0%)	-	-	52.0% (76.9%)
Other	11.1% (70.0%)	20.0% (75.0%)	0%	10.0% (100%)	70.0% (64.3%)
Mean	100% (70.6%)	19.4% (68.6%)	3.9% (57.1%)	8.3% (66.7%)	68.3% (72.4%)

Notes: The first column shows the share of first-movers applying the respective gaze strategy. The next four columns show the box choices conditional on the gaze strategy: "Most = Last" is the share of first-movers choosing the box they looked at for the longest time if this is also the last one they looked at, "Most Not Last" is the share choosing the box they looked at most if this doesn't coincide with the last one, "Last Not Most" is the share choosing the box they looked at last if this doesn't coincide with the most inspected one, and "Neither" is the share choosing neither of the two. The numbers in parentheses correspond to the first-movers' success rates conditional on their gaze strategy (first column) and choice (other columns).

Recall that, on average, first-movers in both *LiveGaze* treatments were able to reach success rates statistically indistinguishable from those in *NoGaze* (70.5%). However, in *LiveGaze-ForcedChoice*, much higher success rates were reached by first-movers who chose neither the box they inspected most nor last. Subjects that looked at only one box, but then chose a different one even reached an average success rate of 90%. As can be seen in Table 6, this effect is also significant. It shows the marginal effects of several probit models of first-movers' success in the hide & seek game regressed on the different strategies. The baseline choice strategy that is left out in the models is choosing the most emphasized box (i.e., the box that was looked at last when this was also the box that was looked at most).

TABLE 6—FIRST-MOVER SUCCESS REGRESSED ON GAZE STRATEGY (PROBIT MODELS, MARGINAL EFFECTS).

	LiveGaze-ForcedChoice			
	Probit Dependent Variable: First-mover Success (binary)			
(Sub-)Sample:	Full	Looked at All	Looked at One	Other
Most Not Last	.010	(omitted)[†]	-	(omitted)[†]
	(.087)			
Last Not Most	.140*	.117*	-	-.174
	(.083)	(.069)		(.435)
Neither	.337***	.283**	.588***	.145
	(.121)	(.128)	(.154)	(.201)
N	180	102	36	31

	LiveGaze-FreeChoice			
	Probit Dependent Variable: First-mover Success (binary)			
(Sub-)Sample:	Full	Looked at All	Looked at One	Other
Most Not Last	-.104	-.055	-	(omitted)[†]
	(.176)	(.197)		
Last Not Most	-.018	-.015	-	(omitted)[†]
	(.153)	(.173)		
Neither	.038	.091	.019	-.111
	(.083)	(.124)	(.168)	(.314)
N	180	119	25	18

Notes: Baseline category is "Most = Last", i.e., choosing the box that was looked at most when it coincides with the box that was looked at last. Explanatory variables are dummies corresponding to the other choice strategies. The same model is estimated on different sub-samples. The whole sample was used in the models in the first column. In the second column, only those trials were included in which all four boxes were inspected at least once. In the third column, only those in which exactly one box was looked at and in the last column all trials in which two or three boxes were inspected. Robust standard errors clustered at the subject level. Standard errors for marginal effects in parentheses obtained via the Delta-Method.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
[†]Omitted due to too few observations in cell.

The top half of the table shows the results for *LiveGaze-ForcedChoice*. In the first column we see that the probability of a first-mover success increases by more than 30% if he chooses neither the last nor the most inspected box. Looking at the same model estimated for different sub-samples, we see that this effect is especially pronounced for those subjects that only looked at one single box but then chose a different one. These subjects even significantly increased their success probability by 58.8% compared to those that chose the only box they looked at (column "Looked at One"). The effect of choosing neither the most nor the last inspected box is also significantly positive for those subjects who looked at all four boxes at least once (+28.3%, column "Looked at All"). For the same group of subjects, also choosing the box they looked at last significantly increased their success probability by 11.7% when this box did *not* coincide with their most inspected box. This indicates that not all first-movers that tried to blur their intention by looking at all four boxes succeeded in doing so and that the second-movers still managed to deduce some meaning from their gaze.[15]

In *LiveGaze-FreeChoice*, however, none of the strategies significantly affected the first-movers' success probabilities, neither in the whole sample nor in any of the sub-samples. At least the tendencies are the same: Both when only one or when all boxes were looked at, success rates are highest when neither the most nor the last inspected box was chosen. It thus seems that although some people tried to mislead their counterpart, only few succeed and only in specific circumstances. More precisely, the ability in *LiveGaze-ForcedChoice* to fully focus on one's gaze strategy without having to worry about the actual choice (which is practically made by the computer) seems to help at least some subjects in choosing a good gaze strategy.

IV. Discussion

We have shown that people are generally able to correctly interpret non-strategic gaze in common interest games and, to a lesser extent, in a competitive hide & seek game. The differences in the degree to which non-strategic gaze is understood can be explained by differences in the non-strategic gaze patterns: Subjects were more predictable when they chose the option that they looked at last or for the longest time. Subjects strategically adapted their eye-movements when they were live transmitted to their current opponent, making their gaze particularly easy to interpret in the common interest games and making it more difficult to read in the competitive game.

We used simple games to explore the effects of gaze transfer, but the results also shed light on what can be expected in more complex situations. The strategic use of eye-movements is of importance in all situations in which people meet face-to-face and try to anticipate each other's actions, e.g., when playing games or sports. The hide & seek game, for instance, captures the strategic situation of penalty kicks in soccer. Indeed, Tay et al. (2010) find that goal keepers are worse at predicting the direction of a shot when the kicker was instructed to try to deceive the goalie, e.g., by looking in the opposite direction before taking the shot (Dicks et al. 2010; Nagano et al. 2006). Also, for other games, sports psychology has investigated how an athlete's action can be predicted from cues observable shortly before the action, often in-

[15] More than 50% of second-movers chose the box that the first-mover either looked at most or last (or both) in the hide & seek game in *LiveGaze-ForcedChoice* even when the first-movers tried to blur their intention and looked at all four boxes (see Table 7).

cluding the direction of gaze. Some studies also showed that such cues can be mimicked in order to deceive the opponent (tennis (Rowe et al. 2009), rugby (Jackson et al. 2006), basketball (Sebanz and Shiffrar 2009), or handball (Cañal-Bruland and Schmidt 2009)).

The general question how being observed changes behavior and how others will infer motives from subtle cues like the direction of gaze is likely to gain importance in the digital age, with implicit messages being read into response times and search patterns. With this broad interpretation, other considerations come into play, for example the role of experience and learning. More research is needed to investigate whether strategically deceptive signals, be it with the eyes or via other cues, can systematically fool others. In particular, one would like to know whether people are overconfident regarding their ability to read cues or whether they learn to disregard cues that can easily be manipulated.

It would also be interesting to compare different kinds of signals. There is for example a recent literature that sheds light on the ability of people to predict what players will do from their facial expressions (Kovács-Bálint et al. 2013; Van Leeuwen et al. 2017) or response times (Frydman and Krajbich 2017). For cooperative situations, the question is whether it is easier to convey information using gaze, movement, facial expressions, language, or a combination. For competitive situations, it would be interesting to know whether some signals are more resistant to being mimicked than others.

Another open question is whether gaze can also signal things other than intentions such as sophistication, commitment, trustworthiness, attitude, or cooperativeness: Can people discern whether the eye movements they see stem from an expert or novice? Are they able to predict how trustworthy or cooperative a person will act judging from her gaze? It would then again be interesting to see whether live gaze transmission is strategically utilized by the eye-tracked subjects also in these settings, e.g., to signal their own or a different type to evoke a specific response.

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Appendix

Detailed Procedures and Instructions

Before entering the lab, all participants were welcomed by the experimenters and given oral instructions about the general rules and procedures inside the lab. If the session included eye-tracking, the experimenters also showed the participants one of the chin rests and introduced them to the general eye-tracking procedures. After an ID-check to assure that all participants were properly registered to the experiment, they were randomly allocated to individual booths. At their booths they found brief written instructions reminding them of the general rules in the lab and announcing that the experiment will comprise four parts and one questionnaire in the end. This questionnaire was merely used to keep participants busy while the experimenters prepared the receipts. Subjects that were randomly allocated to one of the booths with an eye-tracker further received written instructions regarding the calibration procedure. Once the participants were finished reading these instructions, participants in the *LiveGaze-FreeChoice* treatment received the following oral instructions read out by one of the experimenters (instructions for the other treatments as well as all written instructions are available upon request):

> *Before we begin we will briefly explain the structure of the experiment. Today there are two types of participants: A and B. The first half—who have an eye-tracker—are participants A and the other half are participants B.*
>
> *There will be 4 parts, each with 5 rounds and in each round, one participant A and one participant B are in a group together. The composition of the groups is randomly re-drawn before every round.*
>
> *All rounds have the same general structure—only the income changes. At the end of the experiment you receive the points you earned in all rounds in cash. 10 points are worth 1 Euro.*
>
> *You will learn how much you earned at the end of the experiment. This means there will be no feedback between rounds.*
>
> *When you look at your screens now, you will see four gray boxes. In each round, both participants sequentially choose one of the four boxes: First participant A and then participant B.*
>
> *On each box you see the amount of points you could theoretically earn when you choose this box. You will always either earn the amount displayed on the box you choose or zero points. The numbers on the boxes are always the same for both participants. So if, for in-*

stance, you see a 10 in the top left box, then there will always also be a 10 in the top left box for the other participant.

Before each of the four parts you will learn how exactly your income will be determined. In general, it will depend on whether participants A and B will choose the same or a different box.

There is a special feature for participants A: As soon as the eye-trackers are running, the box that they are currently looking at will be red instead of gray.

Also participant B can see which box participant A is looking at until participant A has chosen a box. This means that participant B always sees the same screen or rather the same red boxes flashing as participant A.

For example, if participant A looks at the top right box, this box will turn red. If participant A then looks at another box, this one will turn red and the first one will turn gray again—and that is both for participant A and participant B. Hence, participant B knows which box participant A is currently looking at.

Participant B can only decide once participant A is done. This will be signaled to him by a green frame that appears around the four boxes. On participant B's screen this will look like this. [The green frame was then displayed on all participants' screens.]

As soon as this green frame appears, participant B can decide. To choose a box, all participants use the four keys with the stickers on their keyboards. To choose the top left box, you have to press the top left key, for the top right box, the top right key, and so forth.

We will now begin with the calibration of the eye-trackers. This will be followed by four practice rounds to familiarize you with the controls and procedures. These practice rounds have no influence on your income. We ask all participants B to wait while participants A are being calibrated.

The four trial rounds mentioned in the instructions existed in all treatments. Their only purpose was to make the participants accustomed to the input method and the look and feel of the visualization of the gaze data. For the first movers, their true gaze data was visualized already in these practice rounds, whereas second movers saw a randomly generated gaze pattern (except for the *NoGaze* treatment in which the second movers saw no gaze patterns but simply had to wait for an equivalent amount of time). Another difference between the practice rounds and the actual experiment was that in each of the practice rounds participants saw an arrow pointing at one of the four boxes. In order to advance to the next round, they had to press the key that corresponded to the box with the arrow.

The instructions concerning the individual games were shown on screen before each part and read like this (here, we show the instructions for the case that the coordination game was played in part 1):

Part 1 (rounds 1 to 5)

In Part 1, your income will be determined like this:
If participant B chooses the same box as you, you will earn 10 points.
If participant B chooses a different box than you, you will earn 0 points.

Participant B's income will be determined like this:
If participant B chooses the same box as you, he will earn 10 points.
If participant B chooses a different box than you, he will earn 0 points.

If you have any questions, please raise your hand, otherwise you can now press Space to continue.

Before each individual round, there was an additional reminder of the random re-matching of partners ("*You will now be randomly matched with a new participant A[B].*") as well as of the income structure ("*Participant A earns points, if the chosen boxes are the same[different]. // Participant B earns points, if the chosen boxes are the same[different].*"). This screen was shown for eight seconds, followed by a screen announcing the beginning of the next round for two seconds, and finally the next round started with the display of a fixation cross in the center of the screen for one second and then the four boxes were displayed.

Further Analyses

TABLE 7—SHARE OF SECOND MOVER CHOICES IN LINE WITH HEURISTICS BY TREATMENT.

	Coordination	Focal Coordination	Focal Discoord.	Hide & Seek
RecordedGaze				
Most Looked	0.81	0.77	0.93	0.68
Last Looked	0.86	0.82	0.94	0.67
Frugal Tree	0.86	0.80	0.92	0.66
LiveGaze-ForcedChoice				
Most Looked	0.94	0.96	0.93	0.46
Last Looked	0.94	0.94	0.91	0.45
Frugal Tree	0.94	0.94	0.92	0.45
LiveGaze-FreeChoice				
Most Looked	0.96	0.99	0.93	0.31
Last Looked	0.94	0.99	0.91	0.30
Frugal Tree	0.96	0.99	0.92	0.33

Notes: A second mover's choice is counted as in line with the heuristic, if it is a best response to the heuristic's predicted choice of the first mover. Note that, since the heuristics always make point predictions for the first mover, there always are three best responses in the focal discoordination game whereas there is only one in all other games.

The share of second mover decisions in line with the respective heuristics never differ significantly between the coordination and the focal coordination game in none of the treatments (all corrected p-values > .1). In both *LiveGaze* treatments, all three heuristics' hit rates with respect to second mover behaviour are significantly lower in the hide & seek game than in all other games (all corrected p-values < .002). Additionally, in the *LiveGaze-FreeChoice* treatment, hit rates of all three heuristics are also significantly higher in the focal coordination game than in the focal discoordination game (all corrected *p*-values < .05).

In the *RecordedGaze* treatment, the hit rate of the *Most Looked* heuristic is significantly higher in the focal discoordination game than in the other three games (all corrected *p*-values < .05). Similarly, also in the *RecordedGaze* treatment, the hit rates of the *Last Looked* heuristic and the *Frugal Tree* are significantly higher in the focal discoordination game than in the focal coordination game (both corrected *p*-values < .05) but not compared to the coordination game (both corrected *p*-values > .6). Further, the hit rate of the *Last Looked* heuristic is significantly lower in the hide & seek game than in all other games (all corrected *p*-values < .1). Finally, the *Frugal Tree*'s hit rate is significantly lower in the *RecordedGaze* hide & seek game than in the focal discoordination and the coordination game (both corrected *p*-values < .02) but not compared to its hit rate in the focal coordination game (corrected *p*-value > .1). All unmentioned comparisons are insignificant.