

OPPONENT RECOGNITION AND PREDICTIVE CANCELLATION IN THE ANTICIPATION OF DECEPTIVE SPORT ACTIONS

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ABSTRACT

To determine how uncertainty about the acting opponent changes the predictive value of a directional cue and the movement justified by that prediction. Conditional probabilities are derived for two opponents whose cues agree with their final actions with probabilities of 0.80 and 0.20. The analysis specifies balanced action directions, symmetric recognition errors, unequal action frequencies, and asymmetric movement losses. The numerical values are calculated from these distributions; they are not measurements of athletes. With equal identity probabilities, the opposed cue relations yield a right-action probability of 0.50. Optimal mean direction accuracy equals $0.20 + 0.60r$, where r is recognition-channel reliability, and rises from 0.50 to 0.80 as r rises from 0.50 to 1.00. Shared cue relations of 0.80 yield 0.80 accuracy throughout. A common right-action frequency of 0.70 preserves 0.70 optimal accuracy even when the cue carries no directional information. With a 3:1 ratio of wrong-movement losses, moving right requires a right-action probability above 0.75; under the opposed relations, the corresponding identity probability must exceed 11/12. The calculations separate uncertainty about the opponent, information carried by the cue, and the consequences of movement. A clear-versus-ambiguous recognition comparison has an analytical accuracy contrast of 0.24 for opposed relations and zero for shared relations when recognition reliability is 0.90 versus 0.50. Behavioural tests must establish contingency learning, preserve cue visibility, and distinguish long-run tendencies from retrieval of the most recent response.

Keywords: opponent recognition; deceptive movement; anticipation; conditional probability; perceptual learning; sports theory.

INTRODUCTION

A defender must interpret a head turn, shoulder rotation, or preliminary step before the opponent's final action becomes visible. Deceit supplies misleading information about that action, whereas disguise withholds information about it. An incorrect prediction alone does not demonstrate deceptive intent (Raffan et al., 2024). The distinction matters because the directional relation between an early cue and the final action can be measured without inferring the attacker's intention on every trial.

Basketball head turns interfere with pass-direction judgements even when observers are instructed to ignore head orientation (Kunde et al., 2011). In virtual rugby, experienced defenders initiated interception later than novices and made fewer directional errors while using movement information differently (Brault et al., 2012). Soccer step-over movements can reverse spatial cueing toward the eventual turn (Wright and Jackson, 2014). These observations concern different movements and response tasks, but each demonstrates that an early visible action can direct the observer away from the eventual outcome.

Player-specific head-fake frequencies also affect basketball responses (Güldenpenning et al., 2024). For two familiar

attackers with opposed tendencies, the same rightward head turn can favour a rightward pass by one player and a leftward pass by the other. Learning both tendencies is insufficient if the defender cannot determine which player is acting. The cue can remain clearly visible while uncertainty about the opponent removes its directional value.

Probabilistic knowledge and contextual information influence anticipation (Cañal-Bruland and Mann, 2015; Loffing and Cañal-Bruland, 2017). The question addressed here is the conditional probability of the final action when that knowledge is available but the opponent is uncertain. Three quantities are kept separate: the probability assigned to each opponent, the cue-action relation for each opponent, and the loss associated with the defender's movement. Their combination determines whether recognition changes a prediction, an optimal directional choice, or both.

OPPONENT ATTRIBUTION AND ACTION PROBABILITY

IDENTITY UNCERTAINTY AND TENDENCY KNOWLEDGE

An opponent's action preference can improve anticipation while that preference persists and impair anticipation when it changes (Mann et al., 2014). In soccer, explicit action tendencies influence anticipation together with the available visual information (Gredin et al., 2018, 2021). A defender therefore needs both a usable tendency estimate and evidence that this estimate belongs to the acting opponent.

Opponent attribution is the probability assigned to each plausible opponent given the available identifying evidence. It need not involve naming the player aloud. Recognising a familiar individual or a category with a stable cue-action relation can be sufficient. Conversely, recalling a player's name does not establish that the currently observed movement belongs to that player.

Here, opponent identity means the individual producing the action. Panten and colleagues use "identity deception" for ambiguity between action techniques, such as a spike and a poke shot (Panten et al., 2019). The two meanings concern different uncertainties. A defender can know the tendencies of two players but be unable to distinguish them in a brief view. Another defender can recognise a player without knowing that player's tendencies. A third can confidently assign the wrong tendency to the visible player. Similar overall accuracy can arise from these different errors, so identity choice, confidence, and tendency knowledge require separate assessment.

During play, a screen, a change of direct opponent, or a restricted viewpoint can remove identifying features before the final action is clear. Their relevance to anticipation depends on what the defender can recognise at that moment. Identification from an unrestricted portrait cannot establish recognition during the earlier movement interval.

JOINT USE OF IDENTITY AND MOVEMENT EVIDENCE

Identity and action information can arrive together. A distinctive movement may indicate both who is acting and what that player will do. Court position can also constrain both identity and available actions. In interactive sport, the attacker may change the action after observing the defender's position (Panten et al., 2019). Independence between identifying evidence and outcome evidence is therefore unnecessary for the general calculation.

Let T be final action direction, J the opponent, and e_t the identifying, kinematic, and situational evidence available at time t . For m possible opponents, the probability of a rightward action is

$$p_R(t) = P(T = R \mid e_t) = \sum_{j=1}^m P(J = j \mid e_t) P(T = R \mid J = j, e_t). \quad (1)$$

Both terms condition on the same evidence. Each player's action probability is weighted by the probability that this player is acting. The expression retains uncertainty about identity instead of treating the most likely player as certain.

If every possible opponent has the same conditional right-action probability, changing the identity weights leaves $p_R(t)$ unchanged. Recognition changes the prediction only when the player-specific probabilities differ. Its influence on direction selection is clearest when these probabilities lie on opposite sides of the relevant decision threshold.

CANCELLATION AND RECOGNITION RELIABILITY

OPPOSED CUE RELATIONS

Consider two opponents, A and B , binary action direction T , and binary cue direction C . Set $P(T = R \mid J) = 0.50$ for each opponent. Cue agreement is symmetric: $P(C = T \mid T, J = j) = a_j$. The values a_j are fixed and known. Identifying

evidence Z is independent of (T, C) conditional on J , and no additional outcome information is available at the prediction time. These conditions isolate identity uncertainty from uncertainty about the cue relation.

Define $q = P(J = A | Z)$. For either player, $P(C = R | J, Z) = 0.50$, so a rightward cue does not change the identity probability. Conditional on a known player, its right-action probability equals that player's cue agreement. Eq. (1) consequently becomes

$$P(T = R | C = R, Z) = qa_A + (1 - q)a_B. \quad (2)$$

The quantity q refers to identity A ; it is not a proportion of correctly recognised trials. Values of 0.25 and 0.75 express equally strong evidence for different players. An athlete's stated identity probability also requires a calibration check before it can be treated as q .

With $a_A = 0.80$ and $a_B = 0.20$, the right-action probability is $p(q) = 0.20 + 0.60q$. When $q = 1$, a rightward cue favours right; when $q = 0$, it favours left. At $q = 0.50$, $p(q) = 0.50$. The cue retains directional information for each known player, but neither direction is favoured when the identities are equally probable.

TABLE 1. CALCULATED ACTION PROBABILITIES, OPTIMAL DIRECTION ACCURACY, AND CUE INFORMATION FOR $a_A = 0.80$ AND $a_B = 0.20$.

Identity probability q	Right-action probability	Direction favoured by a rightward cue	Optimal direction accuracy	Cue information (bits)
0.00	0.20	Left	0.80	0.2781
0.25	0.35	Left	0.65	0.0659
0.50	0.50	Neither	0.50	0.0000
0.75	0.65	Right	0.65	0.0659
1.00	0.80	Right	0.80	0.2781

Note. $q = P(J = A | Z)$. Rightward and leftward actions are equally frequent. Optimal accuracy is $\max[p(q), 1 - p(q)]$ for a forced choice with equal error costs. Information follows Eq. (4). Values describe the specified distributions, not athlete measurements.

For $a_A > 0.50 > a_B$, setting Eq. (2) equal to 0.50 gives the cancellation probability

$$q^* = \frac{0.50 - a_B}{a_A - a_B}. \quad (3)$$

With cue agreements of 0.90 and 0.40, cancellation occurs at $q^* = 0.20$. Equal identity probabilities are therefore sufficient for cancellation in the 0.80/0.20 pair but are not necessary for cancellation in every opposed pair. If both cue agreements exceed 0.50, all identity weights favour agreement with the cue. If both are below 0.50, all favour the opposite direction.

INFORMATION CARRIED BY THE CUE

For a fixed identifying observation $Z = z$, the balanced distribution gives a symmetric binary channel. Its conditional information is

$$I(T; C | Z = z) = 1 - h_2[p(q)], \quad h_2(p) = -p \log_2 p - (1 - p) \log_2 (1 - p). \quad (4)$$

The limiting terms at zero and one are defined by continuity. Reducing q from 1.00 to 0.75 changes $p(q)$ from 0.80 to 0.65. Cue information falls from approximately 0.2781 to 0.0659 bits, a 76.3% reduction, while optimal directional accuracy falls by 0.15. Information and accuracy quantify different properties of the distribution; neither calculation assumes that athletes compute entropy.

Table 1 conditions on an identity probability. Average accuracy across a recognition test also depends on how identity evidence varies over trials. Moreover, low certainty differs from confident misidentification. Applying the 0.80 agreement rule to opponent B , whose true agreement is 0.20, can produce consistently wrong directional choices even though the observer feels certain.

RECOGNITION ERRORS ACROSS TRIALS

Set $P(J = A) = P(J = B) = 0.50$ and let the recognition label Z be A or B . Define $r = P(Z = J | J)$, with the same reliability for both players and $0.50 \leq r \leq 1$. Under the independence conditions above, Bayes' rule gives

$$P(Z = A) = P(Z = B) = 0.50, \quad P(J = A | Z = A) = r, \quad P(J = A | Z = B) = 1 - r. \quad (5)$$

The average identity probability remains 0.50 at every value of r . Improved recognition separates the two conditional identity probabilities rather than increasing their average.

For opposed relations, a rightward cue gives action probabilities of $0.20 + 0.60r$ after label A and $0.80 - 0.60r$ after label B . Their optimal accuracies are equal for $r \geq 0.50$. Averaging over recognition labels and cue directions yields

$$\mathcal{A}_{\text{opp}}(r) = 0.20 + 0.60r, \quad \mathcal{A}_{\text{shared}}(r) = 0.80. \quad (6)$$

The shared relation sets $a_A = a_B = 0.80$. Its prediction is independent of the identity weight, so recognition reliability does not change optimal accuracy. Mean conditional cue information is $1 - h_2(0.20 + 0.60r)$ for opposed relations and $1 - h_2(0.80)$ for shared relations.

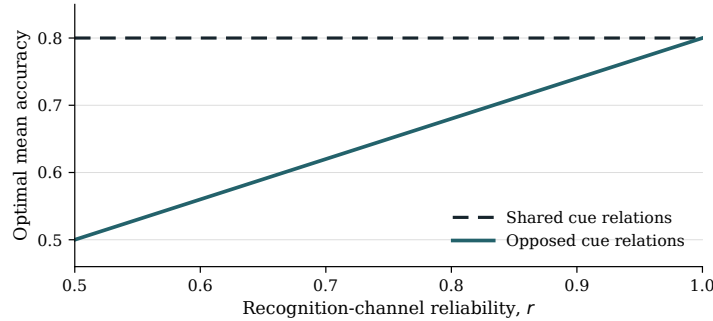


FIGURE 1. CALCULATED OPTIMAL ACCURACY AS RECOGNITION-CHANNEL RELIABILITY VARIES FROM 0.50 TO 1.00. OPPOSED CUE AGREEMENTS ARE 0.80 AND 0.20; SHARED CUE AGREEMENTS ARE 0.80 AND 0.80. OPPONENTS AND FINAL DIRECTIONS ARE EQUALLY FREQUENT. THE CURVES FOLLOW EQ. (6); THEY DO NOT CONTAIN PARTICIPANT OBSERVATIONS.

At $r = 0.90$, opposed-relation accuracy is 0.74; at $r = 0.50$, it is 0.50. Shared-relation accuracy is 0.80 at both values. The difference between the two recognition benefits is therefore $(0.74 - 0.50) - (0.80 - 0.80) = 0.24$. This is a property of the specified recognition channel, not an estimated human effect size. Unequal player frequencies, asymmetric recognition errors, and miscalibrated identity estimates require their own likelihoods.

UNEQUAL ACTION FREQUENCIES

Allow $b_j = P(T = R \mid J = j)$ while retaining symmetric cue agreement and conditional independence of identifying evidence. The probability of a rightward cue for player j is $\ell_j = a_j b_j + (1 - a_j)(1 - b_j)$. The conditional right-action probability is

$$P(T = R \mid C = R, Z) = \frac{q a_A b_A + (1 - q) a_B b_B}{q \ell_A + (1 - q) \ell_B}. \quad (7)$$

For a leftward cue, the numerator uses $(1 - a_j)b_j$ and the denominator uses $1 - \ell_j$. When $\ell_A \neq \ell_B$, cue direction also changes the conditional identity probabilities. The symmetric-channel information expression in Eq. (4) then need not apply.

Set $q = 0.50$, $a_A = 0.80$, $a_B = 0.20$, and $b_A = b_B = 0.70$. The right-action probability is 0.70 after either cue direction. Although the cue contributes no directional information, always choosing right achieves optimal accuracy of 0.70. Cancellation of cue information therefore does not imply accuracy of 0.50 when action directions are unbalanced.

With $b_A = 0.70$ and $b_B = 0.40$, the two weighted numerator terms for a rightward cue are 0.28 and 0.04. Their sum is 0.32, and the denominator is 0.59. The resulting probability is $0.32/0.59 \approx 0.5424$. For a leftward cue, the probability is $0.23/0.41 \approx 0.5610$. Neither direction can be interpreted from identity uncertainty alone; the cue agreements and action frequencies must both be retained.

DIRECTIONAL PREDICTION AND MOVEMENT LOSS

A direction judgement and an interceptive movement have different consequences. Moving the wrong way can remove a feasible interception route, whereas an incorrect verbal judgement need not change the attacker's action. Let c_{RL} denote the loss from moving right when the attacker acts left, and c_{LR} the loss from moving left when the attacker acts right. Restrict the choice to these two movements and assign zero loss to each corresponding correct move. Expected losses are $(1 - p_R)c_{RL}$ and $p_R c_{LR}$. Moving right has lower expected loss when

$$p_R > \frac{c_{RL}}{c_{RL} + c_{LR}}, \quad c_{RL} > 0, \quad c_{LR} > 0. \quad (8)$$

Equal losses produce a threshold of 0.50. With $c_{RL} = 3$ and $c_{LR} = 1$, the threshold is 0.75. For the opposed relations, $q = 0.90$ gives $p_R = 0.74$. Moving right then has expected loss $0.26 \times 3 = 0.78$, whereas moving left has expected loss $0.74 \times 1 = 0.74$. Left is preferred despite right being the more probable action. Moving right becomes preferable only when $q > 11/12 \approx 0.9167$. The three and one units define a loss ratio; they are not measured sporting penalties.

Judgement utility changes the use of contextual priors and visual information in soccer anticipation (Gredin et al., 2019). That evidence establishes that consequences can affect judgements, but it does not estimate the movement losses used here. Eq. (8) determines the choice only after those losses have been defined.

The relevant physical variables include support position, lateral velocity, braking capacity, and available interception routes. A directional error that requires braking and reversing a committed step can have a different cost from an error made while stationary. Actual movement choice also includes holding position, delaying commitment, and moving diagonally. These options require additional action-specific losses. The two-movement calculation assumes that the defender's choice does not change the attacker's outcome distribution.

Recognition matters only while player-specific predictions differ and the defender can still act on that difference. If later kinematics reveals the final pass direction equally well for both players, the conditional probabilities in Eq. (1) converge. Identity uncertainty then has less influence. The relevant interval is the overlap between identity-dependent predictive information and the time remaining for a feasible movement, rather than a fixed duration common to every sporting action.

TESTS OF RECOGNITION-DEPENDENT ANTICIPATION

LEARNED QUANTITIES AND RESPONSE POLICY

The behavioural hypotheses concern an observer's use of identity and cue relations; the probability identities themselves do not require behavioural confirmation. Let $\hat{q}$ and $\hat{a}_j$ denote an observer's identity and agreement estimates. Under the balanced distribution, the corresponding prediction is $\hat{p}_R = \hat{q}\hat{a}_A + (1 - \hat{q})\hat{a}_B$. Agreement with an observer's stated right-action probability would support this prediction, but would not identify a unique memory or neural mechanism.

Optimal direction accuracy additionally requires choosing the more probable action. Probability matching, a preferred directional response, incomplete learning, or inaccurate identity estimates can reduce accuracy below Eq. (6). Movement performance also depends on whether the observer estimates the losses and retains a feasible response. The tests below are prospective; no observers have completed them for this analysis.

OPPOSED AND SHARED RELATIONS

A factorial recognition test would use an opposed pair with cue agreements of 0.80 and 0.20 and a shared pair with agreements of 0.80 and 0.80. Player frequency, final direction, and cue orientation would be balanced. Identifying evidence would vary between clear and ambiguous conditions while the movement trajectories and visibility of the directional cue remained identical. Assignment of appearances to cue relations would be counterbalanced across observers and repeated across several player sets.

The primary outcome would be forced-choice direction accuracy at a prespecified occlusion point before decisive outcome kinematics. The contrast would compare the clear-minus-ambiguous accuracy difference between the opposed and shared pairs:

$$\Delta = (\mathcal{A}_{\text{clear}} - \mathcal{A}_{\text{ambiguous}})_{\text{opp}} - (\mathcal{A}_{\text{clear}} - \mathcal{A}_{\text{ambiguous}})_{\text{shared}}. \quad (9)$$

For the analytical channel with clear reliability of 0.90 and ambiguous reliability of 0.50, $\Delta = 0.24$. A human comparison must use the recognition separation actually achieved, rather than assume these two reliability values. Matched probability-judgement trials would establish whether lower certainty moves predictions toward the correct mixture.

Before testing recognition, observers would learn each cue relation with outcome feedback. A learning rule would require estimates within 0.10 of each assigned agreement probability on two successive assessments. This tolerance defines a procedural choice rather than a validated learning threshold. A prespecified maximum-training rule would govern further training and exclusions before the recognition conditions are tested. Analysis would retain exclusion counts and assess sensitivity to the learning rule. Identity trials at the same observation durations would measure choices, confidence, and probability calibration. Separate cue-direction and outcome-kinematic tasks would verify preserved movement information.

If cue learning, recognition separation, and cue visibility are established but Δ is absent, recognition-weighted prediction would lack support in that task. An accuracy reduction of similar size in opposed and shared pairs would instead suggest an attentional or perceptual cost. A selective opposed-pair reduction would support recognition dependence without resolving whether learned tendencies or recent responses produced it.

LONG-RUN TENDENCIES AND RECENT-RESPONSE RETRIEVAL

Movement exemplars not used in training would test whether observers apply the cue relation beyond memorised clips. A familiar appearance or head orientation could nevertheless retrieve an earlier response. Binding-and-retrieval accounts distinguish association formation from response retrieval (Frings et al., 2020); conflict-task research also requires control of sequence and contingency effects before attributing them to adaptive control (Braem et al., 2019). In the player-specific basketball experiment, controlling recent-response retrieval removed the reaction-time interaction and reduced, but did not eliminate, the accuracy interaction (Güldenpenning et al., 2024).

Trial records would therefore include the previous occurrence of the same player-cue combination, the required response, the executed response, repetition or alternation relative to the current response, and elapsed time. Unequal cue contingencies constrain response sequences, so generation must verify that these predictors can be estimated separately. An opponent-contingency model, a most-recent-response model, and a combined model would be compared on trials excluded from fitting. Conditions presenting only prior information, only movement information, or both would further identify what each judgement depends on.

A separate diagnostic block would place the learned long-run relation against a controlled most-recent response. Observers would judge unfamiliar movement exemplars without outcome feedback. Judgements following the long-run relation despite an opposed recent response would weigh against an exclusively last-response explanation; judgements following the recent response would favour retrieval. These probes require separate analysis because their sampling and absence of feedback differ from the maintained-contingency task. An identifying symbol carrying the same cue relations would test whether the effect depends on recognising a person or identifying a learned context.

OBSERVATION TIME AND MISTAKEN IDENTITY

Recognition dependence should occur at observation times when player-specific predictions differ and final-action kinematics remains insufficient. Multiple prespecified occlusion points aligned to pass execution would examine that interval. Identity judgements would be measured at the same points. A reduction in the identity effect after final direction becomes visible would support a timing-dependent role for recognition. Work on deceptive soccer actions shows that prior information cannot be assumed helpful for every action (He et al., 2025).

Exchanging identifying appearances after learning while preserving movement trajectories would test mistaken assignment of a learned relation. If early judgements follow the appearance-linked agreement, exchanging opposed-player appearances can reverse the predicted direction. Exchanges between shared-relation players would quantify the cost of visual novelty without reversing the learned relation. Identity choice and probability calibration would distinguish calibrated ambiguity from confident assignment to the wrong player.

STATISTICAL ESTIMATION AND INTERCEPTION

For the primary test, a binomial mixed-effects model would include recognition condition, cue-relation pair, their interaction, and prespecified sequence predictors. Participant and player-set effects would reflect the sampling design. Estimated marginal accuracies and Δ would be expressed on the probability scale with uncertainty intervals. Direction judgements, response time, first-step direction, corrective movement, and interception success would remain distinct outcomes. Response-time analysis would account for incorrect trials and speed-accuracy trade-offs.

Participant and trial counts require a pilot estimate of recognition separation, participant and stimulus variability, and a prespecified precision or effect target. The analytical difference of 0.24 cannot substitute for an observed human effect when calculating sample size. The sampling plan, learning exclusions, missing observations, model terms, primary contrast, and diagnostic comparisons would be fixed before confirmatory data collection.

An interception task would subsequently allow the defender and attacker to move, preserving the information-action relation required by representative learning design (Pinder et al., 2011). Transfer would require evidence that recognising the opponent changes a feasible movement and improves interception. Accuracy in a seated direction-judgement task cannot establish that benefit.

SCOUTING INFORMATION AND PERCEPTUAL PRACTICE

A scouting profile needs to specify the action, situation, and cue-outcome relation. An overall head-fake frequency is not interchangeable with the probability of a rightward pass after a rightward head turn. The 0.80/0.20 calculation concerns this conditional relation, not a player's overall preference for one direction. Profiles that combine different actions or situations into a single percentage can remove the distinction required by Eq. (1).

Practice also needs to examine whether the athlete can connect a tendency with its player under the viewpoints and viewing durations available during play. Giving the player's name before each clip tests use of an explicitly supplied identity. Requiring recognition from the sporting scene tests an additional demand. A comparison between these conditions would retain identical action information and response requirements, so any accuracy difference could be examined alongside identity calibration.

Training with low spatial-frequency information improved anticipation of deceptive actions in novice badminton players (Ryu et al., 2018). Removing visual detail can assist reading of movement while also removing identifying features. For opposed player tendencies, these consequences can work in different directions: kinematic information becomes easier to use, but the relevant cue relation becomes harder to select. The shared-pair condition distinguishes an identity cost from a general loss of movement visibility.

Perceptual training can improve anticipation of direct and deceptive handball throws (Alsharji and Wade, 2016). Whether recognition practice adds interception benefit requires a comparison that preserves movement information, verifies learning, and separates response retrieval. Training recommendations must depend on that evidence rather than on the analytical accuracy curve alone.

LIMITS OF THE PROBABILITY AND MOVEMENT CALCULATIONS

The fixed cue agreements isolate recognition, whereas athletes learn tendencies from finite encounters. Score, position, fatigue, and the defender's behaviour can change those tendencies. Uncertainty about cue agreement a_j is therefore distinct from uncertainty about opponent identity J . A correctly recognised player can still have an uncertain tendency estimate. Unequal action frequencies must also be retained when interpreting directional accuracy: zero cue information coexists with 0.70 optimal accuracy in the common 0.70 right-action calculation.

Identifying kinematics can also carry outcome information. Eq. (1) allows this dependence by conditioning both terms on the available evidence. The symmetric recognition channel removes it to isolate the effect of identity reliability. An identity manipulation must verify the action information retained; an application to recorded play must estimate the relevant joint probabilities rather than insert the 0.80/0.20 values.

Recognition-dependent responses can arise from accumulated cue knowledge, attention to context, retrieval of an earlier response, or combinations of these processes. An appearance-dependent response establishes the relevance of an identifying cue but does not, alone, establish recognition of a particular person. Generalisation across appearances and comparison with identifying symbols address that distinction. Agreement with the probability mixture does not establish Bayesian computation in the nervous system.

The two-movement choice omits holding position, waiting, diagonal movement, and changes in the attacker's action after the defender responds. Their probabilities and losses can change the preferred movement. The result therefore concerns a defined choice between left and right, not every tactical decision. For more than two directions or opponents, the relevant outcome probabilities and action losses must be specified before accuracy or information is calculated.

CONCLUSIONS

For cue agreements of 0.80 and 0.20, uncertain opponent identity changes the right-action probability according to $0.20 + 0.60q$. Equal identity probabilities cancel the cue's directional value. Under symmetric recognition errors, optimal mean accuracy is $0.20 + 0.60r$; with shared 0.80 agreements, it remains 0.80 regardless of recognition reliability. A common right-action frequency of 0.70 shows that cue cancellation need not produce 0.50 accuracy. Asymmetric 3:1 movement losses require a right-action probability above 0.75, corresponding to $q > 11/12$ in the opposed calculation. These results identify separate requirements for using an opponent tendency: learning the cue relation, assigning it to the acting player, and selecting a feasible movement with acceptable loss. The decisive behavioural comparison is whether reduced identifying information selectively lowers early direction accuracy for opposed relations after cue visibility, learning, and recent-response retrieval are controlled. Competitive benefit additionally requires improvement in movement and interception. Recognition is consequential when it changes the conditional action probability while time remains to act on that change.

DECLARATIONS

CONFLICT OF INTEREST

The author declares that there are no conflicts of interest related to this study.

DATA AVAILABILITY

The data supporting the findings of this study are available from the author upon reasonable request.

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