Reversing the Cumulative Redundancy Bias to Demonstrate Metacognitive Flexibility in Cue Utilization

David J. Grüning ^{ab*}

Hans Alves ^c

André Mata ^d

Klaus Fiedler ^a

a: Heidelberg University, Hauptstraße 47, 69117, Heidelberg, Germany

(david.gruening@stud.uni-heidelberg.de; klaus.fiedler@psychologie.uni-heidelberg.de)

b: GESIS - Leibniz Institute for the Social Sciences, B6 4, 5, 68159, Mannheim, Germany

(david.gruening@gesis.org)

c: University of Bochum, IB 4/161, 44780, Bochum, Germany

(Hans.Alves@ruhr-uni-bochum.de)

d: University of Lisbon, Alameda da Universidade, 1649-013 Lisboa, Portugal

(aomata@psicologia.ulisboa.pt)

*Corresponding author

Abstract

The cumulative redundancy bias (CRB) refers to people's difficulty in ignoring the redundancy in cumulatively presented information. When people consider which of two competing agents is better, they are influenced by the sequence of events that led to their accumulative total performance. If one agent was ahead most of the time, people consider this agent better – even if the agents are tied eventually. However, we show that an opposite performance-slope bias (PSB) emerges when participants focus on the performance trajectories of agents. When a trailing agent is substantially catching up to the leading agent, people judge the former as the better agent. In four experiments where we manipulated the magnitude of performance slope difference between two agents, we obtained both effects. In Experiments 1 and 2, a large slope difference between agents overshadowed other factors that may have influenced the reversal from CRB to PSB. In Experiments 3 and 4 we showed conclusively with the same design, but for different real-life contexts that the CRB emerges when the slope difference between agents is small while it reverses as the PSB when the slope difference is large. The four experiments demonstrate individuals' ability for flexible cue utilization.

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Introduction

The formation of attitudes, judgments, and decisions is the result of a sequential process, in which more information becomes available to perceivers over time (Hogarth & Einhorn, 1992). For example, we may form an impression about a person by observing that person's behavior across situations, we may decide whether to buy a product by sampling reviews from several sources, or we may follow our favorite sports team's performance over the course of the season and estimate its chances for the championship. To form valid attitudes and make correct judgments and decisions, individual pieces of information need to be integrated subsequently in a larger body of knowledge, for example, by means of summation (e.g., Betsch et al., 2001; Fishbein & Ajzen, 1974) or averaging (Anderson, 1965, 1981; Anderson & Alexander, 1971; Kahneman et al., 1993). Such information aggregation is a central function of the human mind. It has been the target of extensive research in the past.

Alves and Mata (2019; see also Alves et al., accepted) recently pointed out that many natural environments provide the perceiver with already aggregated sequential observations such as a running total or a running average. Vote counts of presidential candidates, the total number of points collected by sports teams in a season, or current stock prices are just some of many examples. When an observation sequence is comprised of such *cumulative* information, perceivers do not need to integrate information over time, but ought to rely only on the most recent observation and disregard previous observations, as they are redundant. For instance, across all games in a soccer season, the best estimate of success might be given by a team's total collected points. Previous point scores, after an intermediate number of games, do not necessarily provide additional informational value about the team's success beyond the most recent score. Cumulative redundancy emphasizes the diagnostic value of the total score and downplays the informative value of all interim scores. However, people often fail to adequately account for information redundancy (e.g., Fiedler et al., 2018; Unkelbach et

al., 2007). Based on this well-documented human tendency, Alves and Mata (2019) predicted, and found robust evidence for, a *cumulative redundancy bias* (hereafter CRB). When sequences of information were cumulative, judgments not only relied on the most recent summary score, but were also systematically influenced by preceding interim scores. Judges tended to favor the competitor who was ahead during most of the competition sequence, even when the end result was a draw. This outcome of repeated rank-frequency learning was inconsistent with the notion that the most recent performance is most diagnostic.

The CRB has relevant theoretical and practical implications. It represents a distinct type of a generalized primacy effect, transcending the domain of person impression formation (Alves & Mata, 2019) and pointing to similar primacy effects in marketing, politics, and sports, to name just a few other domains. A recent memorable CRB example was observed during the 2020 US presidential election vote count, when high-ranking Republicans including the President Donald Trump himself long refused to revise the early impression that he was winning the electoral college amid the ongoing vote count.

CRB revisited and reversed. Yet, the CRB may not be the only viable outcome in a sequence of cumulative observations. As we shall explain in this section, attention to another cue can produce the opposite effect. Explaining and testing such a CRB reversal is the purpose of a series of four experiments reported in the present article. We first report two experiments with plainly opposite results. They show that cumulative coding does not determine any fixed cognitive-processing constraints that favor the leading agent. It is rather easy to modify the experimental task conditions in a way that facilitates incremental coding, resulting in a bias that favors the trailing competitor, that is, the agent that starts behind but finally reaches a tie or even overtakes the leading competitor. Such a reversal can be understood as a *trend effect*, whereby observers extrapolate a recent trend (slope) to the future (Hohle & Teigen, 2015). Specifically, we propose that the small difference in performance

slopes of leading and trailing agents in the experiments of Alves and Mata (2019) promoted the reliance on ranking frequency as the dominant cue that informed participants' judgment of agent performance. However, a trailing agent with a steep performance trajectory should be favored despite them lagging behind the leading competitor for most of the time. This consideration is in line with insights from other fields, like behavioral economics (e.g., Carlson & She, 2007) and research on forecasting (De Bondt, 1993), which demonstrate influences of performance trends on judgment and decision making.

Considered against the original evidence from Alves and Mata (2019), our present experiments corroborate the conclusion that illusions in sequential evaluation cannot be explained mechanistically in terms of a fixed advantage of one encoding mode, or an inability to switch to another encoding process. Rather, people possess the cognitive capacity to engage in both cumulative and incremental encoding. Which encoding strategy they turn to depends on the most salient cues provided by the task. If the task focus shifts from the competitors' ranking frequency, as in previous research, to their relative performance slope over time, judges might give more weight to the slope than to ranking frequencies. As a result, they may produce evaluations and future predictions that favor the competitor that catches up over time. Moreover, different performance slopes may receive even more weight if the two competitors' results are not presented in isolation but embedded in a more comprehensive display of many other agents' performance, while ranking frequency may receive even lesser weight then. Given an enriched comparative context, unequal performance slopes may be even more visible than when an impoverished context displays only the two focal competitors.

Resulting biases depend on metacognition. Crucial for a rational evaluation strategy in multi-cue settings is the individual's metacognitive ability to choose informative cues by the logic of the evaluation task and not to be misled by whatever cue happens to be salient in a given situation. Judges are capable of encoding either type of information: ranking

frequencies and performance slope differences. They are sensitive to any cues provided by the task context, calling for either cumulative or incremental encoding, following these cues spontaneously and possibly missing the logical constraints imposed on the evaluation task. The deficit that causes serious bias in such sequential evaluation does not lie in lacking or insufficient cognitive algorithms to process the different informative cues but rather originates from a deficit, a myopia, at the metacognitive level (Fiedler, 2012), to understand when certain cues are (un)informative and should (not) be used.

Sequential evaluation of competing targets: Analyzing the task setting

To inspect the structure of the sequential evaluation task in more detail, consider the stimulus series used in Alves and Mata's (2019) Experiment 6. As in the present Experiments 1-3, it referred to the performance of two soccer teams, A and B, over 15 weeks (see Table 1). Both teams performed equally well, as the number of points gained every week was invariant for both teams (+0 for a loss, +1 for a tie, +3 for a won match) except for the fact that A outperforms B in week 1 (+3 vs. +0), whereas B outperforms A in week 15 by the same margin (+0 vs. +3; see incremental format). A final draw between both teams at 24 points in total after the 15 weeks highlights their equivalence. Yet, because the leading Team A was ahead of the trailing Team B in 14 weekly updates, A received more positive evaluations as well as more optimistic future performance prospects than B.

This unwarranted bias in favor of Team A could not be due to a primacy effect *per se* because the bias only arose when weekly stands were presented in cumulative format; it disappeared when the same data were presented in incremental format (i.e., in terms of the difference between present and preceding records, see Table 1). Apparently, Team A's superiority was confined to a redundant encoding illusion in the cumulative-format condition. The 14-fold leading status of Team A was coded as if it reflected 14 independent success outcomes for Team A over the trailing Team B. Ruling out this redundancy illusion by

presenting the same sequence in an incremental format (Table 1), the bias favoring Team A disappeared.

Table 1: Stimulus sequences used in Experiment 6 by Alves and Mata (2019)

Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cumulative Format															
Team A	3	6	6	7	10	13	14	14	17	18	19	22	23	24	24
Team B	0	3	3	4	7	10	11	11	14	15	16	19	20	21	24
Incremental Format															
Team A	+3	+3	+0	+1	+3	+3	+1	+0	+3	+1	+1	+3	+1	+1	+0
Team B	+0	+3	+0	+1	+3	+3	+1	+0	+3	+1	+1	+3	+1	+1	+3

While the incremental format led to divergent results, this format appears to be less natural than the cumulative format that is commonly used to represent performance curves in sports, political elections, the stock market, or scientific citation indices. The strong and persistent CRB in favor of the frequently leading agent that Alves and Mata (2019) found was robust across multiple experiments.

Yet, it would be premature to equate a frequently replicated finding with a universal law or mechanism. Here we present new evidence from the same paradigm, revealing that the CRB only reflects one possible outcome triggered by a selected cue (i.e., tallying of leading positions). Participants were also capable of utilizing other cues triggering other mechanisms of sequential evaluation. We will show that enhancing the salience of cues other than the redundant rank-frequency cue can undo the elusive advantage of the early-leading agent and instead create a reverse bias in favor of a late-rising competitor that started weak but exhibited a stronger leeway over time.

Sequential evaluation as a multi-cue task. Keeping with the example of two focal soccer teams' performance over time, sequential evaluation can be conceived as a multi-cue

inference task with comparative coding in various cues: (1) both focal teams' ranking frequency on a cumulative index; (2) the focal teams' outcome on the current trial; (3) both teams' relative performance trajectories across trials; and (4) the contextual embedding of both focal teams among all other teams of the league. The first cue (1), which gave rise to the CRB, is not necessarily the most powerful. While cue (1) highlights the superiority of the leading team, cue (2) underscores the equality of both teams, and cue (3) gives an advantage to the trailing team showing a substantial upward performance trend over time. Dependent on the salience of cues, we can thus predict participants arriving at all the different comparative judgments about teams A and B possible. As we shall see, additionally, the contextualization cue (4) serves as catalyst of whatever mechanism lets one cue dominate the evaluation process leading to one or the other evaluation bias.

Sequential evaluation relies heavily on metacognition. Thus, the central insight to be gained from the present extension of the Alves and Mata (2019) paradigm is that accuracy and sensitivity of sequential evaluation is not so much a matter of a constant bias reflecting a single dominant mechanism (e.g., the CRB favoring the leading agent). It is rather a function of the flexible regulation of cue-usage, depending on which cues are most salient.

At first, it seems reasonable to assume that the best criterion of past and present performance evaluation and the best predictor of future performance should be the final summary score. However, ascribing superiority to the one team that outperformed the other at the beginning or at the end of the season can also be justified. On one hand, one might argue that a recency advantage is more suggestive of the future than a primacy advantage. On the other hand, one might argue that a permanently leading team has to cope with all opponent teams' enhanced motivation to beat the best and can therefore be considered superior.

However, neither possibility is more valid on a-priori grounds.

Preview of the Present Research

To establish the basic assumption that participants are equally prepared to utilize different cues triggering different evaluation mechanisms and judgment biases, we started by conducting two experiments intended to highlight reversals of the results reported by Alves and Mata (2019). By contrasting the task conditions giving rise to opposite findings, we then demonstrate in a third experiment that either of two opposing evaluation biases (CRB vs. PSB), can be reproduced, contingent on the salience of cues. We replicate this reversal of CRB and PSB in a fourth experiment in which we also show that both biases still occur when their dominant cues (i.e., rank frequency and slope difference) are uninformative for the agents' actual performance. In the four studies, we report all measures, manipulations and exclusions.

Experiment 1

Experiments 1 and 2 were conducted simultaneously, using the same basic task setting and procedure and the same student participant pool. The purpose was to reverse Alves and Mata's (2019) systematic CRB findings, demonstrating that participants do not lack the cognitive capacity or sensitivity to recognize the steeper upward slope of the trailing team's performance curve and to shift from the redundant ranking frequency cue to the performance-slope cue. To demonstrate this shift from a CRB to a performance-slope bias, we established a slightly modified task, referring to the performance of two soccer teams across an entire second-half season (equaling 17 weeks).

Rather than only providing information about the relative point balance of the two focal teams, as was done by Alves and Mata (2019), the stimulus presentation was embedded in the richer context of the entire soccer league table, encompassing 18 teams and 9 games every week. Within this context, the ranking frequency of two focal teams should become less salient. The leading team is not at the absolute top but only superior to the other focal team. At the same time, we increased the salience of the relative slope favoring the trailing team.

Whereas the teams' slopes were rather small and similar in Alves and Mata's (2019) original setting, with the trailing team lagging only slightly behind the leading team (see Table 1), the present design renders an upward slope of the trailing team clearly steeper than the slope of the leading team (see Table 2; and Table 3).

Using these constant modifications, we manipulate two factors, the Final Outcome of the competition (i.e., whether the leading or the trailing team finally wins the race on the last game day) and the Simultaneous versus Successive Presentation Mode. The rationale of the latter manipulation is that in the sequential-mode condition, when participants first follow only one focal team before they focus on the other team in a subsequent separate run, the encoding of ranking frequency should be impaired if not eliminated, while the encoding of each team's slope should be facilitated. In a Simultaneous Presentation Mode, when the results of both focal teams can be observed and compared on each game day within a single stimulus sequence, the participants should have at least a fair chance to encode ranking frequency of both teams; performance slope should, therefore, be less dominant.

Table 2: Stimulus sequences (trailing Team Y vs. leading Team E wins) used for Experiments 1-2 from a cumulative or incremental perspective, representing 2nd half of a soccer season

Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cumulative Format – Team Y Wins (Experiments 1 and 2)																	
Team E	31	31	32	32	35	35	36	37	37	38	41	41	42	42	45	45	45
Team Y	17	20	21	24	24	27	27	28	31	32	33	36	36	39	40	43	46
Incremental Format – Team Y Wins (only in Experiment 2)																	
Team E	+0	+0	+1	+0	+3	+0	+1	+1	+0	+1	+3	+0	+1	+0	+3	+0	+0
Team Y	+3	+3	+1	+3	+0	+3	+0	+1	+3	+1	+1	+3	+0	+3	+1	+3	+3

Cumulative Format – Team E Wins (Experiments 1 and 2)

Team E	34	34	35	35	38	38	39	40	40	41	44	44	45	45	48	48	48
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Team Y	17	20	21	24	24	27	27	28	31	32	33	36	36	39	40	43	46
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Incremental Format – Team E Wins (only in Experiment 2)

Team E	+3	+0	+1	+0	+3	+0	+1	+1	+0	+1	+3	+0	+1	+0	+3	+0	+0
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Team Y	+3	+3	+1	+3	+0	+3	+0	+1	+3	+1	+1	+3	+0	+3	+1	+3	+3
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Method

Participants and design. Aiming for a test power of at least 0.80 detecting a medium effect size, we planned to collect data from around 160 participants.¹ Participants were recruited via an online-recruitment platform of the University of Mannheim. After exclusion due to missings on relevant variables a total of 158 participants remained. Sample size was determined before data analysis and never contingent on preceding data analysis. The participant sample consisted primarily of students (96.8%); 122 (77.2%) were female, 34 (21.5%) were male; two persons (1.3%) indicated „diverse“. Age ranged from 18 to 68 years ($M = 25.27$, $SD = 8.43$). Participants were randomly assigned to the conditions of a Final Outcome (Team Y wins vs. Team E wins) $\times$ Presentation Mode (Simultaneous vs. Successive) between-participants design.

Procedure. Participants first gave their informed consent. Then, general instructions informed them that they would see the second half of a soccer season (17 weeks played) and would, afterward, be asked to predict the course of the subsequent season. Participants were then first presented with the table of a soccer league, which reflected the standings right after the first half of the season (Illustration 1 in the Appendix). Depending on the condition, the focal teams' results on every game day were then presented either simultaneously, facilitating

¹ As an exact odds ratio for an informed logistic regression was not derivable from past literature.

comparative encoding of both teams' updated point account on each game day, or sequentially, with all 17 results for one team presented prior to the 17 results of the other team in a separate run. The order of team presentations in the Successive Presentation Mode was determined randomly for each participant. As the league included 18 teams, one stimulus sequence comprised 17 game days presented to the participants in total, after the initial presentation of the teams' standings within the table before the second half-season.

The stimulus display on each trial unfolded over three stages. First, participants saw the full table of all 18 teams for one and a half seconds, with no team highlighted, along with an updated point account indicated on the right (Illustration 2a, Appendix). During this stage, the table view was the same for both Presentation Modes. For a second period of 1.5 seconds, the name and point account of a focal team (Successive Mode) or of both focal teams (Simultaneous Mode) were highlighted in the table (Illustration 2b). In a final two-second stage, only the highlighted part of the latter stage was conserved (clearly visible and enlarged); the remaining part of the table was blurred, thus inviting participants to encode the critical part of the complex display, namely the two focal teams' information (Illustration 2c).

After watching the animated stimulus display over all 17 trials, or two runs of 17 given Successive Mode, and observing which of the two teams finally won the competition, participants completed a single comparative (dichotomous) rating of future performance: "Which of the two teams do you think will have the edge next season – Team E or Team Y?"

Results and Discussion

The participants in all four conditions rated the trailing Team Y more favorably than the leading Team E, contrary to the findings reported by Alves and Mata (2019). Average ratings were consistently lower than the scale midpoint of 1.5 of the dichotomous Y- (coded 1) versus E-scale (coded 2); the mean deviation score was $M_{dev} = -0.15$, (SD = 0.48). This favorable evaluation over all conditions was not only significant in a nonparametric Wilcoxon signed-

rank test across all 158 participants, $Mdn = 1.00$, $W = 4372.50$, $p < .001$, with a rank-biserial correlation (Cureton, 1956) $r_{rb} = -.30$ (medium effect), but also in separate tests within three of four condition combinations. Respondents significantly favored the trailing Team Y over the leading Team E in the Simultaneous Presentation Mode, both when Y won in the end, $Mdn = 1.00$, $W = 260.00$, $p = .038$, $r_{rb} = -.33$, and when team E won, $Mdn = 1.00$, $W = 246.00$, $p = .012$, $r_{rb} = -.40$, and in the Successive Presentation Mode, when team Y won, $Mdn = 1.00$, $W = 294.00$, $p = .043$, $r_{rb} = -.32$. When Team E won after Successive Presentation, ratings of Team Y were also more favorable to those of Team E, though this difference was not significant, $Mdn = 1.00$, $W = 312.00$, $p = .335$, $r_{rb} = -.16$. Notably, applying a Bonferroni correction for multiple comparisons via all four combinations of Presentation Mode x Final Outcome, we only find a significant favoring of the trailing Team Y in the Simultaneous Presentation Mode when Team E wins. Figure 1 displays the mean deviations for the four conditions (Final Outcome x Presentation Mode) that all point to favoring the trailing Team Y.

A logistic regression did not reveal any moderating influence of conditions on the Y superiority over E. Main effects Presentation Mode, $\chi^2(1) = .185$, $p = .667$, and Final Outcome, $\chi^2(1) = .362$, $p = .547$, as well as for the interaction, $\chi^2(1) = .538$, $p = .463$, were negligible. An omnibus test of the full 2×2 model, including Presentation Mode, Final Outcome and their interaction, did not outperform a null model in predicting whether Team Y or Team E was evaluated more favorably, $\chi^2(3) = 1.330$, $p = .722$.

Thus, the results of Experiment 1 clearly support the expectation that it is possible to eliminate and even reverse the CRB findings obtained by Alves and Mata (2019). A general tendency to provide a better prognosis for Team Y than for Team E in the next season testifies to the possibility to convert the CRB into an opposite PSB, due to a shift from one salient cue (ranking frequency) to another cue (slope difference). The CRB was eliminated in all experimental conditions, significantly in three of four experimental conditions. For the slope

cue to overrule the impact of redundant rank-ordering, it was not necessary that the trailing Team Y (with the superior slope) finally won the race or that both teams' results were presented successively, in separate runs. The modified task surface, embedding the teams in a full soccer table that made Team Y's superior slope more salient, was sufficient to induce the expected reversal, from CRB to PSB.

Figure 1: Changes in agent evaluation as a function of Final Outcome and Presentation Mode

Experiment 2

The second experiment offers an extended replication of Alves and Mata (2019) and an attempt to overcome the weakness of a single dichotomous performance measure included in Experiment 1. Using a very similar basic procedure – same instructions, soccer-related task, enriched context and three-stage stimulus trial per game day – we only replaced the presentation mode factor by another manipulation supposed to moderate the weight of ranking frequency and relative slope. With Alves and Mata's (2019) divergent results for cumulative versus incremental coding in mind, we manipulated the display of results on each trial, highlighting either all teams' current cumulative balance or the incremental information about the points gained on the current game day (i.e., +3, +1 or 0, for winning, tie, or losing, respectively). According to Alves and Mata (2019), encoding cumulative balance scores

should facilitate the CRB effect, whereas an incremental stimulus format should facilitate slope encoding leading to PSB reversals. This experiment included three graded performance measures of Team Y and E.

Method

Participants and design. In addition to increasing the number of dependent performance measures, we aimed to detect a small effect size with constant test power by an increased sample size of around 300 participants. Participants were recruited via the online platform of the University of Mannheim. After exclusion due to missing values, 286 participants remained. Recruitment was never contingent on interim data analyses. Most participants were students (95.8%); 219 (76.6%) were female and 67 (23.4%) were male. Age ranged from 18 to 91 years ($M = 24.88$, $SD = 11.01$). Participants were randomly assigned to conditions of a Final Outcome (Team Y wins vs. Team E wins) $\times$ Stimulus Format (Cumulative vs. Incremental) design.

Procedure

The procedure of Experiment 2 was identical to that of Experiment 1, except for the replacement of the Presentation Mode by the Stimulus Format (Cumulative vs. Incremental) manipulation. As in the Simultaneous Presentation Mode of Experiment 1, the results for every game day were embedded in the context of the full soccer league table. The focal teams' results were highlighted. Yet, in addition to the cumulative scores, in both conditions stimulus displays also indicated each team's point increments gained on a game day. Depending on Stimulus Format, the display highlighted either the teams' overall score (Cumulative Format) or the points gained on the current game day (Incremental Format) as displayed in Illustration 3 in the Appendix.

When stimulus presentation was complete, participants provided comparative ratings of Team Y versus Team E on three 11-point Likert scales, with "Team E" and "Team Y" as left

and right scale anchors, respectively. The three ratings, administered in constant order, referred to past performance, “Which of the two teams was the better one in the past season you just watched?”, future performance, “Which of the two teams do you think will have the edge next season?”, and a direct comparison of present performance, “If the two teams were to play against each other right now, which team would win?” Note that the past-performance question offers a manipulation check for actual team performance. Ratings below (above) the scale midpoint indicated higher evaluations of Team Y (Team E).

Results and Discussion

To anticipate, while participants’ past performance ratings were sensitive to the manipulation of the Final Outcome, their average ratings of present and future performance (below the midpoint) obviously reflected the same perceived superiority of the trailing Team Y over the leading Team E across all conditions, replicating the results of Experiment 1.

Past performance ratings. Across all 286 participants, the average ratings of past performance were not significantly different from 6 (the scale midpoint), as indicated by the mean midpoint deviation, $M_{dev} = 0.11$ ($SD = 3.72$), $t(285) = .478$, $p = .633$, $d = 0.03$.

Figure 2 shows that past-performance ratings were higher (reflecting an advantage of the leading Team E) when the leading team was the final winner, but were lower when the trailing team was the final winner, giving rise to a Final Outcome main effect, $F(1, 285) = 23.53$, $p < .001$, $\eta^2 = .08$. Another main effect for the Stimulus Format, $F(1, 285) = 4.97$, $p = .027$, $\eta^2 = .016$, was due to generally higher ratings of the leading Team E in the Cumulative than in the Incremental Format, consistent with Alves and Mata (2019). The interaction was negligible, $F(1, 285) = .006$, $p = .940$, $\eta^2 < .01$. Thus, participants were obviously sensitive to the manipulation of the presented performance reports.

Direct Comparisons of Present Performance. Figure 2 also indicates the same tendency as in Experiment 1 to consider the trailing Team Y superior to the leading Team E in

a direct comparison of present performance. The perceived superiority of the trailing team was manifested in ratings below the scale midpoint across all conditions, $M_{dev} = -1.02$ ($SD = 2.62$), $t(285) = -6.56$, $p < .001$, $d = -0.39$. Separate analyses revealed the same trend for the Cumulative Format condition with trailing Team Y winning, $M_{dev} = -1.43$ ($SD = 2.56$), $t(68) = -4.66$, $p < .001$, $d = -0.56$; Cumulative Format with leading Team E winning, $M_{dev} = -0.79$, $SD = 2.77$, $t(72) = -2.45$, $p = .017$, $d = -0.29$; Incremental Format if the trailing Team wins, $M = -1.04$ ($SD = 2.39$), $t(68) = -3.63$, $p < .001$, $d = -0.44$; and Incremental Format if the leading Team wins, $M = -0.83$ ($SD = 2.74$), $t(74) = -2.62$, $p = .011$, $d = -0.30$.² The lack of any ANOVA effects (all $F_s < 1.91$, all $p_s > .168$) once more corroborated the regularity of this shift from CRB to PSB.

Future performance ratings. Participants also expected the future performance for the trailing Team Y to be superior to the leading Team E, as evident from a negative $M_{dev} = -1.52$ ($SD = 2.68$), $t(285) = -9.59$, $p < .001$, $d = -0.57$. Again, as shown in Figure 2, no differences between conditions were found in an ANOVA (all $F_s < 2.49$, all $p_s > .115$). The trailing Team Y received more favorable ratings in all four experimental conditions: Cumulative Format with Team Y winning, $M_{dev} = -1.91$ ($SD = 2.59$), $t(68) = -6.14$, $p < .001$, $d = -0.74$; Cumulative Format with Team E winning, $M_{dev} = -1.16$ ($SD = 2.73$), $t(72) = -3.64$, $p < .001$, $d = -0.43$; Incremental Format if Team Y wins, $M_{dev} = -1.38$ ($SD = 2.72$), $t(68) = -4.21$, $p < .001$, $d = -0.51$; and Incremental Format if Team E wins, $M_{dev} = -1.63$ ($SD = 2.66$), $t(74) = -5.30$, $p < .001$, $d = -0.61$.³

Ratings across time. Finally, we included past, present, and future performance measures as an additional repeated-measures factor. A significant main effect for Final Outcome (team E vs. Y wins), $F(1, 282) = 14.13$, $p < .001$, $\eta^2 = .02$, showed that winning

² All findings remained significant after a Bonferroni correction for multiple comparisons.

³ A Bonferroni correction, again, changed no significance of the results.

teams received generally higher ratings, $M_{dev} = -1.28$ ($SD = 2.03$), than losing teams, $M_{dev} = -0.37$ ($SD = 2.05$). The rated superiority of the trailing Team Y increased over time, $F(1, 282) = 26.66$, $p < .001$, $\eta^2 = .05$, from past, $M_{dev} = 0.11$ ($SD = 3.72$), to present, $M = -1.02$ ($SD = 2.62$), to future performance, $M_{dev} = -1.52$ ($SD = 2.68$). Notably, the time perspective interacted with the Final Outcome, $F(1, 282) = 9.79$, $p < .001$, $\eta^2 = .02$. The difference between winning Team Y, $M_{dev} = -0.95$ ($SD = 3.60$), and winning Team E, $M_{dev} = 1.09$ ($SD = 3.56$), was only manifest in ratings of past performance, but not in present ($M_{dev} = -1.24$, $SD = 2.47$; $M_{dev} = -0.81$, $SD = 2.75$, respectively) and future performance ratings ($M_{dev} = -1.65$, $SD = 2.66$; $M_{dev} = -1.40$, $SD = 2.70$, respectively). Lastly, a significant result was also obtained for the interaction of the ratings' temporal perspective with Stimulus Format, $F(1, 282) = 3.72$, $p = .025$, $\eta^2 = .006$. Past performance ratings were higher for Cumulative, $M_{dev} = 0.57$ ($SD = 3.62$), than for Incremental Format, $M_{dev} = -0.35$ ($SD = 3.76$), whereas ratings of Final Outcomes ($M_{dev} = -0.93$, $SD = 2.57$; $M_{dev} = -1.11$, $SD = 2.68$, respectively) and future performance ($M_{dev} = -1.51$, $SD = 2.68$; $M_{dev} = -1.53$, $SD = 2.68$, respectively) were not.

Thus, regardless of Stimulus Format (Cumulative vs. Incremental) and Final Outcome (Team Y vs. Team E wins), ratings of present and future performance in all conditions favored the trailing Team Y over the leading Team E. As in Experiment 1, Alves and Mata's (2019) regularly obtained CRB could be easily converted into an opposite PSB, by modifying the cues and the context of stimulus presentation. The reversal received even stronger support in Experiment 2 than in Experiment 1. Together, these results provide strong support for the contention that Alves and Mata's (2019) persistent findings do not reflect an invariant mental disposition but a systematic cognitive strategy that is attuned to distinct cues and stimulus contexts and can therefore be altered in a malleable fashion.

Figure 2: Changes in agent evaluation as a function of Final Outcome and Stimulus Format

Note. Mean bipolar ratings of past, present, and future performance in Experiment 2, as a function of experimental conditions. Negative (positive) deviations from the scale midpoint indicate higher ratings of Team Y (Team X). Error bars indicate standard errors of the mean.

Experiment 3

In both experiments reported so far, we found the expected reversal from CRB to PSB for the teams' present and future performance evaluations. The extra manipulations employed in both experiments were not required to achieve this reversal. Subtle manipulations of cue salience and stimulus context were sufficient to cause a strong reversal. No Successive Presentation (Experiment 1) and no Incremental Format (Experiment 2) were needed to induce a bias in favor of the trailing team (PSB). The reversal was more radical than expected, apparently reflective of the combination of steeper performance slope and contextual embedding.

To validate this explanation of the pervasive reversal, as a causal consequence of the enhanced salience of the performance slope difference between agents and the richer embedding context, we conducted a third experiment, in a deliberate attempt to systematically solicit both phenomena, CSB and PSB, depending on the manipulation of these two factors. Specifically, Experiment 3 manipulated slope difference and context enrichment. First, the relative slope of both teams' performance curve should clearly affect the teams' evaluative ratings. Highly divergent performance slopes between the teams should facilitate a superior evaluation of the trailing team over the leading team (PSB), whereas similar slopes should facilitate a superior evaluation of the leading team (CRB). Second, the enrichment of the context in which the two focal teams are embedded should moderate the main effect of the performance slope difference. The PSB arising when the slope difference between Team Y and Team E is high should be further boosted by an enriched context that renders the display of the slope difference even more salient than an impoverished context concentrated on only the two teams (Y vs. E). Conversely, the CRB given a small slope difference may also be more visible in an enriched context, although it then renders the negligible difference between the teams' performance slopes more salient. Thus, the goal of Experiment 3 was to produce both the CRB and PSB by manipulating the relative salience of these two factors: whether the slope of the two performance curves varied only slightly (as in Alves & Mata, 2019) or markedly (as in Experiments 1 and 2), and whether the focal teams' results were presented in isolation (as in Alves & Mata, 2019) or embedded in an enriched context (as in Experiments 1 and 2).

Method

Participants and design. We lowered the required sample size and aimed for 170 participants to approximate a test power of 0.80 while expecting medium effect sizes. Participants were recruited via the online platform of the University of Mannheim. After

exclusion due to missing values, 161 participants remained. Empirical results never influenced the size or composition of participant samples. 137 of the respondents (85.1%) were female and 24 (14.9%) were male. Age ranged from 18 to 40 years ($M = 21.52$, $SD = 3.11$). Participants were randomly assigned to the conditions of a two-factorial between-participants design: Slope Difference (Low vs. High) $\times$ Embedded Context (Impoverished vs. Enriched).

Table 3: Stimulus sequence used for Experiment 3, representing 2nd half of a soccer season

Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Low performance slope difference - cumulative format																	
Team A	27	28	28	31	34	35	35	36	37	40	43	44	45	48	51	52	52
Team B	24	27	27	28	31	32	33	33	34	37	38	41	44	45	48	49	52
Low performance slope difference - incremental format																	
Team A	+3	+1	+0	+3	+3	+1	+0	+1	+1	+3	+3	+1	+1	+3	+3	+1	+0
Team B	+0	+3	+0	+1	+3	+1	+1	+0	+1	+3	+1	+3	+3	+1	+3	+1	+3
High performance slope difference - cumulative format																	
Team A	31	31	32	35	35	35	36	37	37	38	41	41	42	42	45	45	45
Team B	17	20	21	24	24	27	27	28	31	32	33	36	36	39	39	42	45
High performance slope difference - incremental format																	
Team A	+0	+0	+1	+3	+0	+0	+1	+1	+0	+1	+3	+0	+1	+0	+3	+0	+0
Team B	+3	+3	+1	3	+0	+3	+0	+1	+3	+1	+1	+3	+0	+3	+0	+3	+3

Procedure. Consent form, general task setting, instruction, cover story, computer-based procedure, and dependent measures were the same as in both previous experiments. All participants were administered the Simultaneous Presentation (from Experiment 1) in

Cumulative Format (from Experiment 2). Two factors were manipulated orthogonally between participants: Slope Difference and Embedded Context. Whereas participants in the Enriched Context received information for all 18 teams of the league, in the Impoverished Context condition they exclusively received information about the two focal teams (Illustration 4, Appendix). To manipulate performance-slope differences, the two teams' performance curves either started in highly discrepant positions, with Team Y exhibiting a clearly steeper slope than Team E, or in adjacent positions and exhibited only a small slope difference (Table 3). In all conditions, the Final Outcome was held constant with an equal overall performance of both teams at the end.

Results and Discussion

As in Experiment 2, all three dependent measures were assessed on 11-point rating scales such that ratings lower (higher) than the scale midpoint of 6 indicated superior past, present or future performance ascribed to the trailing Team Y (leading Team E).

General tendency of performance ratings. Pooling across all four conditions, ratings of past performance generally exceeded the scale midpoint, $M_{dev} = 1.60$ ($SD = 3.04$), $t(160) = 6.66$, $p < .001$, $d = 0.53$, but neither the ratings of present performance in a direct comparison, $M_{dev} = -0.02$ ($SD = 2.65$), $t(160) = -.09$, $p = .929$, $d = -0.01$, nor the future performance ratings, $M_{dev} = -0.11$ ($SD = 2.87$), $t(160) = -.47$, $p = .641$, $d = -0.04$, showed any overall difference.

Past performance ratings. To examine the impact of both independent variables, we conducted Slope Difference $\times$ Embedded Context ANOVAs. An analysis of past-performance ratings (see Figure 2) yielded a performance-slope main effect, $F(1, 157) = 25.00$, $p < .001$, $\eta^2 = .13$, with higher ratings (i.e., indicating superiority of the leading Team E) when the performance slope diverged only weakly rather than strongly. No main effect of Embedded Context was obtained, $F(1, 157) = 0.85$, $p = .357$, $\eta^2 < .01$. A non-significant two-way

interaction tendency, $F(1, 157) = 3.33, p = .070, \eta^2 = .02$, only descriptively reflected an accentuated difference between Slope Difference Conditions when the Embedded Context was impoverished ($M_{dev} = 0.78, SD = 2.97$, vs. $2.20, SD = 2.42$) rather than Enriched ($M_{dev} = 0.38, SD = 3.48$, vs. $3.43, SD = 2.02$).

Direct comparison ratings. The ANOVA of comparative ratings of both teams' present performance in a direct comparison (Figure 3) again yielded a significant main effect for Slope Difference, $F(1, 157) = 23.42, p < .001, \eta^2 = .13$. The other main effect for the context manipulation was again negligible, $F(1, 157) = 0.48, p = .489, \eta^2 < .01$. A significant interaction was obtained, $F(1, 157) = 5.19, p = .024, \eta^2 = .03$. The impact of slope was accentuated in the Enriched Context ($M_{dev} = -1.44, SD = 2.55$, vs. $1.31, SD = 2.17$) compared to the Impoverished Context Condition ($M = -0.29, SD = 2.44$, vs. $0.70, SD = 2.56$).

Future performance ratings. The same pattern held for future-performance ratings (Figure 3). In addition to a large main effect for the performance slope, $F(1, 157) = 37.11, p < .001, \eta^2 = .18$, and an absent context main effect, $F(1, 157) = 0.69, p = .408, \eta^2 < .01$, a significant interaction, $F(1, 157) = 9.57, p = .002, \eta^2 = .05$, reflected the same accentuation of the Slope Difference in the Enriched Context ($M_{dev} = -1.67, SD = 2.36$, vs. $2.03, SD = 2.11$) relative to the Impoverished Context ($M_{dev} = -0.76, SD = 2.96$, vs. $0.45, SD = 2.63$) as was shown for direct comparison ratings.

Aggregate ratings. As the internal consistency of all three ratings was reasonably substantial ($\alpha = .65$), we conducted a repeated-measures ANOVA of average ratings, aggregating across past, present and future performance. This analysis corroborated the same pattern as in all three previous ANOVAs, although with higher statistical power. The overall main effect for Slope Difference amounted to $F(1, 157) = 55.62, p < .001, \eta^2 = .14$; no main effect of the Embedded Context was found, $F(1, 157) = 0.30, p = .588, \eta^2 < .01$; but the interaction was substantive, $F(1, 157) = 11.19, p = .001, \eta^2 = .03$.

Figure 3: Changes in agent evaluation as a function of Slope Difference and Embedded Context in the soccer scenario

Note. Mean bipolar ratings of past present, and future performance in Experiment 3. Negative (positive) deviations from the scale midpoint indicate higher performance of Team Y (Team X). Error bars indicate standard errors of the mean.

In summary, Experiment 3 resulted in a successful interpolation between the contrasting findings obtained by Alves and Mata (2019) and in the present Experiments 1 and 2. Based on the orthogonal manipulation of two task features that distinguished between the two series of experiments, we were able to reproduce both the CRB reported by Alves and Mata (2019), as well as the PSB (i.e., reverse the CRB) obtained in the present Experiments 1 and 2. Apparently, the crucial task feature that enables CRB to switch into PSB is the divergence of the two focal teams' performance slopes. If the slopes of both curves are similar, a CRB reflects the rank-frequency cue dominating the performance slopes of the two

focal teams. In contrast, if strongly divergent trajectories render the performance slopes more salient, a similarly strong PSB occurs. The other distinctive feature, context enrichment, serves to accentuate the basic performance slope effect when the two focal teams' performance is embedded in the context of all weekly results and the table updates of the entire soccer league.

Experiment 4

Experiment 3 showed that the CRB can be replicated and reversed within the same design. However, important issues must still be addressed. All findings reported so far might be peculiar to soccer matches. To make a strong point for the flexibility of cognitive processes, it would thus be appropriate at least to replicate similar findings in another content domain. We thus conducted one more experiment designed to demonstrate that a similar strong reversal as in Experiment 3 for two soccer teams can be replicated in a different domain like political elections.

Specifically, in Experiment 4, we replaced the competition of two soccer teams with the competition of two political parties in an election. Participants observed the counting of votes for different parties. However, although the cumulative vote counts also appeared in a step-wise sequence across 17 time periods, the temporal task setting differed from the soccer setting in one crucial way. Whereas the interim results throughout a soccer season might causally influence the subsequent performance of the teams (e.g., motivating better performance when playing against a superior or against an inferior team) the election scenario rules out such a causal interpretation. This is because the scenario said that the voting day is over; the temporal sequence exclusively reflected the time required to count votes in a random order. According to this scenario, interim results could never influence subsequent voting behavior. This scenario rendered both cues, rank frequency and slope difference, uninformative regarding the political parties' real performance as leading and an upwards

performance trend were merely the products of the (random) order in which the collected votes were counted.

As in Experiment 3, we manipulated two factors: whether the slope of the two performance curves varied only slightly (as in Alves & Mata, 2019) or markedly (as in Experiments 1 and 2), and whether the focal parties' results were presented in isolation (as in Alves & Mata, 2019) or embedded in an enriched context (as in Experiments 1 and 2).

Method

Participants and design. Given the rather small interaction effects in Experiment 3, we doubled the sample size and aimed for 320 participants, corresponding to a desired power of 0.80 to detect small effects. A total sample of 321 participants was recruited via Prolific, from which none had to be excluded. Sample size was never contingent on preceding data analysis. The sample consisted of 133 (41.43%) female and 165 (51.40%) male participants; two (.67%) respondents indicated “non-binary” and 21 (6.50%) did not indicate their gender. Age ranged from 18 to 72 years ($M = 32.27$, $SD = 10.01$). As in Experiment 3, participants were randomly assigned to the four conditions of a Slope Difference (Low vs. High) $\times$ Embedded Context (Impoverished vs. Enriched) design.

Procedure. The procedure was the same as in Experiment 3 besides adopting the narrative of a political voting race between different parties instead of a soccer season. Respondents were told that they would watch the second part of the vote counting for an ongoing political race between parties. The second part was divided into 17 days of vote counting. After each day the votes for the parties were updated and presented to the participants. All numerical data for the vote-counting trajectories in Experiment 4 were the same as in Experiment 3. Dependent measures were again assessed on three 11-point rating scales, with ratings lower (higher) than the scale midpoint of 6 indicating superior past, present or future performance of the trailing Party Y (leading Party E). As shown in

Illustration 5 in the Appendix, the two focused political parties were either embedded in an Enriched Context, that is, the whole table of political parties or presented in an Impoverished Context without any other parties and their votes displayed.

Results and Discussion

General tendency of performance ratings. Pooling across all four conditions, ratings of past performance significantly exceeded the scale midpoint, $M_{dev} = 0.90$ ($SD = 2.44$), $W = 3785.00$, $p < .001$, $d = 0.52$, as did ratings for present performance in a direct comparison, $M_{dev} = 0.34$ ($SD = 2.32$), $W = 8531.50$, $p = .012$, $d = 0.20$, but future performance ratings showed no overall difference, $M_{dev} = 0.20$ ($SD = 2.69$), $W = 14447.00$, $p = .195$, $d = 0.09$.

Past performance ratings. To examine the impact of both independent variables, we again conducted Slope Difference $\times$ Embedded Context ANOVAs. An analysis of past-performance ratings (see Figure 4) yielded the predicted Slope Difference main effect, $F(1, 217) = 23.08$, $p < .001$, $\eta^2 = .07$, with higher ratings (i.e., indicating superiority of the leading Party E) when the performance slope diverged only weakly rather than strongly between both parties. No main effect for Embedded Context, $F(1, 157) = 0.85$, $p = .357$, $\eta^2 < .01$, and no significant interaction, $F(1, 157) = 3.33$, $p = .070$, $\eta^2 = .02$ were found. Embedding the results for the two focal political parties in the context of the entire voting table did not strengthen the dominant cue as it had in the soccer scenario of Experiment 3.

Direct comparison ratings. The ANOVA of ratings of both political parties' present performance in a direct comparison (Figure 4) again yielded a significant main effect for Slope Difference, $F(1, 317) = 40.92$, $p < .001$, $\eta^2 = .11$. The other main effect for Embedding Context was negligible, $F(1, 317) = 2.57$, $p = .110$, $\eta^2 < .01$, as well as the interaction, $F(1, 317) = .01$, $p = .940$, $\eta^2 < .01$.

Figure 4: Changes in agent evaluation as a function of Slope Difference and Embedded Context in the voting scenario

Note. Mean bipolar ratings of past, present, and future performance in Experiment 4. Negative (positive) deviations from the scale midpoint indicate higher performance of Party Y (Party E). Error bars indicate standard errors of the mean.

Future performance ratings. A very similar pattern was obtained for future-performance ratings (Figure 4). We found a very large main effect for Slope Difference, $F(1, 317) = 108.14, p < .001, \eta^2 = .25$, but only non-significant tendencies for the Embedded Context main effect, $F(1, 317) = 3.56, p = .060, \eta^2 < .01$, and for the interaction, $F(1, 317) = 2.74, p = .099, \eta^2 < .01$. The interaction tendency reflects a somewhat more accentuated Slope Difference effect for the Enriched ($M_{dev} = -1.62, SD = 2.56$, vs. $1.49, SD = 2.36$) than for the Impoverished Context ($M = -0.71, SD = 2.40$, vs. $1.55, SD = 1.91$) pointing in the direction of enhanced biases in an enriched context.

Aggregate ratings. Finally, given the internal consistency of all three ratings ($\alpha = .80$), we conducted a repeated-measures ANOVA of average ratings, aggregating across past, present and future performance. This analysis corroborated, with enhanced statistical power, the same pattern as in all three separate ANOVAs. The overall main effect for Slope Difference amounted to $F(1, 317) = 74.90, p < .001, \eta^2 = .14$. However, neither an Embedded Context main effect was obtained, $F(1, 317) = 0.09, p = .759, \eta^2 < .01$; nor an interaction, $F(1, 317) = 0.81, p = .370, \eta^2 < .01$.

In summary, Experiment 4 clearly showed that a strong (disordinal) reversal from CRB to PSB is not peculiar to soccer scenarios but extends to a political voting scenario.

Depending on the manipulation of the relative slope over time, we were able to reproduce both the CRB reported by Alves and Mata (2019) but also the PSB in another sensible task setting, namely, the temporal unfolding of vote counts after a political election. Moreover, the task setting used for Experiment 4 rules out a problem that remained unaddressed by the soccer results in Experiment 3. As participants were told that the votes for each political party had already been collected and were counted in random order, the intermediate voting results could not exert any causal effect on the subsequent performance of parties. Rather, the slope difference of parties neither reflected a temporal trend nor a causal influence on subsequent voting results and the same was true for rank frequency, highlighting the notion that the only reasonable index of party performance was the final voting result. Still, more divergent slopes fostered higher ratings of the trailing party (PSB), whereas more similar slopes led to more favorable ratings of the leading party (CBR).

It should be noted that the Slope Difference $\times$ Embedded Context interaction was clearly less pronounced than in Experiment 3; embedding the two focal parties in an enriched context (of all parties in the election) did not render the slope difference significantly more visible. While we refrain from much post-hoc speculations about the causal origin of the

diluted interaction effect, we believe it only makes the reversal more context independent. The very fact that the party scenario ruled out any causal influence of intermediate results on the party trajectories may have served to downplay the impact of comparative context embedding.

General Discussion

The reported experiments corroborate and extend recently published findings (Alves & Mata, 2019; Alves et al., accepted) that performance evaluations of competing agents are not exclusively determined by the final cumulative performance measure (i.e. the overall score), which takes all prior performance into account. Evaluations of past, present, and future performance are also sensitive to the historical trajectories of the final scores. What matters is not just the objective end result reached by a team but also the way in which the teams reached the final end state. Alves and Mata (2019) showed that participants consistently favored the frequently leading team over a trailing team even when both ended with the same score. Similarly to sportive performance, this CRB extended to the evaluation of political and financial success, student grades, and algorithms.

The dependence on the antecedent performance history implies that evaluative judgments go beyond the mere assessment of manifest performance. Judges are sensitive to distinct “theories” about the meaning of the same manifest outcomes. At first glance, the results reported by Alves and Mata (2019) and the present findings evoke “theories” that seem to be contradictory in how they determine the relative evaluation of competing teams. Whereas the earlier investigation pointed to a persistent advantage of the team that takes an early lead and is then more frequently in a better ranking position, judges in the present Experiments 1 and 2 provided more favorable ratings for the other team with the lower starting level but the steeper upward performance slope. These novel findings fit well into the broader evidence from behavioral economics for sensitivity to performance trends in general

(De Bondt, 1993) and people's eagerness to identify trends from scarce information (e.g., Hohle & Teigen, 2015, 2019).

However, closer reflection in Experiments 3 and 4 showed that Alves and Mata's (2019) and the present diametrically opposite findings are by no means contradictory. The diverging results reflect flexible cognitive processes that give different meanings to the same performance scores. As embedding of the two focal teams in the context of an entire league apparently downplayed the salience of frequent leading (relative to the focal rival but not to the entire league), the rank frequency cue was no longer sufficient to induce the CRB, even when cumulative scores rendered leading teams more salient than incremental scores. Yet, the distinct manipulation of the performance slope difference between agents was sufficient for a reversal from PSB to CRB.

Experiments 3 and 4 corroborated the intuition that two seemingly contradictory biases can peacefully coexist. To translate the PSB (performance-slope bias) obtained in Experiments 1 and 2 into the CRB (cumulative redundancy bias) obtained by Alves and Mata (2019), it was only necessary to render the performance slope difference less salient. We were thus able to induce either bias within the same experiment. Moreover, at least for the soccer results, either bias was reinforced when the focal competitors' results were embedded in the broader context of all 18 agents.

To repeat, neither bias, CRB or PSB, is more or less rational than the other one, nor is there an a-priori rationale to assume that either primacy (early leading) or recency (trend toward improvement) affords a better proxy of a team's true performance. No a-priori ground ensures that the final update of all cumulative performance provides a better prediction of future performance, or a fairer account of past performance, than either the performance slope or the number of weeks in a leading position.

The best team may be the one team that was leading most of the time, showing highest resistance and motivation against all competing teams that mobilized their highest motivation against the leading team. It is as well possible that the team with the most positive upward slope will most likely perpetuate a steep upward trend in the future season. A third reasonable theory may assume that the final standing affords the most objective and fairest evaluation, with the highest predictive validity.

Given this agnostic situation, and the lack of a single normatively optimal strategy, our findings demonstrate an adaptive flexibility of our cognitive system, which can (1) switch between different modes of encoding or (2) focus on different invariances (i.e., one team consistently being ahead of the other or the other team's steeper upward performance trend). Moreover, (3) judgments of past, present, and future performance can flexibly rely on manifest records when judging past performance, but giving more weight to their theories of trajectories when predicting future performance. Lastly, (4) the present Experiment 4 attests that the flexible cognitive system can also lead to biased judgments based on uninformative cues.

The present work raises intriguing questions for future research. For instance, it is not clear if the PSB arises from the higher salience of the performance trend cue, from merely a strong trend of the trailing agent, or from both in interaction. That is, while increased salience of the agents' trends reduces the influence of rank frequency on performance judgments, a steeper trend also emphasizes the trailing agent's growing potential. Future experimental research should disentangle this conflation to inspect how much influence comes from salience on the performance slope difference alone.

Further, the Gricean (1975) maxims of cooperative communication (see Schwarz, 1994), which imply that the stimuli presented in an experiment are never uninformative, allow participants to trust in either information, whether ranking frequency or slope difference,

depending on their communication goals. While these norms do not explain the flexible cue utilization shown in Experiments 3 and 4, they urge caution for practical implications of the biases' effects as redundancy under natural conditions might be more readily identified as such and corrected for. Lastly, it is important to consider that cue usage might, in part, also be the result of participants perceiving the experimenters as cooperative communicators. This fact makes presenting specific informative cues themselves a social signal for what type of agent ability respondents should focus on when asked about the agent's past, present, and future performance. The effect of differently salient cues might therefore be partially explained by social signaling perceived by participants rather than the cues inherently triggering a specific type of information processing. Future research should address this possibility.

While social motivation was largely excluded so far, we suspect that motivated reasoning can strategically guide people's attention to whichever cues support a more desired theory and evaluation (e.g., Braga et al., 2017). Fans of the leading team might argue for their team's ranking superiority, whereas fans of a trailing team, which is gaining terrain, might argue that their team is stronger on the basis of the observed performance slopes. Similarly, supporters of a political candidate who was a long-time leader during the vote counting process may attribute this to the *true* outcome, while supporters of the candidate who eventually took the lead may point at the steeper trend favoring their candidate, and that the candidate's win was indeed foreseeable early on. A challenging task for applied cognitive psychology is to exploit this cognitive flexibility, choosing the processing strategy that is most appropriate for the payoff structure in a given problem context.

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Competing interests

The authors declare no competing interests.

Data accessibility statement

All the stimuli, presentation materials, participant data, and analyses can be found on this paper's project page on OSF, Open Science Framework (https://osf.io/hxm37/?view_only=e828cda5951344aba9f496a68c3ba259).

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Appendix

Illustration 1: Table of standings in a football league after the simulated first half of the season.

Mannschaft N	42
Mannschaft K	36
Mannschaft F	33
Mannschaft E	31
Mannschaft A	28
Mannschaft W	27
Mannschaft Q	25
Mannschaft H	24
Mannschaft L	24
Mannschaft J	22
Mannschaft P	21
Mannschaft O	21
Mannschaft B	18
Mannschaft X	18
Mannschaft S	15
Mannschaft Y	14
Mannschaft U	11
Mannschaft T	11

Translation (German). Mannschaft N: Team N.

Illustration 2: First game day of seventeen in the animated second half of the football season with either Cumulative (left) or Successive Presentation Mode (right; Team E as exemplar) in the three presentational stages per game day: a, b and c (in descending order) in Experiment 1.

1. Spieltag der Rückrunde:

a.

1.	Mannschaft N	45
2.	Mannschaft K	39
3.	Mannschaft F	36
4.	Mannschaft E	34
5.	Mannschaft W	30
6.	Mannschaft A	28
7.	Mannschaft Q	26
8.	Mannschaft H	27
9.	Mannschaft L	24
10.	Mannschaft J	22
11.	Mannschaft P	22
12.	Mannschaft O	21
13.	Mannschaft X	21
14.	Mannschaft B	18
15.	Mannschaft Y	17
16.	Mannschaft S	15
17.	Mannschaft U	11
18.	Mannschaft T	11

1. Spieltag der Rückrunde:

1.	Mannschaft N	45
2.	Mannschaft K	39
3.	Mannschaft F	36
4.	Mannschaft E	34
5.	Mannschaft W	30
6.	Mannschaft A	28
7.	Mannschaft Q	26
8.	Mannschaft H	27
9.	Mannschaft L	24
10.	Mannschaft J	22
11.	Mannschaft P	22
12.	Mannschaft O	21
13.	Mannschaft X	21
14.	Mannschaft B	18
15.	Mannschaft Y	17
16.	Mannschaft S	15
17.	Mannschaft U	11
18.	Mannschaft T	11

b.

1.	Mannschaft N	45
2.	Mannschaft K	39
3.	Mannschaft F	36
4.	Mannschaft E	34
5.	Mannschaft W	30
6.	Mannschaft A	28
7.	Mannschaft Q	26
8.	Mannschaft H	27
9.	Mannschaft L	24
10.	Mannschaft J	22
11.	Mannschaft P	22
12.	Mannschaft O	21
13.	Mannschaft X	21
14.	Mannschaft B	18
15.	Mannschaft Y	17
16.	Mannschaft S	15
17.	Mannschaft U	11
18.	Mannschaft T	11

1.	Mannschaft N	45
2.	Mannschaft K	39
3.	Mannschaft F	36
4.	Mannschaft E	34
5.	Mannschaft W	30
6.	Mannschaft A	28
7.	Mannschaft Q	26
8.	Mannschaft H	27
9.	Mannschaft L	24
10.	Mannschaft J	22
11.	Mannschaft P	22
12.	Mannschaft O	21
13.	Mannschaft X	21
14.	Mannschaft B	18
15.	Mannschaft Y	17
16.	Mannschaft S	15
17.	Mannschaft U	11
18.	Mannschaft T	11

c.

1.	Mannschaft N	45
2.	Mannschaft K	39
3.	Mannschaft F	36
4.	Mannschaft E	34
5.	Mannschaft W	30
6.	Mannschaft A	28
7.	Mannschaft Q	26
8.	Mannschaft H	27
9.	Mannschaft L	24
10.	Mannschaft J	22
11.	Mannschaft P	22
12.	Mannschaft O	21
13.	Mannschaft X	21
14.	Mannschaft B	18
15.	Mannschaft Y	17
16.	Mannschaft S	15
17.	Mannschaft U	11
18.	Mannschaft T	11

1.	Mannschaft N	45
2.	Mannschaft K	39
3.	Mannschaft F	36
4.	Mannschaft E	34
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6.	Mannschaft A	28
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10.	Mannschaft J	22
11.	Mannschaft P	22
12.	Mannschaft O	21
13.	Mannschaft X	21
14.	Mannschaft B	18
15.	Mannschaft Y	17
16.	Mannschaft S	15
17.	Mannschaft U	11
18.	Mannschaft T	11

Translation (German). Mannschaft N: Team N; 1. Spieltag der Rückrunde: 1. game day of the second half of the season.

Illustration 3: First game day of seventeen in the animated second half of the football season either with the points gained per game day highlighted (left) or the overall score (right) in the three presentational stages per game day: a, b and c (in descending order) in Experiment 2.

a.

	Gesamtpunkte	Punkte diese Woche
1. Mannschaft N	45	+3
2. Mannschaft K	39	+3
3. Mannschaft F	36	+3
4. Mannschaft E	34	+3
5. Mannschaft W	30	+3
6. Mannschaft A	28	+0
7. Mannschaft Q	26	+1
8. Mannschaft H	27	+3
9. Mannschaft L	24	+0
10. Mannschaft J	22	+0
11. Mannschaft P	22	+1
12. Mannschaft O	21	+0
13. Mannschaft X	21	+3
14. Mannschaft B	18	+0
15. Mannschaft Y	17	+3
16. Mannschaft S	15	+0
17. Mannschaft U	11	+0
18. Mannschaft T	11	+0

b. 1. Spieltag der Rückrunde:

	Gesamtpunkte	Punkte diese Woche
1. Mannschaft N	45	+3
2. Mannschaft K	39	+3
3. Mannschaft F	36	+3
4. Mannschaft E	34	+3
5. Mannschaft W	30	+3
6. Mannschaft A	28	+0
7. Mannschaft Q	26	+1
8. Mannschaft H	27	+3
9. Mannschaft L	24	+0
10. Mannschaft J	22	+0
11. Mannschaft P	22	+1
12. Mannschaft O	21	+0
13. Mannschaft X	21	+3
14. Mannschaft B	18	+0
15. Mannschaft Y	17	+3
16. Mannschaft S	15	+0
17. Mannschaft U	11	+0
18. Mannschaft T	11	+0

c.

	Gesamtpunkte	Punkte diese Woche
1. Mannschaft N	45	+3
2. Mannschaft K	39	+3
3. Mannschaft F	36	+3
4. Mannschaft E	34	+3
5. Mannschaft W	30	+3
6. Mannschaft A	28	+0
7. Mannschaft Q	26	+1
8. Mannschaft H	27	+3
9. Mannschaft L	24	+0
10. Mannschaft J	22	+0
11. Mannschaft P	22	+1
12. Mannschaft O	21	+0
13. Mannschaft X	21	+3
14. Mannschaft B	18	+0
15. Mannschaft Y	17	+3
16. Mannschaft S	15	+0
17. Mannschaft U	11	+0
18. Mannschaft T	11	+0

1. Spieltag der Rückrunde:

	Punkte diese Woche	Gesamtpunkte
1. Mannschaft N	+3	45
2. Mannschaft K	+3	39
3. Mannschaft F	+3	36
4. Mannschaft E	+3	34
5. Mannschaft W	+3	30
6. Mannschaft A	+0	28
7. Mannschaft Q	+1	26
8. Mannschaft H	+3	27
9. Mannschaft L	+0	24
10. Mannschaft J	+0	22
11. Mannschaft P	+1	22
12. Mannschaft O	+0	21
13. Mannschaft X	+3	21
14. Mannschaft B	+0	18
15. Mannschaft Y	+3	17
16. Mannschaft S	+0	15
17. Mannschaft U	+0	11
18. Mannschaft T	+0	11

Translation (German). Mannschaft N: Team N; 1. Spieltag der Rückrunde: 1. game day of the second half of the season. Gesamtpunkte: Overall score; Punkte diese Woche: Points gained this week.

Illustration 4: Presentation of standings of Team Y and E in an Impoverished Context (a.) or an Enriched Context (b.) before the second half of the soccer season (with an implemented low trend as exemplar) in Experiment 3.

a. Tabellenstand für beide Teams nach der Hinrunde:

7.	Mannschaft E	24
8.	Mannschaft Y	24

b. Tabellenstand nach der Hinrunde:

1.	Mannschaft N	42
2.	Mannschaft K	36
3.	Mannschaft H	31
4.	Mannschaft F	30
5.	Mannschaft A	28
6.	Mannschaft W	27
7.	Mannschaft E	24
8.	Mannschaft Y	24
9.	Mannschaft Q	23
10.	Mannschaft J	22
11.	Mannschaft P	21
12.	Mannschaft O	21
13.	Mannschaft B	19
14.	Mannschaft X	18
15.	Mannschaft S	15
16.	Mannschaft L	14
17.	Mannschaft U	14
18.	Mannschaft T	11

Translation (German). Tabellenstand für beide Teams nach der Hinrunde: Standings for both teams after the first half of the season; Mannschaft E: Team E; Tabellenstand nach der Hinrunde: Standings after the first half of the season.

Illustration 5: Presentation of standings of Party Y and E in an Impoverished Context (a.) or an Enriched Context (b.) before the second half of the vote counting (with an implemented low trend as exemplar) in Experiment 4.

a. Tabellenstand für beide Parteien nach der ersten Hälfte:

7.	Partei E	24
8.	Partei Y	24

b. Tabellenstand nach der ersten Hälfte:

1.	Partei N	42
2.	Partei K	36
3.	Partei H	31
4.	Partei F	30
5.	Partei A	28
6.	Partei W	27
7.	Partei E	24
8.	Partei Y	24
9.	Partei Q	23
10.	Partei J	22
11.	Partei P	21
12.	Partei O	21
13.	Partei B	19
14.	Partei X	18
15.	Partei S	15
16.	Partei L	14
17.	Partei U	14
18.	Partei T	11

Translation (German). Tabellenstand für beide Parteien nach der ersten Hälfte: Standings for both parties after the first half; Partei E: Party E; Tabellenstand nach der ersten Hälfte: Standings after the first half.