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Player Benchmarking and Outcomes: A Behavioral Science Approach

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1. Introduction

Benchmarking is important to monitor and provide feedback to players on their performance. (i.e. are they under or overperforming). Behavioral science research, especially that grounded in social psychology, indicates that performance feedback has a strong impact on human behavior including: individual motivation (Deci, 1972; DeNisi, Randolph, & Blencoe, 1982; Pavett, 1983), risk-taking (Kacperczyk et al., 2015; Krueger Jr & Dickson, 1994; March & Shapira, 1992), and performance (Sehunk, 1984; Smither, London, & Reilly, 2005). As a result, performance feedback that is provided to players has the potential to induce changes in player performance.

For example, Hall of Famers Shaquille O'Neal and Charles Barkley recently gave voice to negative performance feedback regarding Philadelphia 76ers Center Joel Embiid by openly criticizing him on TNT's Inside the NBA. Early in the 2019 season, Joel Embiid's player efficiency rating (PER) currently ranks an impressive 11th in the league (24.73), but is under his own past performance (2018/2019 PER = 26.21)[1]. Shaq and Charles suggested that Embiid's recent relative underperformance was due to a lack of motivation and made a point of comparing Embiid to centers on other teams with higher PERs, such as Giannis Antetokounmpo and Anthony Davis. In the next game following Shaq and Charles comments (December 12, 2019 vs. the Boston Celtics) Embiid posted his best game of the season with a season high 38 points and a plus minus of +21 (in a game that the Sixers only won by 6 points). Media reports reflected the perception that Embiid's performance was induced by the negative performance feedback he received. For instance, ESPN's article was titled "76ers' Joel Embiid takes criticism to heart, dominates Celtics in win" (Bontemps, 2019) and the Athletic featured: "'I like when I get criticized': Joel Embiid responds with both aggression and poise against Celtics." (Hofman, 2019). Indeed, Embiid himself indicated that the negative feedback played a strong role in his performance when interviewed after the game (NBA on TNT, 2019).

While the recent Embiid example illustrates the potential power of performance feedback, systematic examination of the effects of performance feedback in NBA players is lacking. Moreover, the efficacy and impact of benchmarking is likely to depend on the point of comparison (i.e. referent). Referents can be the players own past performance (self), team average performance

[1] http://insider.espn.com/nba/hollinger/statistics

(other-internal), or the performance of comparable players on other teams (other-external). It is important to simultaneously consider multiple referents for several reasons.

First, the choice of referent influences whether performance is assessed as good or bad. A player may outperform their own past performance (self), while simultaneously underperforming team average performance or comparable players on other teams. Thus, performance feedback is not necessarily consistent across referent categories

Second, referents may have differential effects on players' motivation. Indeed, there is a compelling paradox in team based performance assessment: team members are both expected to work towards common goals and pitted against each other in rivalrous conditions. Hence, while comparison to other teams' players may induce healthy competition, comparison relative to teammates may accentuate rivalry and undermine team chemistry.

Third, player outcomes may vary with referent. While performance feedback may regulate player motivation, motivation can have differential impacts on outcomes. Motivation is likely to induce risk-taking, but risk-taking does not necessarily lead to higher contributions to the team and is also likely to be associated with increases in errors. Thus, it is important to examine feedback effects across a broad range of player outcomes.

We draw on a rich behavioral research tradition to infuse theoretical grounding to the strategy of NBA player benchmarking by addressing the question:

> *How does performance feedback impact player outcomes?*

2. A Behavioral Science Framework for Player Benchmarking

Behavioral science research recognizes that performance feedback is an important factor in both individual motivation (Deci, 1972; DeNisi, Randolph, & Blencoe, 1982; Pavett, 1983), risk-taking (Kacperczyk et al., 2015; Krueger Jr & Dickson, 1994; March & Shapira, 1992), and performance (Sehunk, 1983, 1984; Smither, London, & Reilly, 2005). Indeed, performance feedback is considered to be directly informative of both individual effort and ability, as well as future expectancies of goal attainment (Festinger, 1954; Heider, 1958; Weiner, 1979).

Behavioral science research focuses on the following process regarding reference points:

- *Form*: A reference point is set. Reference points consists of a performance criteria and referent (i.e. a player's last month performance)
- *Evaluate*: An actor evaluates current performance relative to reference point (i.e. whether a focal player is over or underperforming the chosen benchmark)
- *Interpret*: An actor interprets that positive or negative performance feedback (i.e. a focal player attributes underperformance to lack of effort)
- *Respond*: An actor acts based on her/his own interpretation of the performance feedback (i.e. a focal player increases effort in response to underperformance relative to the chosen benchmark)

In sum, performance feedback can motivate individuals to do better or keep doing well, or it can demotivate individuals from exerting effort. Behavioral science research investigates when these conditions occur.

2.1. Performance Feedback and Responses

When performance is below the reference point, extant theory predicts an increase in risk taking. Individuals below their aspiration level have little to lose, but much to gain and thus become highly risk taking. Moreover, the negative performance feedback triggers problem-solving in pursuit of solutions to poor performance (Cyert & March, 1963). This effect has been confirmed in individuals and organizations, including finding that actors below their reference point are more likely to make dramatic strategic changes (Greve, 2002), take greater risks (Kahneman & Tversky, 1979), and "go for it" on 4th down in the NFL (Lehman & Hahn, 2013).

In contrast, when performance is above the reference point the framing of the same strategic decision is very different. Actors in a gain position immediately value (endow) their gains and become content with this position. Further, actors are loss averse – preferring to not lose existing gains rather than further acquire equivalent gains (Tversky and Kahneman, 1991). As a result, actors avoid risk that would threaten performance losses leading to strategic conservatism (Bromiley, Miller, & Rau, 2001) and a short-term orientation focused on protecting gains (Thaler, 1980). This effect has been confirmed in individuals decreasing their motivation (Weiner, 1974; Weiner et al., 1979) when over performing their reference point.

2.2. Reference groups: Performance and Motivation

The above classic behavioral science approach suggests a fairly straightforward prediction in which negative performance feedback induces greater effort and greater risk taking, while positive performance feedback induces less effort and less risk. However, most studies are based on a single referent and fail to account for the multiplicity of referents (Kacperczyk, Beckman, & Moliterno, 2015).

Drawing on theories of referent selection, we distinguish between three referent categories: self, other-internal (i.e. team-average), and other-external (i.e. non-team peer) (Kulik & Ambrose, 1992). While self-performance is based on one's own past performance, benchmarking against others can occur vis-à-vis others either internal to one's group (i.e. one's team) or external to one's group (i.e. a rival on another team). For instance, academics benchmark tenure cases against recent promotions at their school (i.e. other-internal) and closely monitor the citations count of certain scholars at other schools (i.e. other-external). Basketball players are compared with teammates to allocate limited playing time (i.e. other-internal) and look at box scores to see what their positional rivals on other teams do (i.e. other-external) (Kilduff, Elfenbein, & Staw, 2010).

It is important to consider the choice of referent for several reasons. First, performance feedback is not necessarily consistent across referent categories: a player may outperform his own past performance and team average performance, while underperforming comparable players on other teams. Thus, how a player is performing depends on whom he is being benchmarked against. More importantly, even when performance feedback is highly correlated across reference categories, it does not imply that performance comparisons elicit similar interpretations (Greenberg, Ashton-James, & Ashkanasy, 2007). Indeed, social psychology research indicates that while self-referent performance comparisons tend to be used to assess individual effort, social comparisons are often

interpreted as indicative of individual ability (Festinger, 1985). Therefore, treating performance comparisons across heterogeneous referents as conceptually distinct is fundamental to understand behavioral responses to performance feedback. This is especially true in the NBA where information about referents is publicly available and, thus, not only is used for self-assessment, but also as a basis for social evaluations from external audiences (e.g. coaches, general managers, media, etc…).

Here we argue that different social referents have differential effects on individual motivation and thus behavioral responses to performance feedback. There is a particular paradox in using other-internal (i.e. team member) comparisons for performance feedback. While other-internal comparisons tend to be particularly relevant when individuals identify themselves as a member of a team (Festinger, 1985), they may also engender envy and competitiveness among team members, which, in turn, may undermine team chemistry, or induce free-riding behaviors. Indeed, the literature which has featured other-internal comparisons is replete with conflicting findings. For instance, Baumann et al (2018) discuss the tensions inherent in intra-organizational comparisons as colleagues simultaneously function as competitors, but find largely positive effects on organizational adaptation and performance. Further empirical work shows that competition unleashed by intra-organizational comparisons increases individual risk-taking (Kacperczyk, Beckman, & Moliterno, 2015). Micro-level research provides evidence that performance feedback based on other-internal referents can facilitate high levels of performance when task interdependence is low, but it can also produce team dysfunctional behaviors when task interdependence is high (Blanes i Vidal & Nossol, 2011; Brown et al., 1998; Kilduff et al., 2010; Stark & Hyll, 2011; Tauer & Harackiewicz, 2004),

This body of behavioral research informs our systematic examination of player benchmarking in the NBA. Further, we develop a theoretical framework (Table 1 below) to explain how and why we expect different forms of performance feedback to impact player motivation and, thus, performance outcomes. Essentially, we argue that the choice of referent impacts the interpretation of performance feedback in critical ways. Performance relative to referent thus induces different emotional reactions which effect player motivation.

Table 1. Performance Feedback, Referent Type, and Attributions

		Emotional Reactions Effects on motivation (Increase vs. Decrease)	
Referent category	**Attribution**	**Negative feedback**	**Positive feedback**
Self	Effort	Dissatisfaction Increase Motivation	Satisfaction Decrease Motivation
Other-internal (team average)	Social standing	Self-worthlessness Decrease Motivation	Self-worth Increase Motivation
Other-external (peer rivals)	Ability	Incompetence Decrease Motivation	Competence Increase Motivation

First, performance relative to one's own past performance is likely to be attributed to individual effort. Results across many studies provide evidence that performance below historical self-performance induces goal striving by making individuals feel that they are in control and that the performance target is within reach (Weiner, 1974; March & Simon, 1958). In particular, behavioral

research has provided evidence that dissatisfaction ensuing from negative performance feedback from self-comparison, stimulates motivation (DeShon et al., 2004; March & Simon, 1958). The corresponding increase in effort is likely to lead to risk-taking initiatives (Kacperczyk et al., 2015), higher number of errors, and greater individual contributions to team performance. In contrast, performance above past performance tends to demotivate individuals and lead to satisficing behavior. The general logic is the individuals are motivated by the desire to surpass their referent, but once they have, satisfaction makes them less motivated become averse to falling below this desired goal. Indeed, performance above past performance has been linked to reduced effort and risk taking (Tversky & Kahneman, 1991).

Second, we contend that players interpret other-internal performance feedback as an indication of their status and hierarchy within the team (i.e. am a I high or low status member of the team). While self-underperformance may represent an achievable opportunity to rise back to the level of one's past performance, underperformance relative to the group may be viewed as a status threat (Hoffman, Festinger, & Lawrence, 1954). More specifically, in contexts where performance of similar others affects social evaluations a focal individual's value, social comparisons have been found to cause stress, mental anguish, and self-worthlessness (Fein & Spencer, 1997; Menon, Thompson, & Choi, 2006; Salovey, 1991), thereby resulting in more controlled behavior (i.e., less errors) and risk avoidance (Salovey, 1991). Negative feedback relative to similar others has also been found to generate dysfunctional behavioral tendencies towards the team, including positional concerns (Graf et al., 2012; Solnick & Hemenway, 1998) and unwillingness to maximize joint gains in team contexts (Armstrong & Collopy, 1996), and hostile behaviors (White et al., 2006), thereby undermining one's contribution to team performance. On the other hand, performing above group average may provide positive reinforcement of status position and encourage individuals to keep up their positive performance trajectory, which is likely to manifest in higher levels of risk taking, but also higher number of errors. What is more, when self-worth is accompanied by identification with the team, it is likely to engender helping behavior towards team members (Weiner, 1979), especially when an individual perceives team dynamics and performance as instrumental to maintain individual performance (DeShon et al., 2004). This is likely to be reflected in increased contributions to team performance.

Third, we contend that players interpret other-external performance feedback as an indication of ability. Comparing one's performance to a similar other is widely recognized as a basis for assessing individual ability (Festinger, 1954; Smith & Arnkelsson, 2000; Schwartz & Smith, 1976). Negative performance feedback is thus likely to be interpreted as lack of ability. This ascription elicits feelings of incompetence and frustration (Festinger, 1954; Weiner et al., 1979). Because underperformance due to incompetence cannot be easily remedied, one's responses are perceived as not increasing the probability of goal attainment, thereby resulting in weakened motivation (Weiner, 1974). As a consequence, individuals underperforming other external comparisons will take fewer personal initiatives and risks. Yet, differently from underperformance vis-à-vis team average, negative feedback from other-external social comparison is not necessarily detrimental to team dynamics. Indeed, underperforming individuals may shift their focus from defeating their opponents to sustaining team performance as a compensatory reaction to re-establish their ability and self-esteem (DeShon et al., 2004). On the other hand, positive performance relative to other-external referent is likely to reinforce feelings of competence. Individuals high in self-confidence display greater motivation and risk taking (Bandura, 1977). At the same time, self-confidence may lead players to be less vigilant and commit more errors. Furthermore, outperforming a rival may

increase pressure to win in future competition (Kilduff, 2014), which, in turn, is likely to increase contribution to the team due to the instrumentality of team performance to individual goal achievement.

3. Methods

3.1. Data Sources

We used longitudinal data from the 1996-97 season to the 2016-17 season. Data on team performance, player performance, salaries, and demographics were obtained from diverse official sources, including the official NBA website (nba.com), Basketball Reference (https://www.basketball-reference.com/players/a/) and Patricia Bender's basketball website (https://www.eskimo.com/~pbender/) (Ertrug & Castellucci, 2013).

3.2. Independent Variables: Performance Feedback

We introduce a novel approach for player benchmarking: performance feedback is the discrepancy between a player's performance in month t-1 and a referent's performance. In line with prior research, for each feedback variable we constructed two continuous but censored variables to test for players' responses to positive and negative feedback. Performance in each month is measured by either the player efficiency rating (PER) developed by Hollinger (2005) or the number of field goals made (FGM).

Referents:
Self: players' own performance in the month t-2
Other-internal: the team average player performance in month t-1.
Other-external: performance of a comparable player on another team. Comparable players are identified using exact and nearest neighbor matching. To identify the other-external referent used by each player for social comparison we built on arguments from social psychology, that competition tends to leave a lasting psychological residue (Kilduff et al., 2010), leading other-referent selection to reflect past competitive conditions (Johnson, Hollenbeck, Humphrey, Ilgen, Jundt, & Meyer, 2006). Hence, we used exact matching based on conference and position, and nearest neighbor matching on three main performance variables: *scoring, quickness,* and *toughness* (Staw & Hoang, 1995) and *the number of games played*, selecting the player with minimum average discrepancy from the focal one across the prior season. To ensure that at least one other-referent was playing in the current season, we identified three other-referents for each focal player. Hence, if the "best" match was unavailable in the current season, we used the second match as a reference for social comparison, if both the best and the second best are unavailable in a given season, we use the third best match. Hence, *other-external performance feedback* in each month is measured by the difference in field goals made (FGM) between the focal player and the referent in month t-1, similar results are found using PER.

3.3. Dependent Variables:

Our dependent variables are salient player outcomes, including:
Contribution to the team: Plus-minus
Risk-taking: field goals attempted and 3-point field goals attempted
E*rrors*: personal fouls, field goal missed (FG misses), and 3-pointer missed (3-pt FG missed)

3.4. Control Variables

We control for player and team factors that influence player outcomes on the player and team level, including:

Player-level control variables

Minutes. We control for the minutes that a player has played in the previous month

Age.

Reputation. A dummy variable that is set equal to 1 if player's performance (PER) is above the 85th percentile of the overall performance distribution in month t-1 (Ertrug & Castellucci, 2013), and 0 otherwise.

Player salary. We used yearly salary figures in US dollars. To reduce the skewness of the distribution, we used the natural logarithm of salaries

Player position

Team-level control variables.

Playoff qualification distance. The distance in rank of the focal player's team to the position required for playoff qualification in month t-1.

Conference. An indicator variable set to 1 for teams playing in the Western conference and 0 for teams playing in the Eastern conference.

Past champion. An indicator variable that was set to 1 if the team won the championship in the previous season

Playoff season. An indicator variable equal to 1 when current month was part of the playoff season and 0 otherwise

3.5. Empirical Strategy and Model Specification

To relax the assumption of conditional independence among the responses for the same player given the covariates, we estimated a series of multilevel generalized linear mixed models (Snijders & Bosker, 1999), with time-points (year-month) nested in players (level $i^{(1)}$), nested in teams (level $j^{(2)}$) using the "xtmixed" option in Stata 15. The models included two random intercepts at the team-level (j) and player-level (i), respectively. The team-level random intercept induces dependence among players in the same team and the player-level random intercept induces additional dependence among observations on the same player. We also included team and season-month fixed effects.

We specified the linear regression model for each of the dependent variables y_{tij} as follows:

$$y_{tij} = \alpha + \beta' x_{t-1ij} + \gamma' z_{t-1ij} + \delta' z_{t-1j} + \zeta_{ij}^{(1)} + \zeta_{j}^{(2)} + \varepsilon_{tij}$$

Where x_{t-1ij} is a vector including all performance feedback variables, and the vectors z_{t-1ij} and z_{t-1j} include player-level and team-level control variables, respectively. $\zeta_{ij}^{(1)} \sim N\left(0, \psi^{(1)}\right)$ and $\zeta_{j}^{(2)} \sim N\left(0, \psi^{(2)}\right)$ are the random intercepts, and $\varepsilon_{tij} \sim N(0,1)$ is an error term. $\zeta_{ij}^{(1)}$, $\zeta_{j}^{(2)}$, and ε_{tij} are assumed to be mutually independent, and independent of explanatory variables. Our coefficients of interest are the vector β' and represent the magnitude and direction of individual behavioral responses to negative and positive performance feedback adopting diverse referents.

4. Results

Appendix 1 provides full descriptive statistics and correlations for all variable used in the analysis. Table 2 provides the results of our multilevel GLMM Analyses. They reveal significant differences in player outcomes depending on performance referent. The first six variables are the variables of primary interest.

Table 2. Effects of Performance Feedback on Risk Taking, Errors, and Contribution to the Team

	Risk-taking		**Errors**			**Contribution to Team**
Variable	FG attempted (1)	3pt FG attempted (2)	Personal fouls (3)	Field goals missed (4)	3pt field goals missed (5)	Plus-minus (6)
Self-referent performance feedback < 0	**0.440*** **	**0.047** **	**0.046*** **	**0.243*** **	**0.035*** **	**0.170*** **
	(0.060)	**(0.020)**	**(0.014)**	**(0.033)**	**(0.013)**	**(0.053)**
Self-referent performance feedback > 0	**-0.017**	**0.000**	**-0.001**	**-0.008**	**0.000**	**0.003**
	(0.018)	**(0.006)**	**(0.004)**	**(0.010)**	**(0.004)**	**(0.015)**
Other-internal-referent performance feedback < 0	**-0.556*** **	**-0.066*** **	**-0.083*** **	**-0.311*** **	**-0.050*** **	**-0.148** **
	(0.069)	**(0.023)**	**(0.016)**	**(0.038)**	**(0.015)**	**(0.061)**
Other-internal-referent performance feedback > 0	**0.562*** **	**0.105*** **	**0.024**	**0.297*** **	**0.067*** **	**0.141** **
	(0.073)	**(0.024)**	**(0.017)**	**(0.040)**	**(0.015)**	**(0.065)**
Other-external-referent performance feedback < 0	**-0.069*** **	**-0.030*** **	**-0.023*** **	**-0.042*** **	**-0.019*** **	**0.025**
	(0.021)	**(0.007)**	**(0.005)**	**(0.012)**	**(0.005)**	**(0.018)**
Other-external-referent performance feedback > 0	**0.213*** **	**-0.003**	**-0.025*** **	**0.110*** **	**-0.001**	**-0.008**
	(0.017)	**(0.006)**	**(0.004)**	**(0.010)**	**(0.004)**	**(0.015)**
Minutes	0.123***	0.022***	0.028***	0.063***	0.014***	0.009***
	(0.003)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)
Age	-2.652***	-0.192***	-0.445***	-1.332***	-0.130***	-0.446***
	(0.138)	(0.064)	(0.033)	(0.078)	(0.040)	(0.106)
Reputation	9.294***	0.682*	0.131	4.437***	0.612**	4.499***
	(1.154)	(0.383)	(0.269)	(0.637)	(0.242)	(1.022)
Log salary	15.803***	2.224***	1.655***	8.432***	1.484***	4.610***
	(0.596)	(0.244)	(0.141)	(0.336)	(0.153)	(0.474)
Power forward *vs* Center	9.994***	4.409***	-1.352***	6.624***	2.877***	1.742
	(1.478)	(0.612)	(0.351)	(0.835)	(0.384)	(1.150)
Point guard *vs* Center	23.313***	18.662***	-5.666***	17.396***	12.022***	2.267*
	(1.721)	(0.841)	(0.412)	(0.983)	(0.525)	(1.272)
Small forward *vs* Center	20.977***	14.939***	-3.945***	14.673***	9.567***	0.955
	(1.656)	(0.754)	(0.395)	(0.941)	(0.472)	(1.250)

	Risk-taking		Errors			Contribution to Team
Variable	FG attempted (1)	3pt FG attempted (2)	Personal fouls (3)	Field goals missed (4)	3pt field goals missed (5)	Plus-minus (6)
Shooting guard *vs* Center	26.983***	19.560***	-5.652***	19.459***	12.610***	1.077
	(1.660)	(0.779)	(0.397)	(0.945)	(0.487)	(1.245)
Team playoff qualification distance	0.183**	-0.014	0.097***	0.300***	0.043**	-5.499***
	(0.093)	(0.031)	(0.022)	(0.051)	(0.020)	(0.082)
Playoff season	-0.568	0.402	0.275	-0.440	0.324	8.196***
	(0.927)	(0.328)	(0.217)	(0.515)	(0.207)	(0.790)
Prior season champion	-0.309	0.895**	0.171	-0.608	0.503**	5.605***
	(0.988)	(0.348)	(0.232)	(0.549)	(0.220)	(0.841)
Western conference	-4.221	-2.614	-0.566	-2.738	-2.088	11.787**
	(7.656)	(3.396)	(1.825)	(4.347)	(2.129)	(5.809)
Constant	-113.144***	-30.474***	11.677***	-63.284***	-19.988***	-64.348***
	(8.638)	(3.691)	(2.049)	(4.873)	(2.313)	(6.834)
Team random intercept	-20.220***	-12.572	-21.589	-20.539***	-22.312***	-18.679***
	(3.757)	(134.894)	(298.512)	(4.593)	(4.378)	(3.798)
Player random intercept	3.117***	2.654***	1.708***	2.584***	2.174***	2.624***
	(0.027)	(0.017)	(0.025)	(0.025)	(0.018)	(0.030)
Error term	3.669***	2.539***	2.211***	3.072***	2.081***	3.571***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Team random intercept standard deviation	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Player random intercept standard deviation	22.572	14.213	5.520	13.247	8.793	13.793
	(0.599)	(0.247)	(0.137)	(0.326)	(0.154)	(0.418)
Error term standard deviation	39.215	12.667	9.125	21.577	8.016	35.539
	(0.226)	(0.072)	(0.052)	(0.124)	(0.045)	(0.200)
Team fixed effects	Included	Included	Included	Included	Included	Included
Month-season fixed effects	Included	Included	Included	Included	Included	Included
Observations	18,011	18,011	18,011	18,011	18,011	18,011
Number of groups	30	30	30	30	30	30
χ^2	12346	4177	9045	11541	4320	7539
Log-likelihood	-92965	-73795	-66780	-82303	-65509	-90679

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.1 Self-Referent results

We found that when underperforming a self-referent, players take greater risks in terms of field goals attempted (Model 1: $\beta = 0.440$, $p<.001$) and 3-pt field goals attempted (Model 2: $\beta = 0.407$, $p<.05$). To give a sense of the practical significance, a one standard deviation decrease in a focal player's performance below his own performance in the previous month causes a 5-unit increase in the number of field goals attempted in month t.

Performing below self-past performance also increases errors in terms of personal fouls (Model 3: $\beta = 0.046$, $p<.01$), number of field goals missed (Model 4: $\beta = 0.243$, $p<.001$), number of 3 pointers missed (Model 5: $\beta = 0.035$, $p<.01$). For example, a one-standard deviation decrease in a focal player's performance below his own performance in the previous month leads the number of field goal missed in month t to increase by approximately 3 units.

Furthermore, negative historical performance feedback significantly increases individual contribution to team performance (Model 6: $\beta = 0.170$, $p<.01$). A one standard deviation decrease in a focal player's performance below his own performance causes a 2-unit increase in the player's plus-minus score in month t.

Thus, when underperforming a self-referent, players take *greater risks* and are *more likely to make errors*. In addition, they *contribute more* to the team as indicated by +/-. However, there is no significant difference in player outcomes when outperforming their own past performance.

4.2 Team Average (other-internal) Referent results

As the coefficients for other-internal performance feedback in Models 1 and 2 indicate (Model 1: $\beta = -0.556$, $p<.001$; Model 2: $\beta = -0.066$, $p<.01$), negative performance feedback from social comparisons with team peers decreases risk taking. For example, one standard deviation increase in the absolute value of the distance between a focal player's performance and the team average performance in month t-1, leads to a decrease in the number of field goals attempted in the current month by approximately 6 units. As shown in Models 3-5, In addition to display greater risk taking, players underperforming the team average become significantly less likely to make errors. For example, a one-standard deviation increase in the distance of a focal player's performance above the team average in month t-1 results in a 3-unit increase in the number of field goals missed in month t (Model 4: $\beta = -0.311$, $p<.001$).

On the other hand, when positive, internal social performance feedback increases risk taking (Model 1: $\beta = 0.562$, $p<.001$; Model 2: $\beta = 0.105$, $p<.001$): one standard deviation increase in the distance of a focal player's performance above the team average in month t-1 results in a 3-unit increase in the number of field goal attempted in month t. It also increases errors: as shown in Model 4 ($\beta = 0.297$, $p<.001$), a one-standard deviation increase in the distance of a focal player's performance above the team average in month t-1 results in a 1.7-unit increase in the number of field goals missed in month t. Finally, as shown in Model 6, when underperforming team average, players contribute less to the team (Model 6: $\beta = -0.148$, $p<.05$), whereas their contribution increases as their performance increases above team average (Model 6: $\beta = 0.141$, $p<.05$).

Thus as a whole, when underperforming team average referent, players take *fewer risks* in terms field goals attempted and 3-pt field goals attempted and are *less prone to make errors* in terms of missed FG and 3pointers as well as fouls. In addition, they *contribute less* to the team as indicated by +/-. When outperforming team average referent, players take *greater risks* in terms field goals attempted and 3-pt field goals attempted and are *more prone to make errors* in terms of missed FG and 3pointers, but not in terms of fouls. In addition, players in this condition *contribute more* to the team as indicated by +/-.

4.3 Non-team Peer (other-external) Referent results

With a comparable external player referent, findings are more mixed. We found that when underperforming an other-external referent, players take fewer risks in terms of field goals attempted (Model 1: $\beta = -0.069$, $p<.01$) and 3-point field goals attempted (Model 2: $\beta = -0.030$, $p<.01$). Additionally, players commit fewer errors when underperforming a rival (Model 3: $\beta = -0.023$, $p<.001$; Model 4: $\beta = -0.042$, $p<.001$; Model 5: $\beta = -0.019$, $p<.001$). For instance, scoring 10 field goals more than a rival in month t-1, results in 0.42-unit decrease in the number of field goals missed in month t. However, when outperforming the referent, players take greater risks in terms field goals attempted (Model 1: $\beta = 0.213$, $p<.001$), but not in terms of 3-pt field goals attempted, and make more errors in terms of field goals missed (Model 4: $\beta = 0.110$, $p<.001$) – approximately 1 additional field goal missed for each 10 field-goal difference between a focal player and his rival, but commit less personal fouls (Model 3: $\beta = -0.025$, $p<.001$). Other-external feedback has little and statistically insignificant impact on plus-minus.

Thus as a whole, when underperforming non-team peer referent, players take *fewer risks* and are *less prone to make errors*. When outperforming non-team peer referent, players take *greater risks* in terms field goals attempted, but not in terms of 3-pt field goals attempted. In addition, they are less prone to foul, but more likely to miss attempted field goals. There is no difference in terms of % of 3pt field goals missed.

5. Conclusion

Our behavioral science approach to player benchmarking makes several contributions to the knowledge and practice of sports analytics. First, we draw on vast and well established literature in behavioral science and social psychology to infuse theoretical grounding to an important topic in sports analytics. Stronger theory not only allows for better predictions about outcomes, but also guides analysts in asking smarter questions to address through data analysis.

Second, we document how performance feedback referents impact player outcomes. We reveal that the choice of benchmark for performance is of critical importance. Different benchmarks can lead to different interpretations of whether a player is over or underperforming and this information can induce very different responses from players in terms of risk-taking, errors, and performance.

Third, we provide a framework to explain why performance referents are differentially linked to player outcomes (Table 1). We contend that differences lie in how individuals interpret feedback from the different referent sources. Specifically, we theorize that each referent is interpreted as a judgement on different behavioral antecedents. Performance relative to one's self is attributed to effort while performance relative to team average is attributed to social standing, and performance

vis-a-vis rival peers to ability. Further, these attributions are linked to distinct emotions – effort is linked to feelings of satisfaction, social standing is linked to self-worth, and ability to a sense of competency. As a result, emotional reactions to performance feedback will depend on the valence of performance feedback (i.e. positive or negative). In particular, we suggest that while performance feedback from self-referents increases motivation when negative and decreases motivation when positive, the opposite is true for performance feedback involving social comparisons – with individuals feeling demotivated when underperforming and motivated when outperforming their social referents.

Table 3. Summary of Findings / Feedback Disclosure Tool

	Referent	**Plus Minus**	**Risk taking**	**Errors**
Positive Feedback (outperforming)	Self	=	=	=
	Team Average	+	+	+
	Non-team Peer	=	mixed	mixed
Negative Feedback (underperforming)	Self	+	+	+
	Team Average	-	-	-
	Non-team Peer	=	-	-

Finally, we contribute a practical tool for a timely issue in sports analytics – when and how to share data with players. The rise of analytics in sports has often been cast as a divide between jocks and nerds. However, these divides are shrinking as front office analytics are being incorporated into coach's decision making and players are showing increasing interest in "the numbers." Our approach provides a practical framework for engaging players in analytics surrounding performance feedback. In particular, our study suggests that performance feedback should be provided selectively – depending on referent and desired performance change. Table 3 above, which summarizes our primary findings, can be used as a tool for providing feedback to players. A "+" sign indicates when feedback would increase the corresponding outcome and, "-" indicates when it decreases it. "Mixed" or "=" indicates no major or consistent effect of that feedback. For example, to maximize a player's plus minus, coaches should provide feedback when a player is underperforming their own standards or exceeding team average performance, but potentially withhold feedback when a player is underperforming their teammates.

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Appendix

Appendix 1. Summary Statistics and Correlation Matrix

	Variable	Mean	S. D.	Min	Max	1	2	3	4	5	6	7	8
1	Field goals attempted	96.76	72.25	0	483								
2	3-point field goals attempted	20.54	24.90	0	181	0.60							
3	Personal fouls	23.98	13.80	0	79	0.64	0.25						
4	Field goals missed	52.62	39.57	0	276	0.99	0.65	0.61					
5	3pt field goals missed	13.14	15.62	0	110	0.61	0.99	0.25	0.67				
6	Plus-minus	3.18	48.09	-233	250	0.14	0.13	0.07	0.10	0.11			
7	Self-referent performance feedback < 0	2.94	11.52	0	1340.93	-0.05	-0.03	-0.06	-0.05	-0.03	0.00		
8	Self-referent performance feedback > 0	3.02	18.36	0	1800.27	-0.04	-0.02	-0.03	-0.04	-0.02	-0.01	-0.04	
9	Other-internal-referent performance feedback < 0	2.20	10.25	0	1259.88	-0.15	-0.07	-0.13	-0.14	-0.07	-0.02	0.87	0.00
10	Other-internal-referent performance feedback > 0	3.39	5.72	0	250.14	0.34	0.08	0.15	0.31	0.09	0.12	-0.07	0.10
11	Other-external-referent performance feedback < 0	11.50	19.51	0	124	-0.40	-0.21	-0.32	-0.38	-0.21	-0.07	0.06	0.04
12	Other-external-referent performance feedback > 0	23.15	30.47	0	203	0.61	0.27	0.29	0.58	0.27	0.13	-0.06	-0.03
13	Minutes	314.86	169.49	0.02	736.98	0.63	0.38	0.42	0.62	0.39	0.14	-0.10	-0.07
14	Age	27.97	4.05	19	41	-0.10	0.00	-0.08	-0.09	-0.01	0.10	-0.01	-0.01
15	Reputation	0.17	0.38	0	1	0.36	0.08	0.13	0.32	0.08	0.17	-0.06	0.05
16	Log salary	15.06	0.97	9.77	17.32	0.41	0.20	0.23	0.39	0.21	0.18	-0.04	-0.05
17	Position	2.94	1.43	1	5	0.19	0.46	-0.14	0.24	0.46	0.00	0.00	0.00
18	Team playoff qualification distance	-0.30	4.26	-7	7	-0.01	-0.03	0.02	0.02	-0.02	-0.57	0.00	0.01
19	Playoff season	0.45	0.50	0	1	0.01	0.03	0.01	-0.01	0.03	0.37	-0.01	-0.01
20	Prior season champion	0.19	0.39	0	1	0.00	0.03	-0.01	-0.01	0.03	0.19	-0.01	-0.01
21	Western conference	0.49	0.50	0	1	0.01	0.01	-0.01	0.00	0.01	0.07	0.00	-0.01

	Variable	9	10	11	12	13	14	15	16	17	18	19	20
9	Other-internal-referent performance feedback < 0												
10	Other-internal-referent performance feedback > 0	-0.13											
11	Other-external-referent performance feedback < 0	0.14	-0.18										
12	Other-external-referent performance feedback > 0	-0.13	0.42	-0.45									
13	Minutes	-0.19	0.26	-0.52	0.68								
14	Age	0.03	-0.08	0.05	-0.08	-0.04							
15	Reputation	-0.10	0.61	-0.17	0.46	0.27	-0.06						
16	Log salary	-0.10	0.24	-0.26	0.40	0.44	0.33	0.27					
17	Position	0.02	-0.07	0.05	0.04	0.14	-0.02	-0.07	-0.06				
18	Team playoff qualification distance	0.00	-0.03	0.02	-0.03	-0.03	-0.15	-0.08	-0.08	0.01			
19	Playoff season	0.00	0.02	-0.02	0.04	0.03	0.14	0.07	0.05	-0.01	-0.56		
20	Prior season champion	0.00	0.03	-0.01	0.01	0.02	0.13	0.06	0.08	0.00	-0.20	0.20	
21	Western conference	0.01	0.01	-0.02	0.00	0.01	0.02	0.04	0.01	0.01	-0.01	-0.05	0.00