

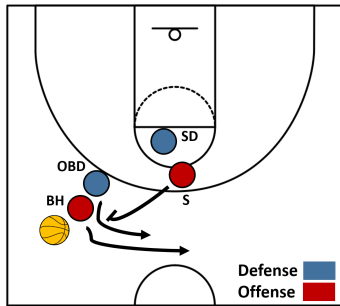
Recognizing and Analyzing Ball Screen Defense in the NBA

A. McIntyre¹, J. Brooks², J. Guttag², J. Wiens¹

¹University of Michigan, Massachusetts Institute of Technology²

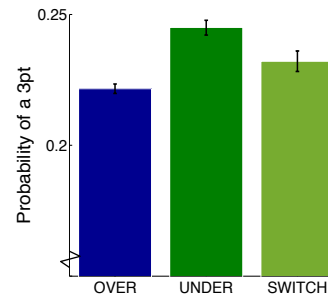
Overview of Talk

① Recognizing Ball Screen Defense

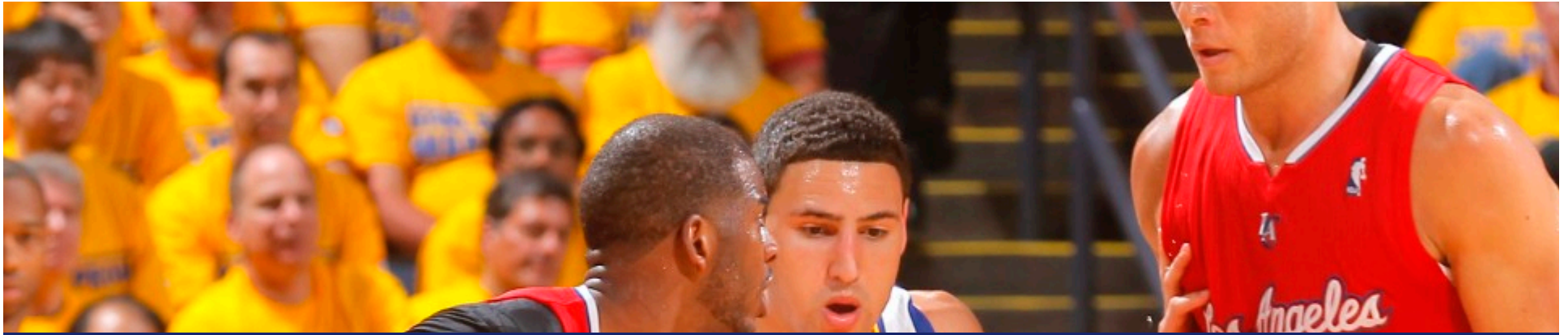


Problem Definition
Approach
Challenges
Performance

② Analyzing Ball Screen Defense



League/Season Trends
Player-level Offense
Player-level Defense
Conclusions



Are teams choosing to go over ball screens more often than in past seasons?



Traditional Methods

Using traditional film analysis...



5 Seasons

× 1230 Games per Season

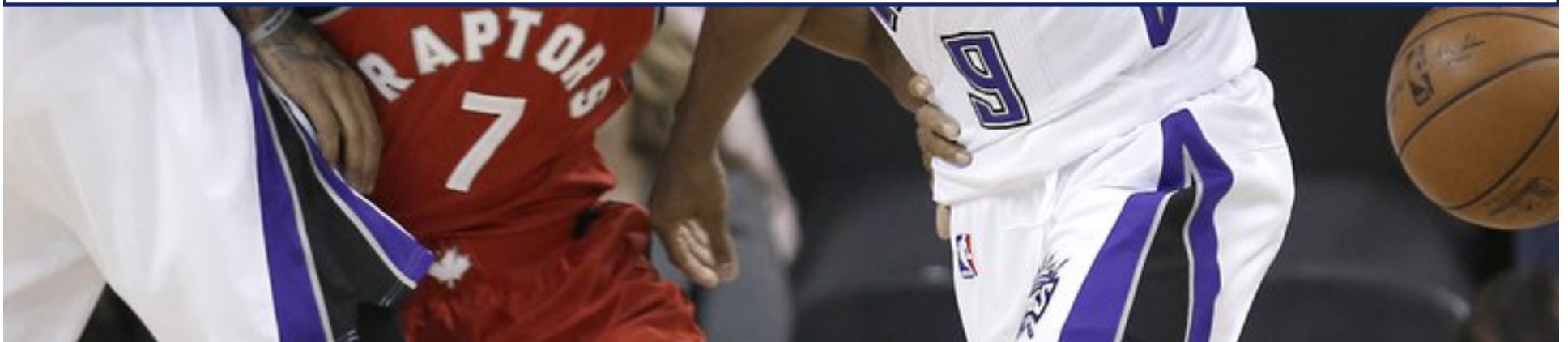
× >100 Ball Screens per Game

× 1 Minute per Ball Screen

≥ 10,250 hours

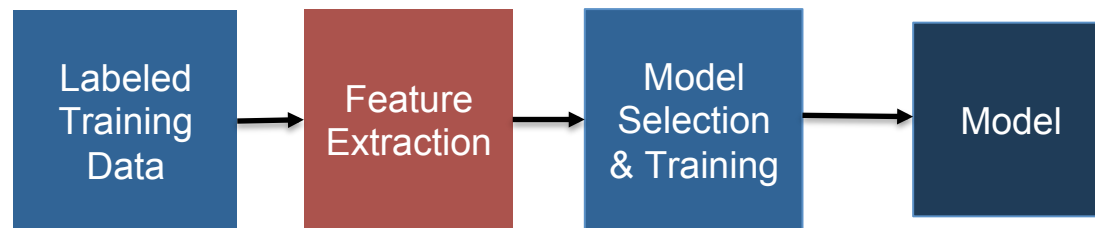


Can we build a system to automatically identify how ball screens were defended?

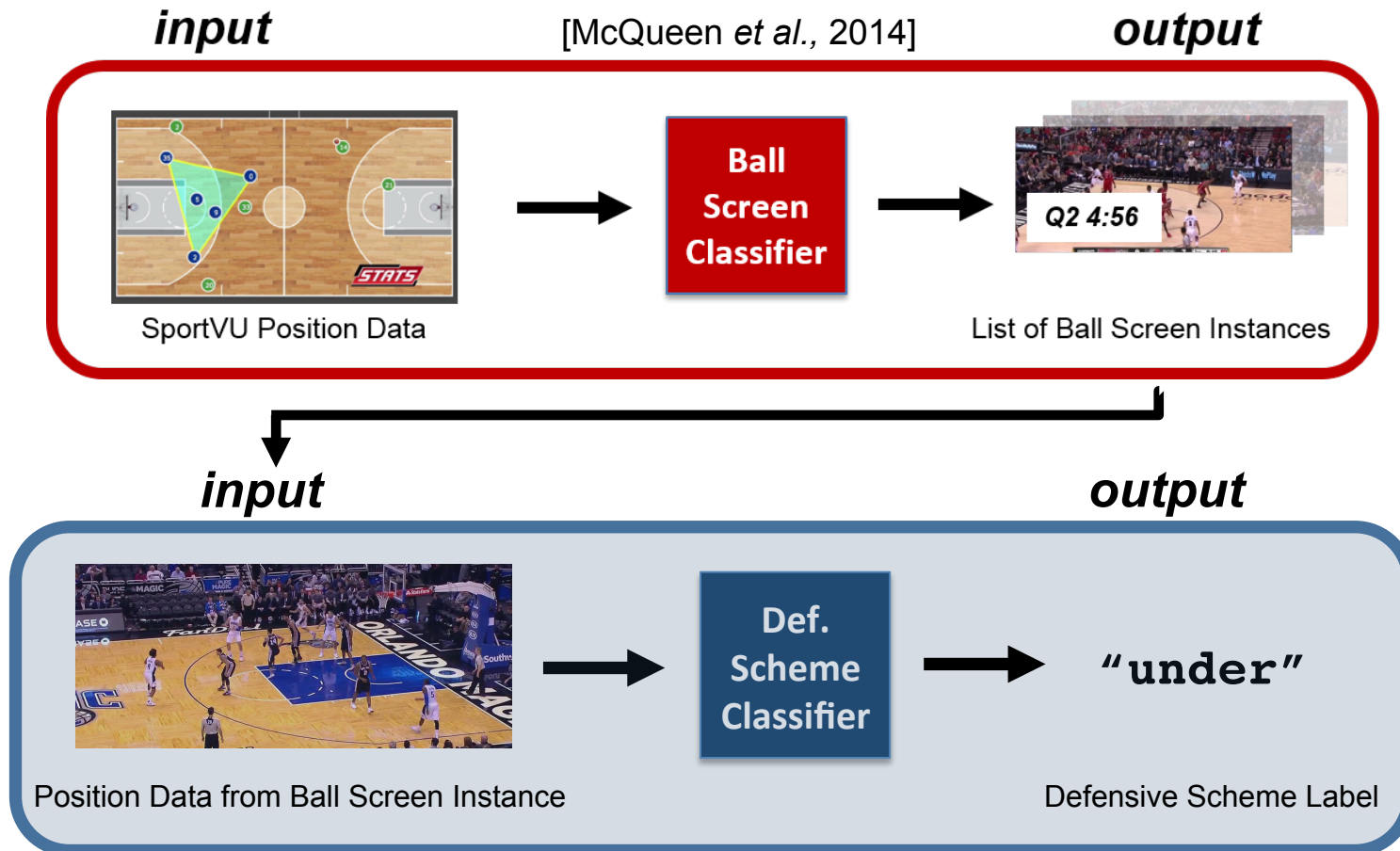


Yes, using machine learning!

Supervised Learning Framework



Overview of Classification Pipeline



Ball Handler (BH)



Ball Handler (BH)
On-ball Defender (OBD)



Ball Handler (BH)
On-ball Defender (OBD)
Screener (S)



Ball Handler (BH)
On-ball Defender (OBD)
Screener (S)
Screener Defender (SD)

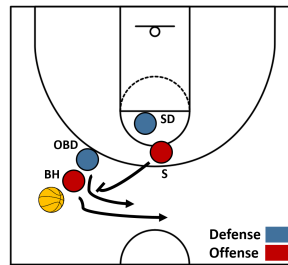


Defending the Ball Screen

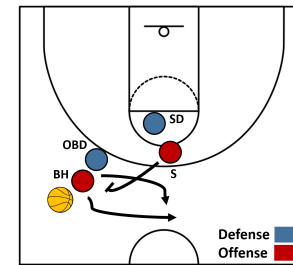
Many strategies, we consider four broad classes:

Sag,
Show & Recover,
Switch,
Hedge & Recover,
Trap/Blitz,
Drop,
Ice,
Jam & Go Under,
Soft Hedge & Through,
...

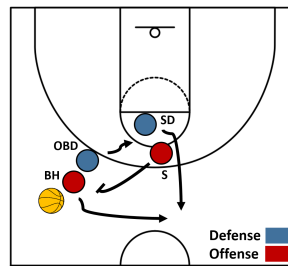
Over



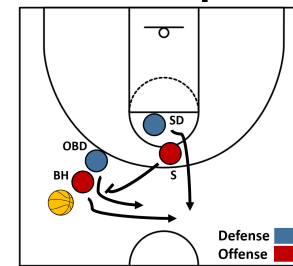
Under



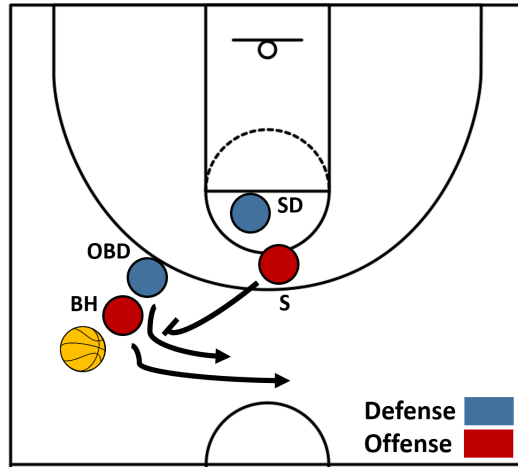
Switch



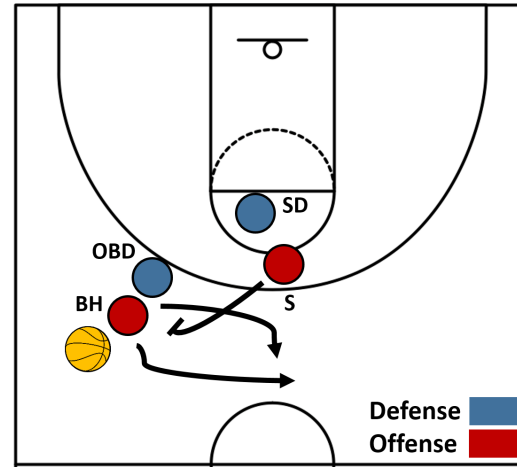
Trap



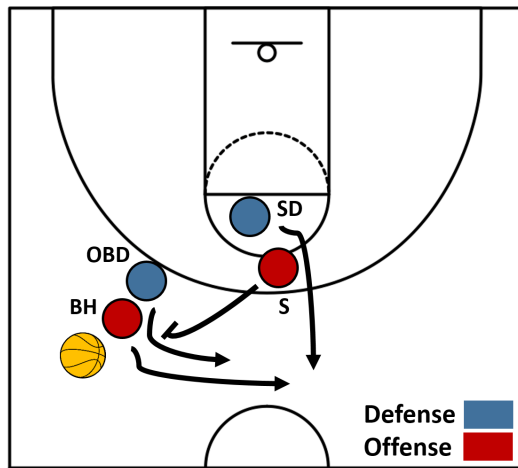
Over



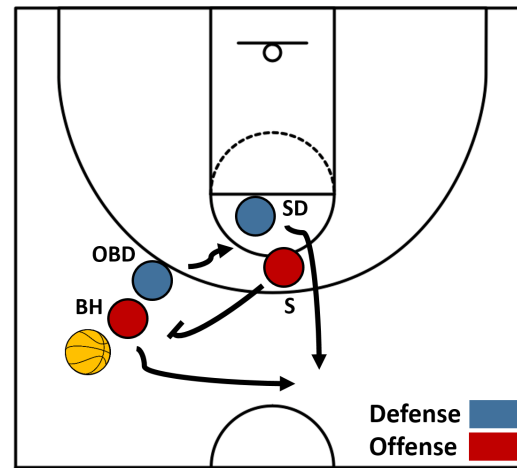
Under



Trap



Switch

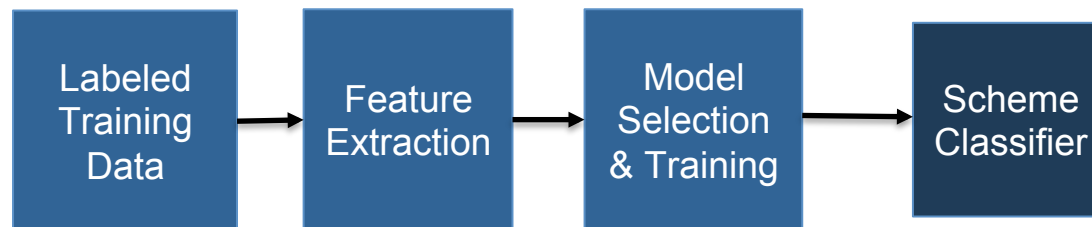
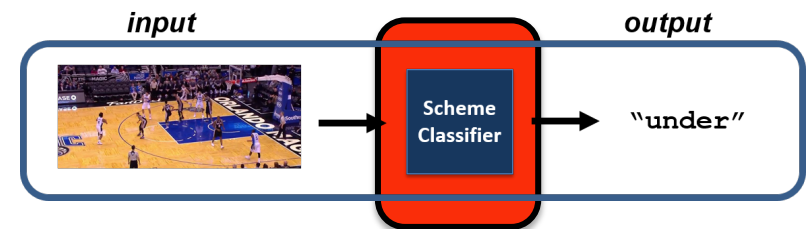


Learning to Automatically Identify Ball Screen Defense

Multiclass Classifier

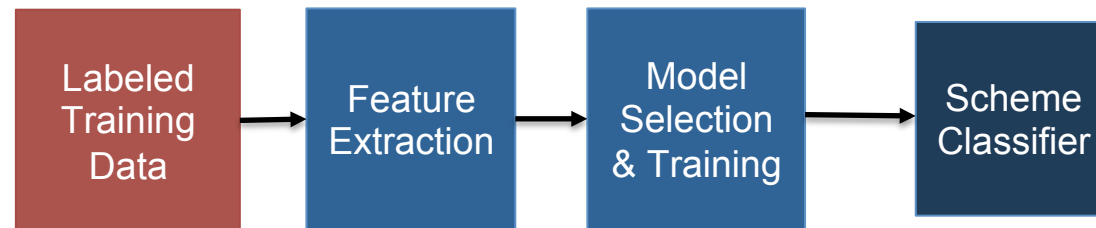
{“over”, “under”, “trap”, “switch”}

Supervised Learning Framework



Learning to Automatically Identify Ball Screen Defense

Supervised Learning Framework

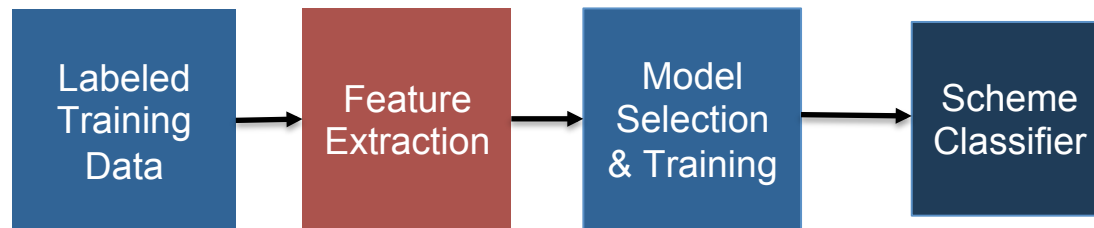


340 hand-labeled training examples

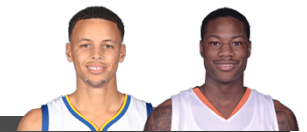
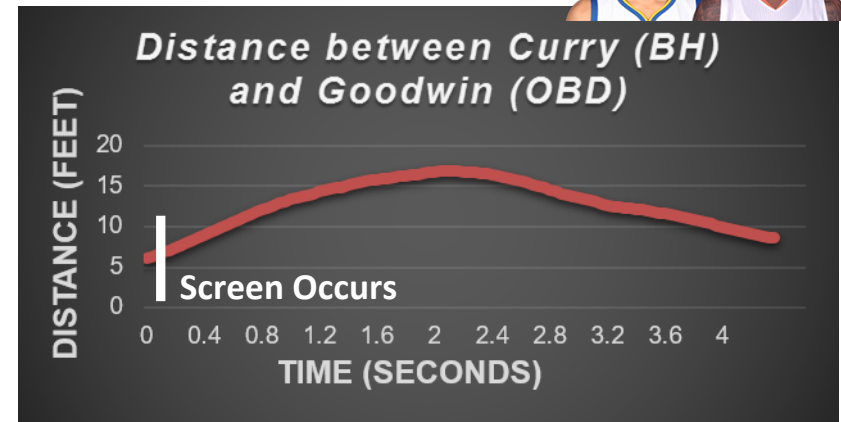
Scheme	Over	Under	Switch	Trap
Training Examples	199	56	57	28

Learning to Automatically Identify Ball Screen Defense

Supervised Learning Framework

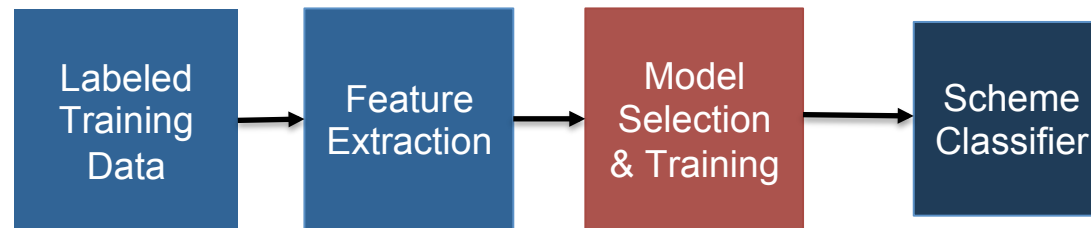


Extracted 180 features based on pairwise distances between BH, OBD, S, SD, Ball, Hoop



Learning to Automatically Identify Ball Screen Defense

Supervised Learning Framework



Easier said than done.

Multinomial logistic regression, we consider a softmax classifier:

$$P(y_k^{(i)} = 1 | \mathbf{x}^{(i)}, \Theta) = \frac{\exp(\theta^{(k)} \cdot \mathbf{x}^{(i)})}{\sum_{j=1}^4 \exp(\theta^{(j)} \cdot \mathbf{x}^{(i)})}$$

Goal \rightarrow minimize L2-regularized multinomial logistic Loss

$$\min_{\Theta} \sum_{k=1}^4 \frac{\lambda}{2} \|\theta^{(k)}\|_2^2 - \sum_{i=1}^n \sum_{k=1}^4 [[y_k^{(i)} = 1]] (\theta^{(k)} \cdot \mathbf{x}^{(i)} - \log \sum_{j=1}^4 \exp(\theta^{(j)} \cdot \mathbf{x}^{(i)}))$$

Learning to Automatically Identify Ball Screen Defense

Challenge: Temporal Variation



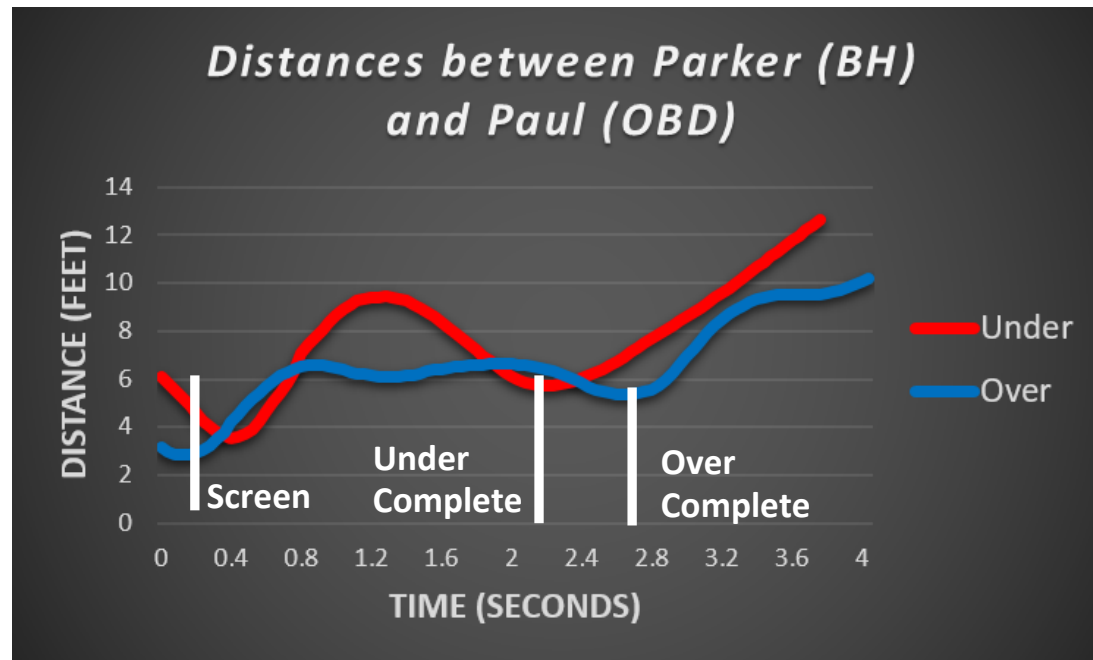
Under – Identifiable after ~1.5 seconds



Over – Identifiable after ~2.25 seconds

Learning to Automatically Identify Ball Screen Defense

Challenge: Temporal Variation



Classifier Performance

Recall: How well does our system recognize a given scheme?

Precision: How true are the assigned labels?

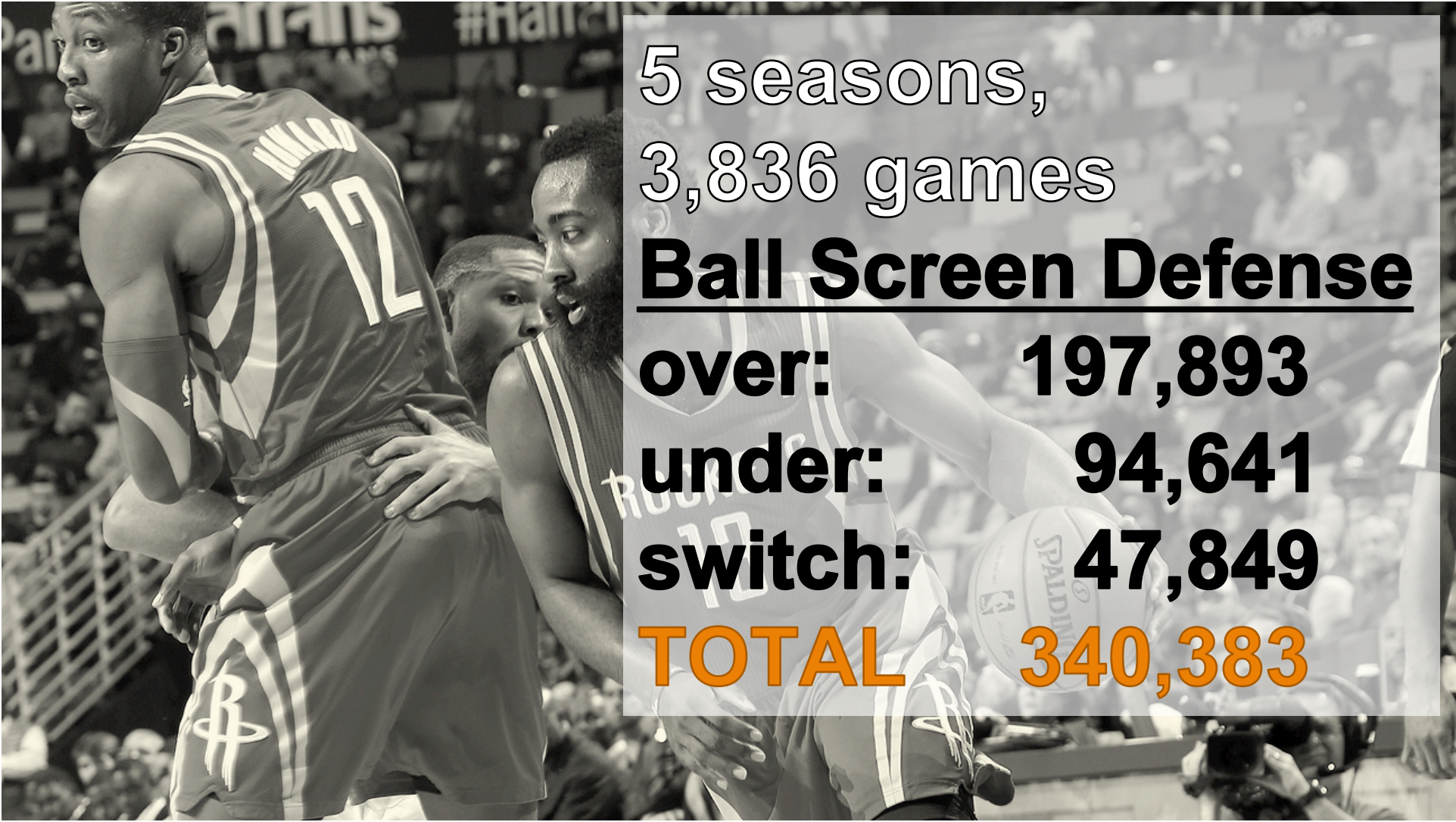
	Over	Under	Switch	Trap
Recall	0.83 (± 0.05)	0.52 (± 0.12)	0.62 (± 0.11)	0.19 (± 0.13)
Precision	0.75 (± 0.03)	0.58 (± 0.09)	0.63 (± 0.09)	0.40 (± 0.25)

Fraction of Examples	0.58	0.16	0.16	.08
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Classifier Performance

Too few examples of trap for meaningful analysis

	Over	Under	Switch	Trap
Recall	0.83 (\pm 0.05)	0.52 (\pm 0.12)	0.62 (\pm 0.11)	0.19 (\pm 0.13)
Precision	0.75 (\pm 0.03)	0.58 (\pm 0.09)	0.63 (\pm 0.09)	0.40 (\pm 0.25)



5 seasons,
3,836 games

Ball Screen Defense

over: 197,893

under: 94,641

switch: 47,849

TOTAL 340,383

Analyzing Ball Screen Defense

Three Different Perspectives



Team and League



Offensive Players



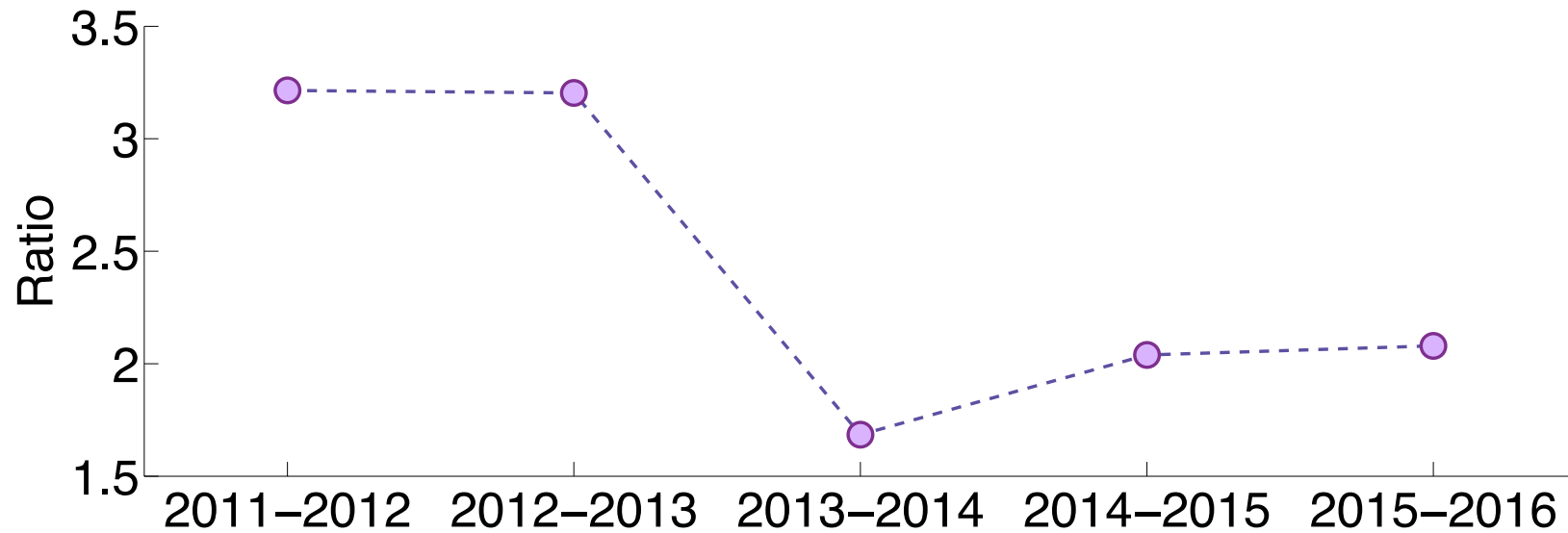
Defensive Players



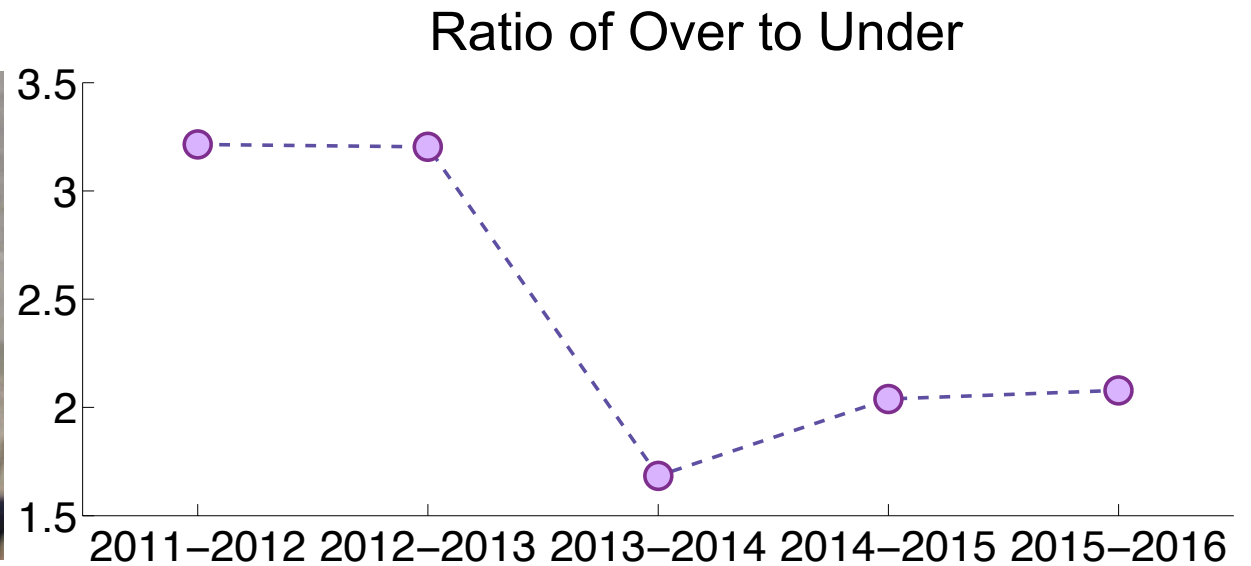
TRENDS ACROSS Seasons 2011- Present

Analysis – League Trends

Ratio of Over to Under

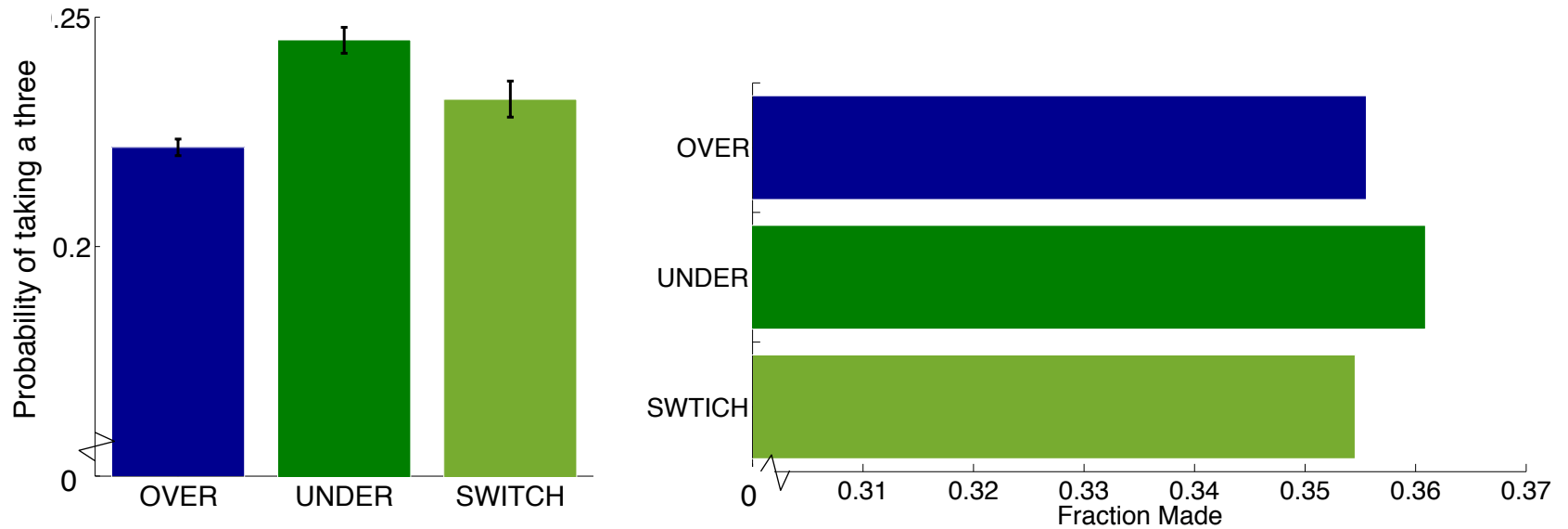


Analysis – League Trends



“I just don't think coaches today in basketball understand the game of basketball. They don't know anything about defenses. They don't know where people are going on the court. *They talk about analytical basketball and stuff like that*” – Oscar Robertson Feb 25, 2016

Analysis – League Trends



Under results in statistically significantly more 3's

Analyzing
Individuals &
Duos on
OFFENSE





NBA's best duo: Westbrook-Durant or Curry-Draymond?

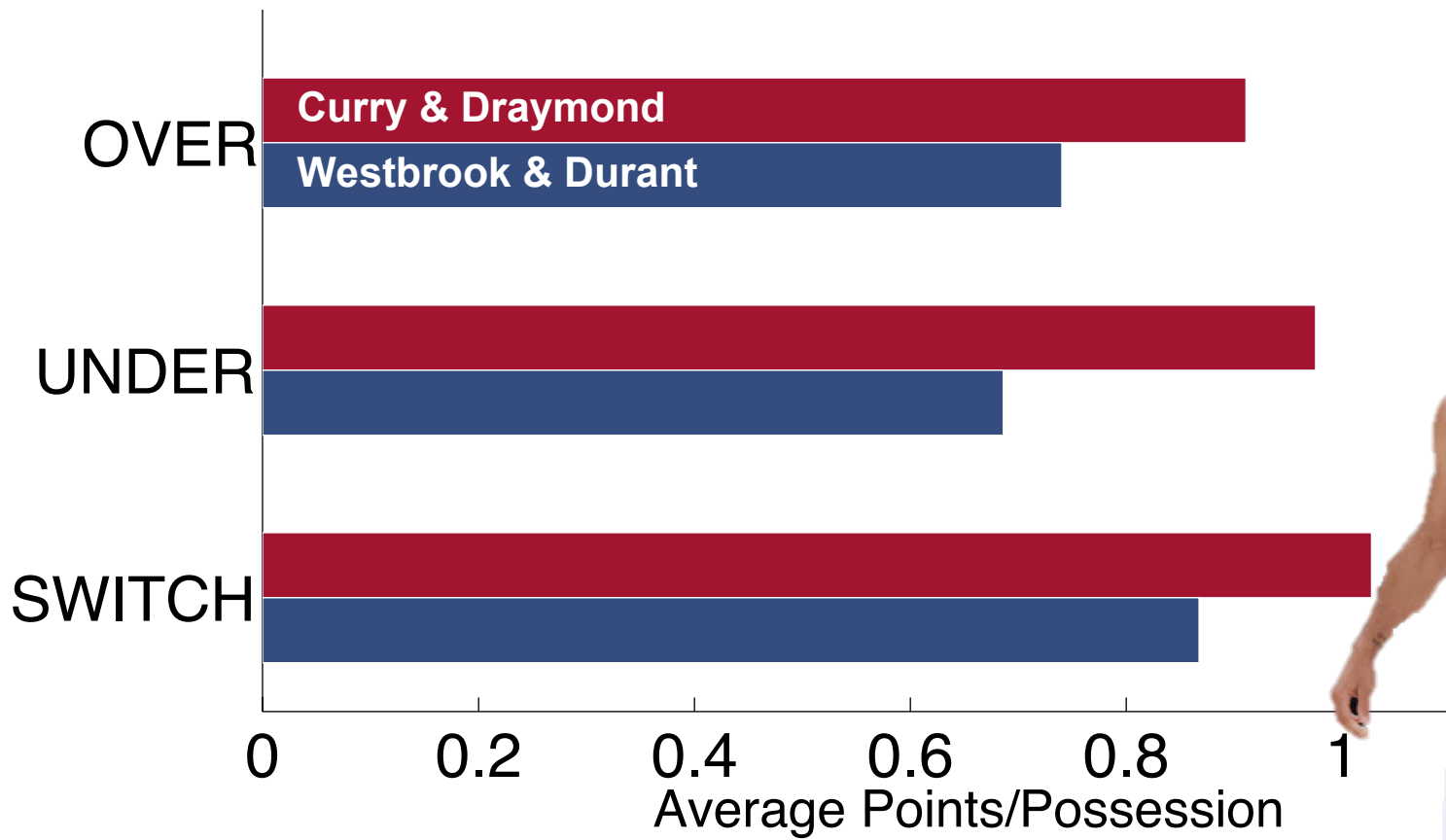


Stephen Curry
Draymond Green

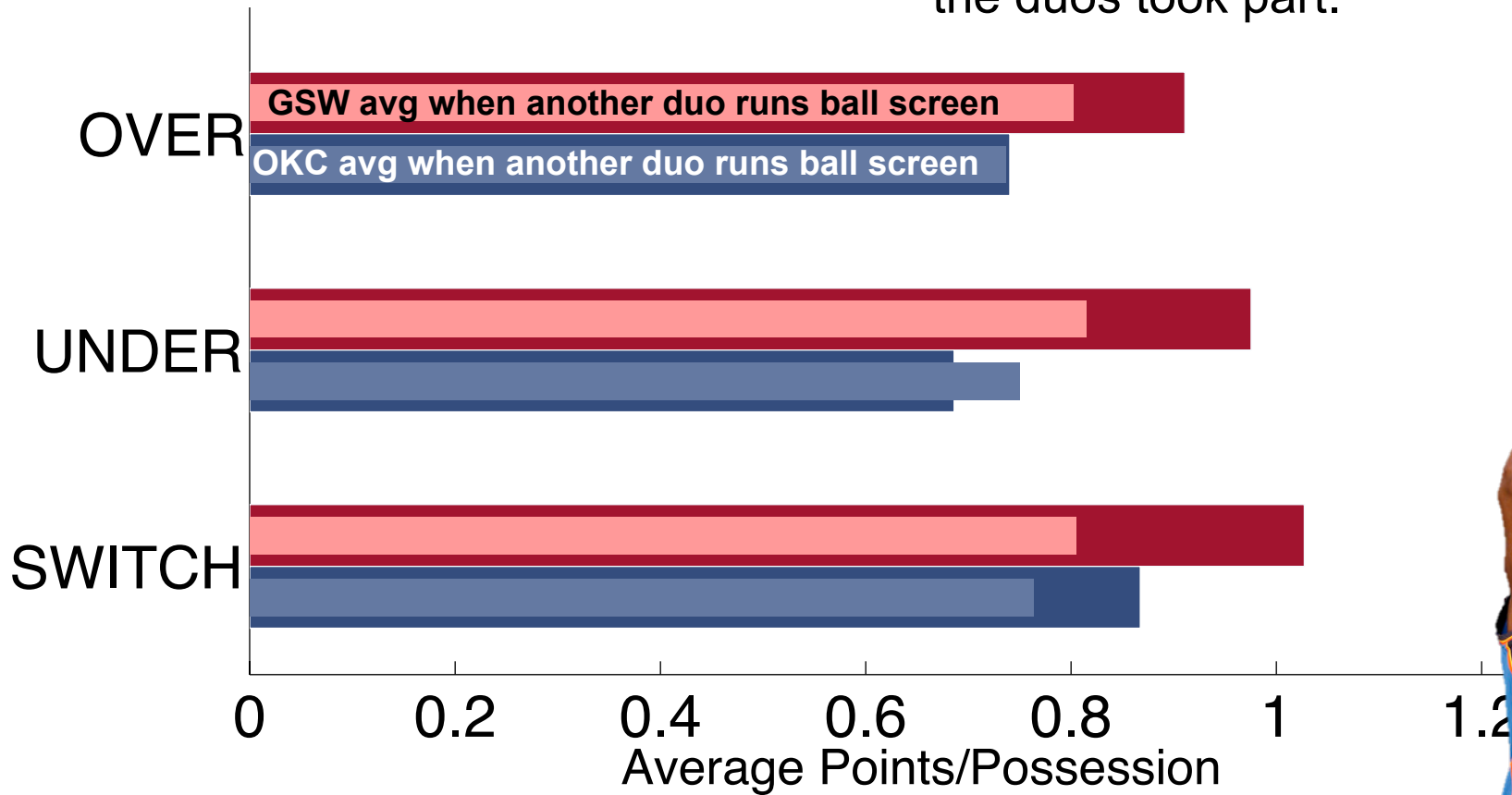


Russell Westbrook
Kevin Durant



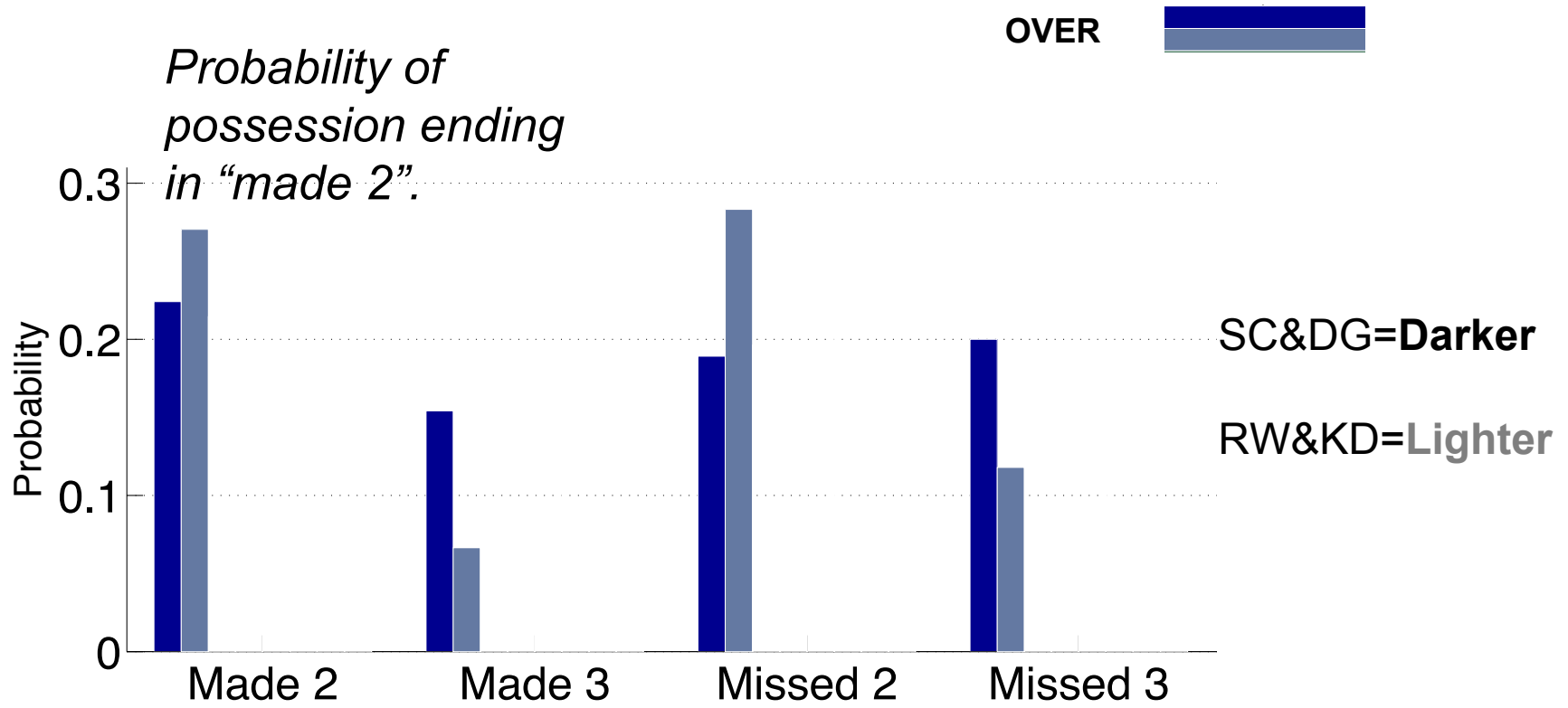


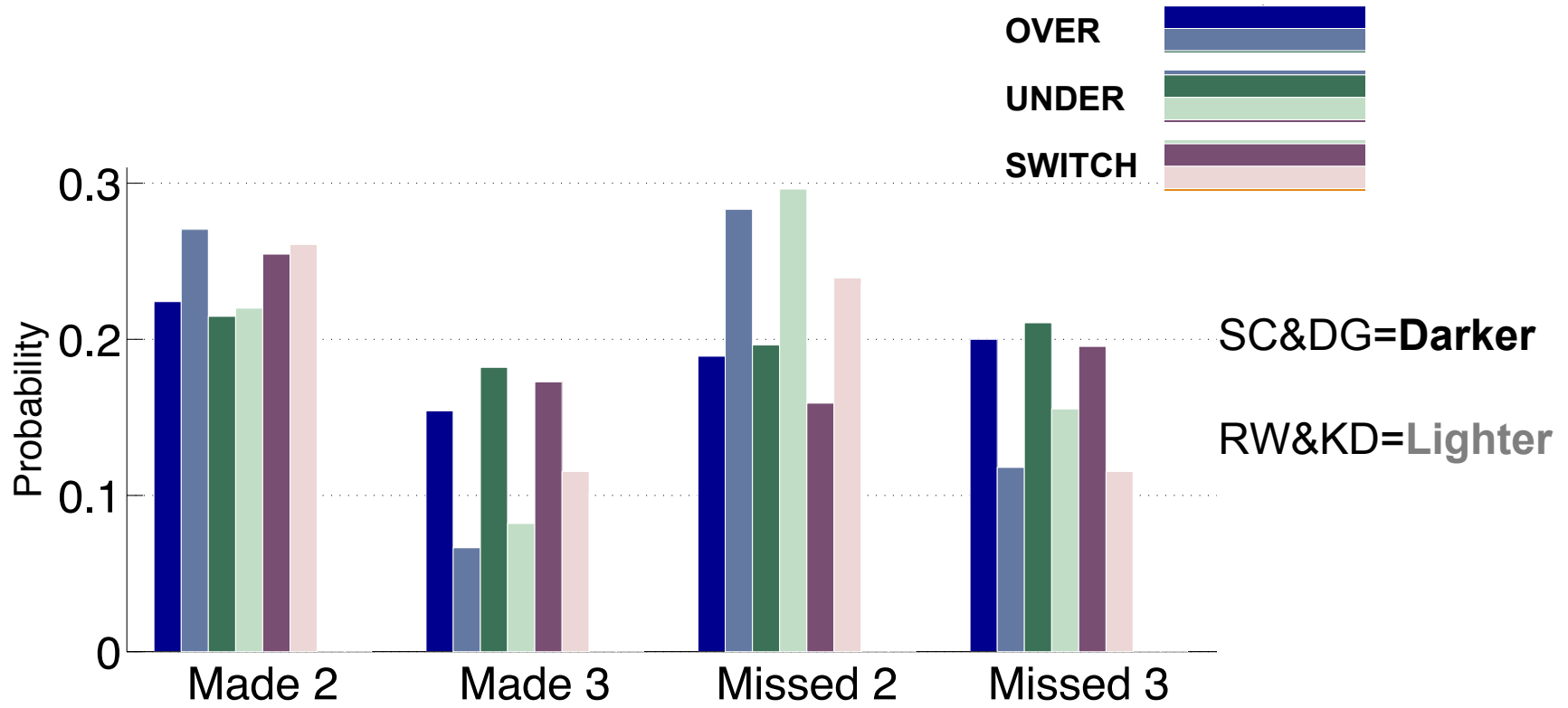
We only consider games in which the duos took part.



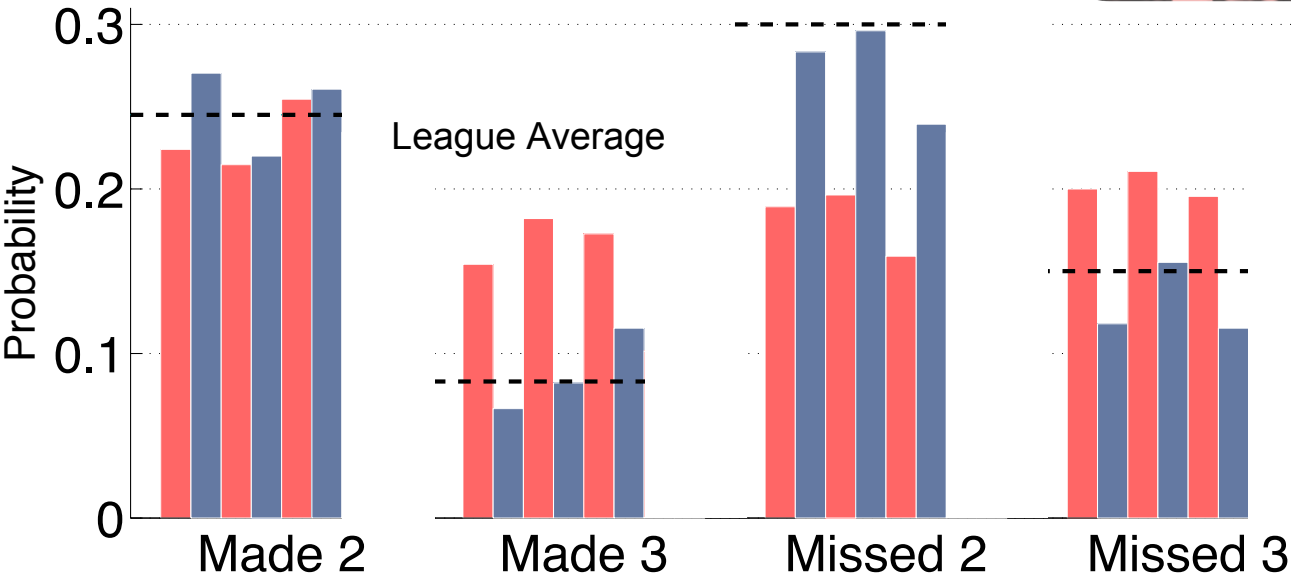
What the defense does when they see each duo

	Over	Under	Switch
Curry & Draymond	49.8%	29.3%	13.2%
Westbrook & Durant	40.5%	29.6%	20.3%





Curry and Draymond are an anomaly
Westbrook and Durant are more typical.





**Other
duos that
stand out
(across
seasons)**

Other duos that stand out (across all seasons)

Ball Handler	Screeener	Total	AvgPts: Over	AvgPts: Under
Stephen Curry	Draymond Green	1319	0.91	0.98

Other duos that stand out (across all seasons)

Ball Handler	Screeener	Total	AvgPts: Over	AvgPts: Under
Stephen Curry	Draymond Green	1319	0.91	0.98
Stephen Curry	Andrew Bogut	728	0.85	1.00

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Stephen Curry	Andrew Bogut	728	0.85	1.00
Stephen Curry	David Lee	1321	0.85	0.93

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Stephen Curry	Andrew Bogut	728	0.85	1.00
Stephen Curry	David Lee	1321	0.85	0.93
Stephen Curry	Grandma W.	?	?	?

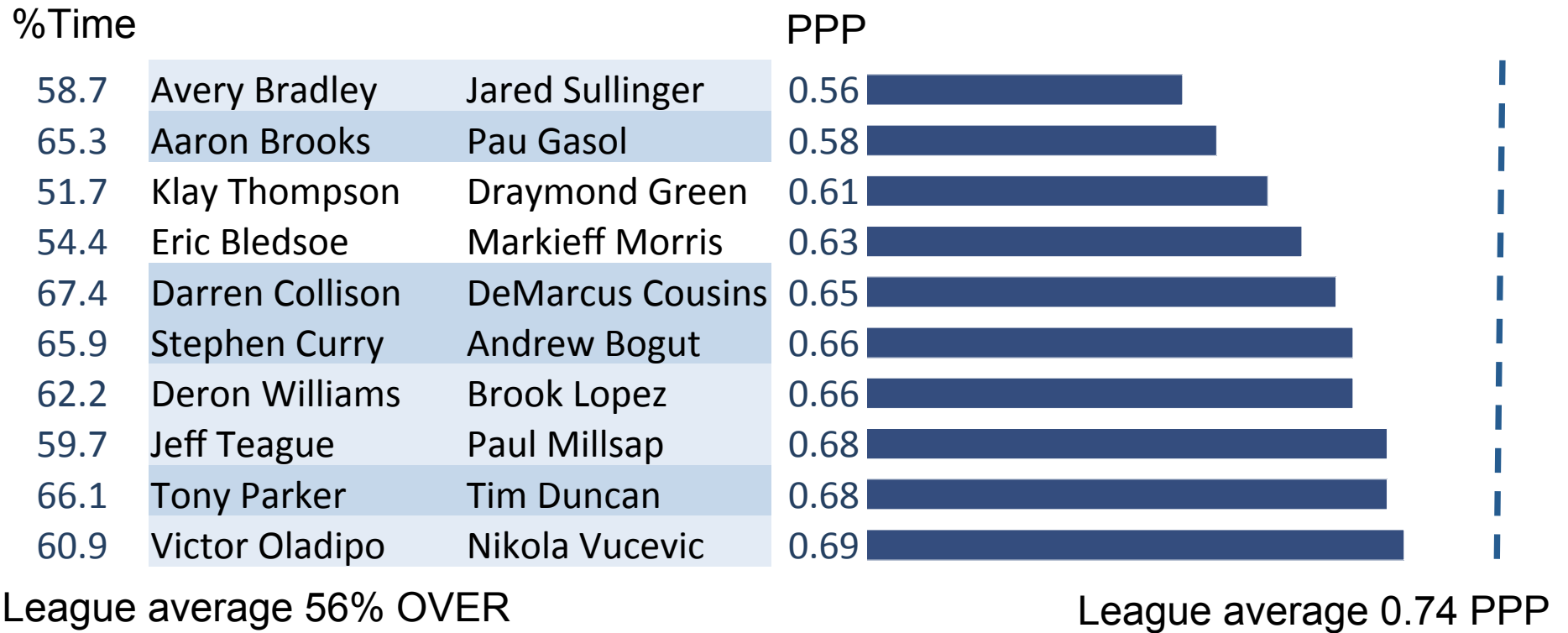
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Stephen Curry	Draymond Green	1319	0.91	0.98
Stephen Curry	Andrew Bogut	728	0.85	1.00
Stephen Curry	David Lee	1321	0.85	0.93
Tony Parker	Boris Diaw	737	0.94	0.88
Tony Parker	Tiago Splitter	1345	0.84	0.90
Chris Paul	DeAndre Jordan	2073	0.83	0.91
Chris Paul	Blake Griffin	1866	0.84	0.85
Damian Lillard	Robin Lopez	998	0.81	0.86
Jrue Holiday	Anthony Davis	741	0.92	0.72
Manu Ginobili	Tim Duncan	589	0.81	0.82

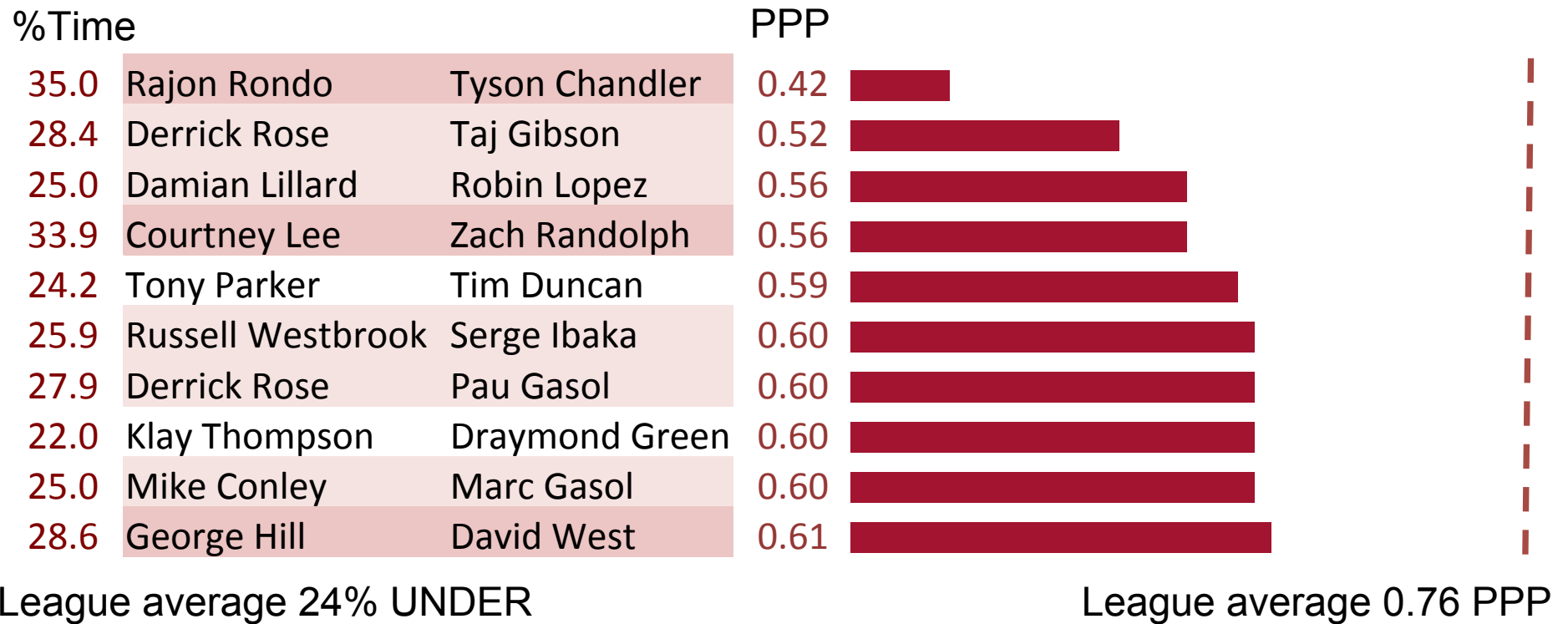
Analyzing
Individuals &
Duos on
DEFENSE



Top Duos at OVER



Top Duos at **UNDER**



Top Duos at UNDER



%Time

PPP

35.0	Rajon Rondo	Tyson Chandler	0.42	<div style="width: 10%;"></div>
28.4	Derrick Rose	Taj Gibson	0.52	<div style="width: 20%;"></div>
25.0	Damian Lillard	Robin Lopez	0.56	<div style="width: 30%;"></div>
33.9	Courtney Lee	Zach Randolph	0.56	<div style="width: 30%;"></div>
24.2	Tony Parker	Tim Duncan	0.59	<div style="width: 35%;"></div>
25.9	Russell Westbrook	Serge Ibaka	0.60	<div style="width: 35%;"></div>
27.9	Derrick Rose	Pau Gasol	0.60	<div style="width: 35%;"></div>
22.0	Klay Thompson	Draymond Green	0.60	<div style="width: 35%;"></div>
25.0	Mike Conley	Marc Gasol	0.60	<div style="width: 35%;"></div>
28.6	George Hill	David West	0.61	<div style="width: 35%;"></div>

League average 24% UNDER

League average 0.76 PPP

Player	Player	Ball Handler	Screener	Total: Over	Total: Under	Total: Switch	Total: Trap	Frac: Over	Frac: Under	Frac: Switch	Frac: Trap	AvgPts:Over	AvgPts:Under	AvgPts:Switch	AvgPts:Under	Frac: OVER	Frac: UNDER	AvgPts:Over er	Total	
Rajon Rondo'	Tyson Chandler'	Stephen Curry'	Draymond Green'	830	485	220	128	0.50	0.29	0.13	0.08	0.91	0.98	1.03						
Tai Gibson'	Derrick Rose'	Stephen Curry'	Andrew Bogut'	477	251	112	43	0.54	0.28	0.13	0.05	0.85	1.00	0.81						
Robin Lopez'	Damian Lillard'	Tony Parker'	Boris Diaw'	478	256	111	97	0.51	0.27	0.12	0.10	0.94	0.88	0.81		0.74	0.26	0.78	3094	
Courtney Lee'	Zach Randolph'	Stephen Curry'	David Lee'	928	393	156	104	0.59	0.25	0.10	0.07	0.85	0.93	0.75		0.70	0.30	0.76	2014	
Tim Duncan'	Tony Parker'	Tony Parker'	Tiago Splitter'	903	442	180	81	0.56	0.28	0.11	0.05	0.84	0.90	0.68		0.70	0.30	0.71	3044	
Russell Westbrook'	Serge Ibaka'	Chris Paul'	DeAndre Jordan'	1496	577	232	112	0.62	0.24	0.10	0.05	0.83	0.91	0.89		0.69	0.31	0.66	3439	
Pau Gasol'	Derrick Rose'	Chris Paul'	Blake Griffin'	1256	610	262	139	0.55	0.27	0.12	0.06	0.84	0.85	0.85		0.69	0.31	0.72	3430	
Klay Thompson'	Draymond Green'	Damian Lillard'	Robin Lopez'	694	304	149	49	0.58	0.25	0.12	0.04	0.81	0.86	0.91		0.66	0.34	0.72	1501	
Mike Conley'	Marc Gasol'	Iruie Holiday'	Anthony Davis'	538	203	74	76	0.60	0.23	0.08	0.05	0.92	0.72	0.82		0.67	0.33	0.77	752	
George Hill'	David West'	Manu Ginobili'	Tim Duncan'	438	151	123	62	0.57	0.20	0.16	0.08	0.81	0.82	0.64		0.62	0.38	0.66	839	
Andrew Bogut'	Stephen Curry'	Monta Ellis'	Dirk Nowitzki'	434	333	203	160	0.38	0.29	0.18	0.14	0.84	0.79	0.90		0.76	0.24	0.79	3367	
Russell Westbrook'	Steven Adams'	James Harden'	Omer Asik'	438	152	131	35	0.58	0.20	0.17	0.05	0.75	0.86	0.89		0.76	0.24	0.79	3367	
Beno Udrih'	Kosta Koufos'	John Wall'	Marcin Gortat'	1387	731	231	130	0.56	0.29	0.09	0.05	0.77	0.83	0.82		0.76	0.24	0.69	2706	
Markieff Morris'	Eric Bledsoe'			76	0.35	0.62			Darren Collison'	DeMarcus Cousins'	D.J. Augustin'	1465	471			0.76	0.24	0.71	1936	
Marcin Gortat'	John Wall'			124	0.27	0.62			Andrew Bogut'	Stephen Curry'	Cory Joseph'	1018	329			0.76	0.24	0.73	1347	
Jarrett Jack'	Brook Lopez'			209	0.25	0.64			Deron Williams'	Brook Lopez'	Patrick Mills'	1240	408			0.75	0.25	0.73	1648	
Iman Shumpert'	Tristan Thompson'			75	0.23	0.65			Paul Millsap'	Jeff Teague'	Tim Duncan'	1215	407			0.75	0.25	0.72	1622	
Paul Millsap'	Jeff Teague'			104	0.40	0.65			Brook Lopez'	Tony Parker'	Brian Roberts'	1884	633			0.75	0.25	0.67	2517	
Kyrie Irving'	Tristan Thompson'			145	0.26	0.66			Tristan Thompson'	Victor Oladipo'	Avery Bradley'	785	268			0.75	0.25	0.75	1053	
Beno Udrih'	Marc Gasol'			119	0.23	0.67			LaMarcus Aldridge'	Damian Lillard'	Randy Foye'	1613	556			0.74	0.26	0.75	2169	
Deron Williams'				76	0.40	0.68			John Wall'	Marcin Gortat'	Brandon Knight'	827	288			0.74	0.26	0.68	1115	
Stephen Curry'									Al Horford'	Jeff Teague'	O.J. Mayo'								1249	
Tyreke Evans'									Nikola Vucevic'	LaMarcus Aldridge'									1396	
Kyle Lowry'									Stephen Curry'	John Wall'									1387	
Al Jefferson'									John Wall'	Jeff Teague'									1371	
Darren Collison'									John Wall'	Jeff Teague'									12435	
J.J. Barea'	Dirk Nowitzki'			82	0.35	0.73			Chris Paul'	DeAndre Jordan'	Shane Larkin'	973	371			0.72	0.28	0.75	1344	
Chris Paul'	DeAndre Jordan'			218	0.23	0.73			Russell Westbrook'	Steven Adams'	Goran Dragic'	2326	892			0.72	0.28	0.73	3218	
Mike Conley'	Zach Randolph'			149	0.27	0.74			Tyler Zeller'	Avery Bradley'	Iruie Holiday'	1603	618			0.72	0.28	0.74	2221	
Pau Gasol'	Jimmy Butler'			92	0.26	0.74			Stephen Curry'	Draymond Green'										
Aaron Brooks'	Pau Gasol'			85	0.26	0.74			Robin Lopez'	Damian Lillard'										
Courtney Lee'	Marc Gasol'			97	0.25	0.74			Kentavious Caldwell-Pope'	Andre Drummond'										
Monta Ellis'	Tyson Chandler'			87	0.32	0.75			'Kyrie Irving'	'Kyrie Irving'										
Aaron Brooks'		599809		87	0.36	0.75			'Nikola Vucevic'	6086										
Nene Hilario'	John Wall'			161	0.31	0.75			'Jonas Valanciunas'	'Stephen Curry'	3439	69.38	30.62	0.66	0.73					
Lou Williams'	Patrick Patterson'			85	0.36	0.75			'Kyle Lowry'	'Rudy Gobert'	839	62.22	37.78	0.66	0.70					
	Channing Frye'			82	0.33	0.76			'Trey Burke'	'Tristan Thompson'	LeBron James'	839	62.22	37.78	0.66	0.70				
Kyle Lowry'	Jonas Valanciunas'			95	0.21	0.76			'Ty Lawson'	'Kenneth Faried'	Chris Paul'	3044	69.51	30.49	0.71	0.72				
Jarrett Jack'	Mason Plumlee'			100	0.28	0.76			'Russell Westbrook'	'Serge Ibaka'	Chris Paul'	3044	69.51	30.49	0.71	0.72				
Avery Bradley'	Jared Sullinger'			86	0.25	0.77			'Derrick Favors'	'Trey Burke'	Chris Paul'	3044	69.51	30.49	0.71	0.72				
Marvin Williams'	Kemba Walker'			85	0.26	0.77			'Kyrie Irving'	'Timofey Mozgov'	James Harden'	1501	65.69	34.31	0.72	0.64				
J.J. Redick'	DeAndre Jordan'			91	0.24	0.79			'Matthew Dellavedova'	'Tristan Thompson'	James Harden'	1501	65.69	34.31	0.72	0.64				
Kyrie Irving'	Timofey Mozgov'			75	0.23	0.80			'Pau Gasol'	'Derrick Rose'	Tony Parker'	3430	68.63	31.37	0.72	0.73				
Chris Paul'	Blake Griffin'			127	0.21	0.80			'Al Jefferson'	'Kemba Walker'	Tony Parker'	3430	68.63	31.37	0.72	0.73				
LaMarcus Aldridge'	Damian Lillard'			117	0.24	0.80			'Mike Conley'	'Marc Gasol'	Rajon Rondo'	2014	69.66	30.34	0.76	0.79				
Carlos Boozer'	Jeremy Lin'			85	0.24	0.81			'Mike Conley'	'Zach Randolph'	Rajon Rondo'	2014	69.66	30.34	0.76	0.79				
Nikola Vucevic'	Victor Oladipo'			76	0.20	0.82					Jamal Crawford'	752	67.42	32.58	0.77	0.64				
Omer Asik'	Tyreke Evans'			76	0.27	0.83														
Joakim Noah'	Derrick Rose'			80	0.25	0.83														
Aaron Brooks'	Tai Gibson'			75	0.25	0.83														
Ty Lawson'	Kenneth Faried'			74	0.23	0.83														
Rudy Gobert'		830636		89	0.23	0.83														
Matthew Dellavedova'	Tristan Thompson'			80	0.23	0.83														

Machine learning → automation → data → insights

On-Ball Defender	Total	Frac: OVER	Frac: UNDER	Over	Under
Stephen Curry'	3439	69.38	30.62	0.66	0.73
LeBron James'	839	62.22	37.78	0.66	0.70
Chris Paul'	3044	69.51	30.49	0.71	0.72
James Harden'	1501	65.69	34.31	0.72	0.64
Tony Parker'	3430	68.63	31.37	0.72	0.73
Rajon Rondo'	2014	69.66	30.34	0.76	0.79
Jamal Crawford'	752	67.42	32.58	0.77	0.64

Thank you to the NBA for access to the Data!