



## Characterization of Space and Time-Dependence of 3-Point Shots in Basketball



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### Players Occupation Models

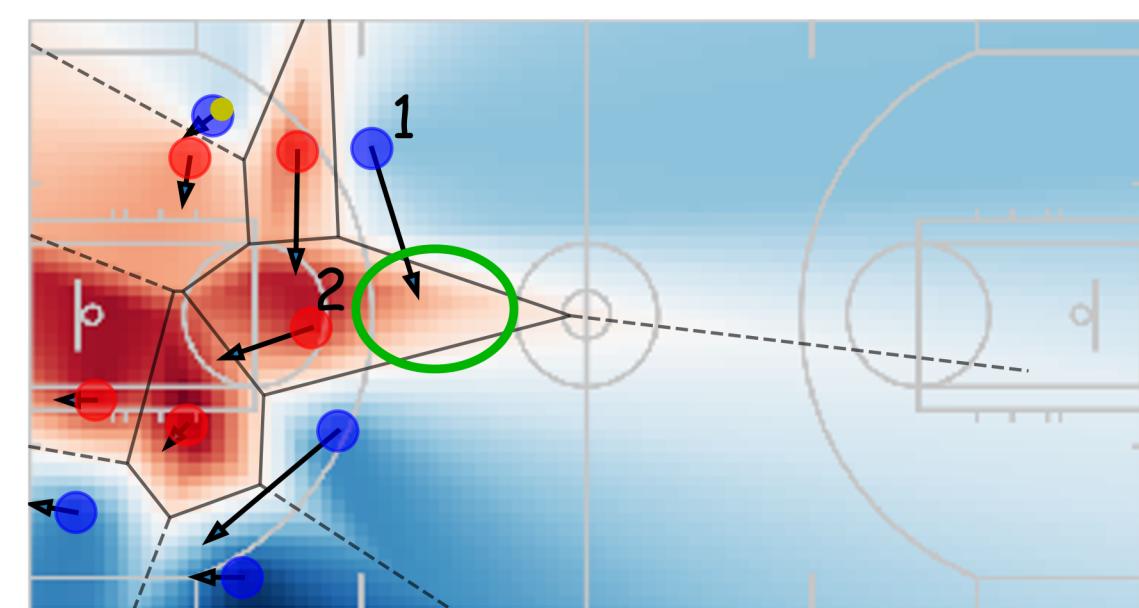
*Introducing static and dynamic metrics to determine the occupation of a point by the players allows us to draw occupation maps and to observe the influence of inertia on occupation.*

#### Static Occupation Model

To quantify space occupation, we introduce a continuous measure, by taking into account the relative distance of a point  $(x, y)$  to a player. This quantity,  $\delta_{space}(x, y)$  is calculated as the difference between the distance  $d$  from the point  $(x, y)$  to the closest player and the distance from the same point to the closest opponent,

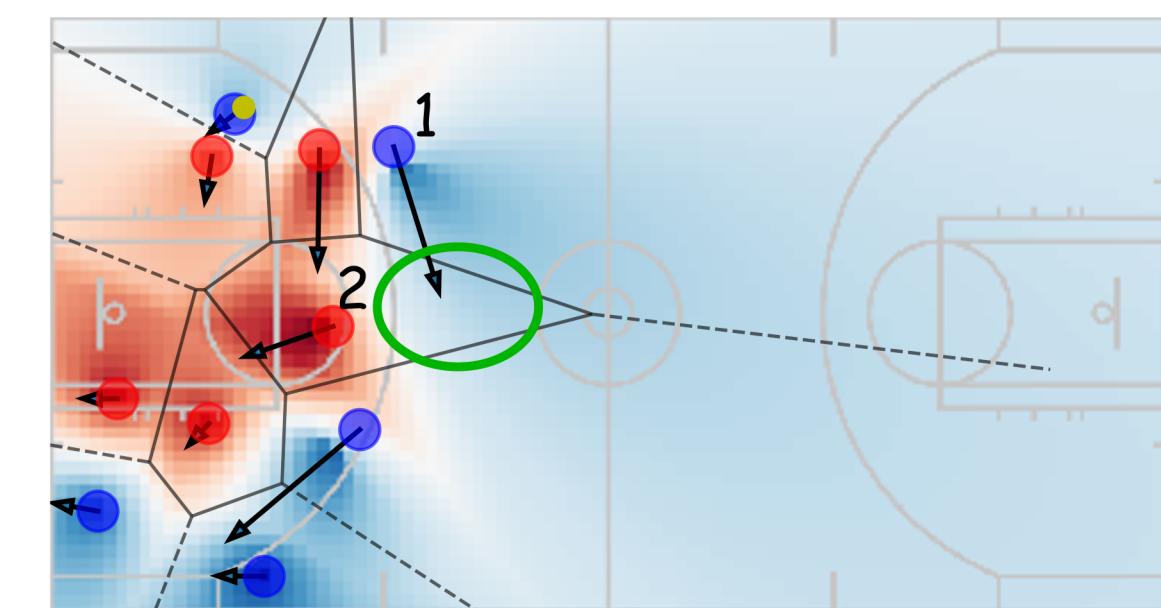
$$\delta_{space}(x, y) = d_{closest\ opponent}(x, y) - d_{closest\ player}(x, y) \quad (1)$$

This quantity does therefore not only take into account the distance to a player, but also the fact that only players of the opposite team will dispute the control of a certain area.



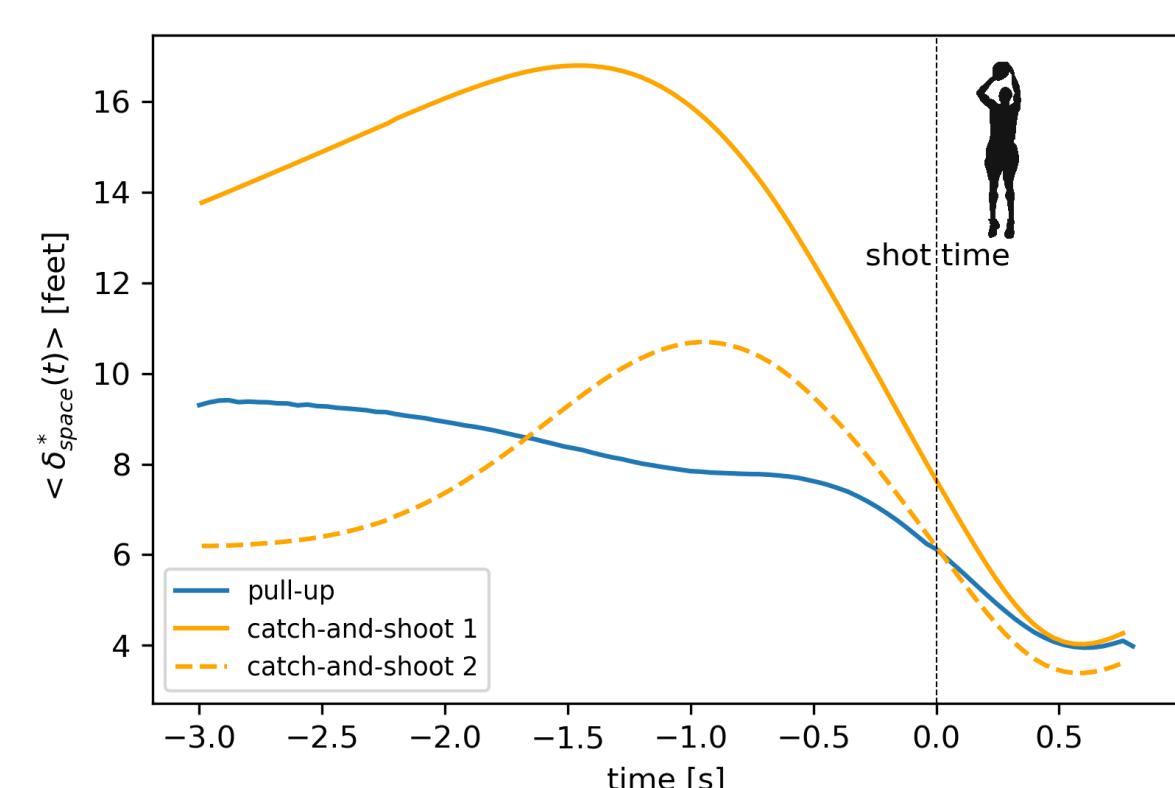
By calculating  $\delta_{space}$  (left) and  $\delta_{time}$  (right) for each point of the court we were able to determine *occupation-maps* describing the occupation of the court by the two teams. Black lines represent Voronoi diagrams. Taking into account inertia (right) best fits with the intuition that offensive player (1) will reach the area inside the green circle before the defensive player (2).

An animated version of the dynamic model is available at <https://amigocap.github.io/MecaSportStats/video.mp4>.



### Free Space Evolution Before a 3-Point Shot

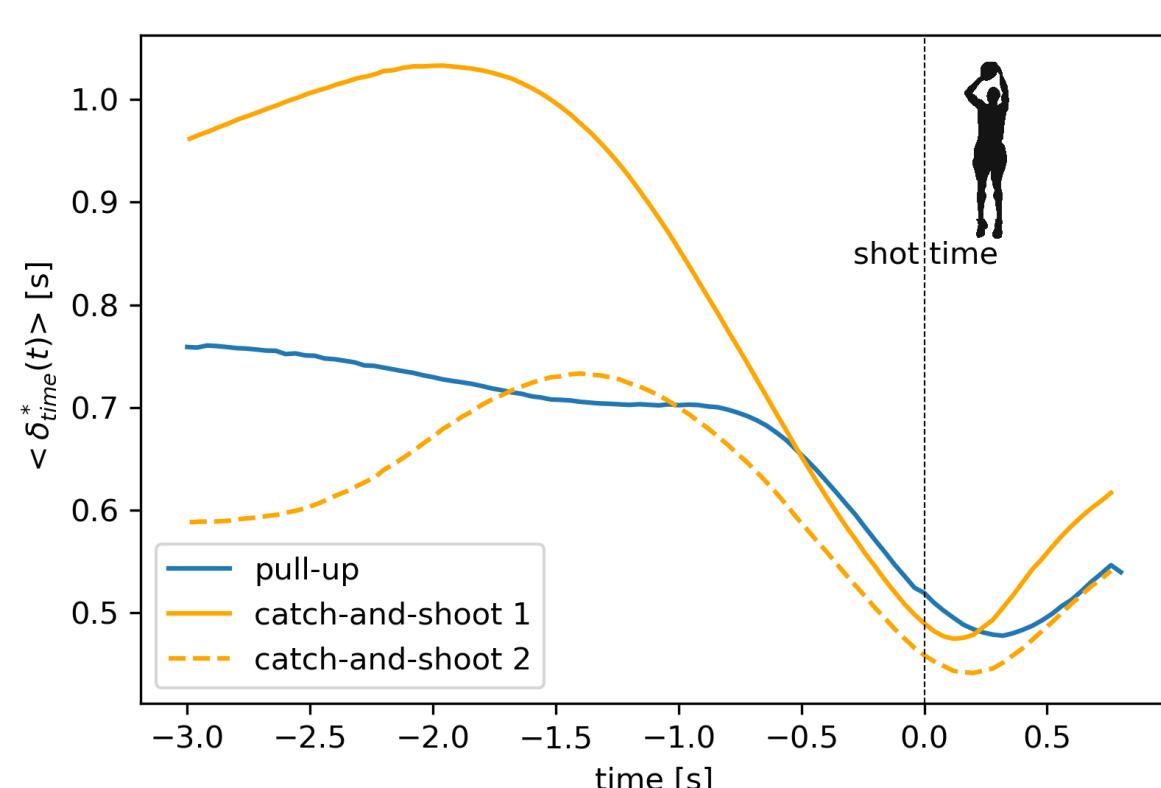
*By calculating the space occupation  $\delta_{space}$  and  $\delta_{time}$  at the 3-point shooter's position (i.e. his static and dynamic free space), we have succeeded in highlighting 3 types of behavior for 3 different types of shots.*



$$\delta_{space}^* = \delta_{space}(x_{player}, y_{player}) \text{ and } \delta_{time}^* = \delta_{time}(x_{player}, y_{player})$$

Figure on the left (respectively on the right) shows average evolution of a shooter's free-space measured by  $\delta_{space}^*$  (respectively  $\delta_{time}^*$ ) before a 3-point attempt. Shots are differentiated into three subclasses: **pull-up shots** with a global decrease as the shooter dribbles over time, **catch-and-shoot shots where the shooter has free space (1)** for a long time and **catch-and-shoot shots where the shooter has to free himself from opponents (2)** to have time to receive the ball.

Both figures reveal the same behaviors, however a clear trend is that free space  $\delta_{time}^*$  lags free space  $\delta_{space}^*$ . This difference clearly shows how inertia introduces a delay in defensive play. The precise value of the delay is 0.3s.



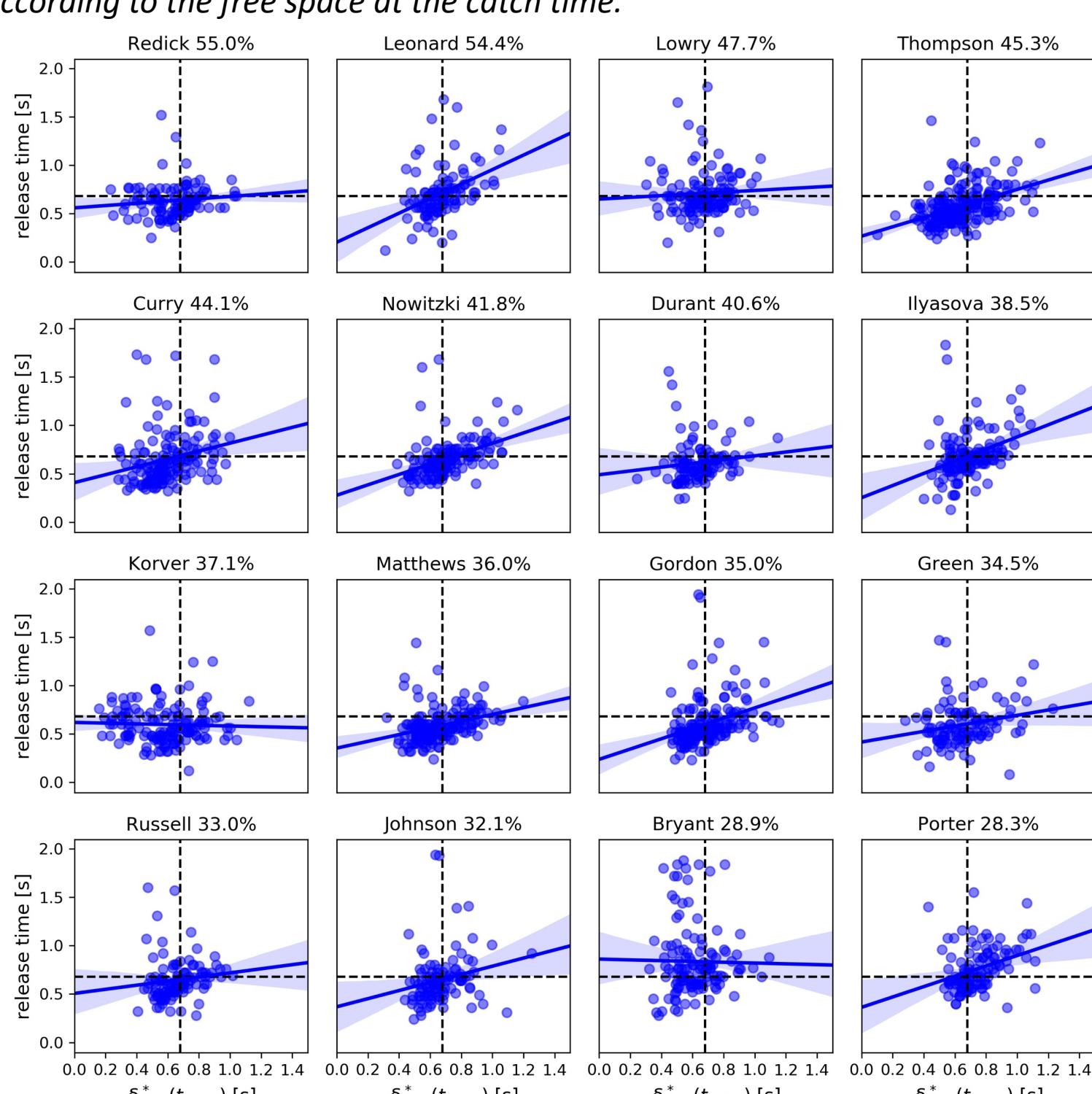
### Comparing Catch-and-shoot Shooters

*How does available time to shoot (value of  $\delta_{time}^*$  at the time the player catches the ball  $t_{catch}$ ) influences the player's release time (delay between  $t_{catch}$  and  $t_{shot}$ )? The answer is that it depends on the shooter.*

Dashed lines show median release time and median  $\delta_{time}^*$ . The regression lines show how players adjust their release time according to the free space at the catch time.

Korver does not seem to adapt his release time to the free space he has at catch time, while Matthews, Nowitzki or Thompson clearly take more time if they are more free when they catch the ball.

Players like Porter or Russell only shoot if  $\delta_{time}^*(t_{catch})$  is superior to 0.5s while Curry or Korver take shots even if they are closely guarded.



#### Open or Closed C&S shots ? Short or long release time ?

Vertical dashed line shows median release time while horizontal dashed lines delimit degrees of a shot opening which is determined by the value of  $\delta_{space}^*$  at  $t_{shot}$ : very tight, tight, open and wide open above the thickest dashed line. Hits and miss are respectively associated with blue and red dots.

