



Rogers Hornsby Chapter  
2013 Winter Meeting

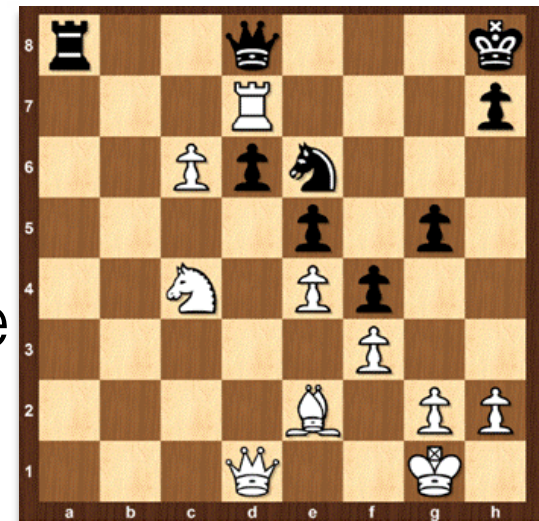


# MLB Umpire Ball/Strike Judgment and Decision Making Expertise

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January 12, 2013

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- Chess experiments
- Expert/novice differences
- Shown game board arrangement
- Task:
  - 5 seconds to look
  - Describe available moves
  - Describe most strategic move
  - Predict action





- No real difference in visual skills
- Experts consistently demonstrate:
  - Selective attention
    - Complex organization of knowledge
  - Advance cues
    - Identify/recognize patterns in environment
    - Predict/anticipate action
  - Situational probabilities
    - Ability to prepare for many potential outcomes

## Measuring Umpire Expertise



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- Strike zone
- 275 – 300+ pitches per game
  - 2012 leader: Joe West (295 pitches p/g)
  - 10,914 during season
- 100 – 125 decisions per game
- How can we analyze those decisions?





- K-Zone and Sportvision technology
- MLB Gameday Directory
  - <http://gd2.mlb.com/components/game/mlb/>

```
<!--
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        <pitch des="Ball" id="9" type="B" tfs="141858" tfs_zulu="2011-07-10T18:18:58Z" x="149.36" y="145.06" on_lb="217100" sv_id="110710_131858" start_speed="89.8" end_speed="83.3" sz_top="3.08" sz_bot="1.44" pfx_x="2.09" pfx_z="6.71" px="-1.421" pz="2.467" x0="-0.138" y0="50.0" z0="6.12" vx0="-4.047" vy0="-131.577" vz0="-5.617" ax="3.685" ay="26.487" az="-20.27" break_y="23.8" break_angle="-7.8" break_length="5.0" pitch_type="FF" type_confidence=".891" zone="11" nasty="39" spin_dir="162.801" spin_rate="1373.998" cc="" mt=""/>
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  </bottom>
</game>
```



- Variables:

[1]	"X"	"X.1"	"date"	"game"	"umpire"
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[11]	"p_dob"	"p_thorws"	"p_tm"	"b_id"	"b_lname"
[16]	"b_fname"	"b_dob"	"b_height"	"b_hand"	"b_tm"
[21]	"inn"	"ab_id"	"ab_count"	"ab_total"	"time"
[26]	"pitch_type"	"pitch_con"	"type"	"pdes"	"b"
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[36]	"millis"	"R1"	"R2"	"R3"	"x"
[41]	"y"	"start_speed"	"end_speed"	"sz_top"	"sz_bot"
[46]	"pfx_x"	"pfx_z"	"px"	"pz"	"x0"
[51]	"y0"	"z0"	"vx0"	"vy0"	"vz0"
[56]	"ax"	"ay"	"az"	"break_y"	"break_angle"
[61]	"break_length"	"zone"	"nasty"	"spin_dir"	"spin_rate"
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[71]	"rb_upper"	"b_name"	"b_sz_top_mn"		



```
> Y2011<-read.csv("/Users/AB/Documents/ABSync/Research Projects/Strike Zone Research/MLB PITCHfx Data/Revised Years/2011_Pfx.csv", header=T, stringsAsFactors=FALSE)
> sz.test <- tail(Y2011, 225)
> attach(sz.test)
> head(sz.test)
  X      X.1      date      game      umpire away_team home_team  p_id p_lname p_fname      p_dob p_thorws p_tm  b_id  b_lname b_fname      b_dob b_height b_hand
707977 707977 707977 September 28, 2011 2011/09/28/wasmlb-flomlb-1 Mike Everitt was flo 458690 Volstad Chris 09/23/1986 R flo 435622 Desmond Ian 09/20/1985 74 R
707978 707978 707978 September 28, 2011 2011/09/28/wasmlb-flomlb-1 Mike Everitt was flo 458690 Volstad Chris 09/23/1986 R flo 435622 Desmond Ian 09/20/1985 74 R
707979 707979 707979 September 28, 2011 2011/09/28/wasmlb-flomlb-1 Mike Everitt was flo 458690 Volstad Chris 09/23/1986 R flo 465668 Bernadina Roger 06/12/1984 74 L
707980 707980 707980 September 28, 2011 2011/09/28/wasmlb-flomlb-1 Mike Everitt was flo 458690 Volstad Chris 09/23/1986 R flo 465668 Bernadina Roger 06/12/1984 74 L
707981 707981 707981 September 28, 2011 2011/09/28/wasmlb-flomlb-1 Mike Everitt was flo 458690 Volstad Chris 09/23/1986 R flo 150029 Werth Jayson 05/20/1979 77 R
707982 707982 707982 September 28, 2011 2011/09/28/wasmlb-flomlb-1 Mike Everitt was flo 458690 Volstad Chris 09/23/1986 R flo 150029 Werth Jayson 05/20/1979 77 R
  b_tm inn ab_id ab_count ab_total      time pitch_type pitch_con type      pdes b s o id
707977 was 1 1 NA NA 15:11:49 FF 0.896 S Called Strike 3 1 0 7
707978 was 1 1 NA NA 15:12:04 SI 0.586 B Ball 3 2 0 8
707979 was 1 2 NA NA 15:12:40 SI 0.963 S Called Strike 0 0 1 12
707980 was 1 2 NA NA 15:12:59 SI 0.952 X In play, out(s) 0 1 1 13
707981 was 1 3 NA NA 15:13:51 SI 0.910 S Called Strike 0 0 2 18
707982 was 1 3 NA NA 15:14:33 SI 0.935 S Foul 0 1 2 20

707977 des tfs millis R1 R2 R3 x
707978 Ian Desmond walks. 161149 1.317241e+12 NA NA NA 115.88
707979 Roger Bernadina ground bunts into a force out, catcher Brett Hayes to shortstop Emilio Bonifacio. Ian Desmond out at 2nd. Roger Bernadina to 1st. 161240 1.317241e+12 435622 NA NA 130.47
707980 Roger Bernadina ground bunts into a force out, catcher Brett Hayes to shortstop Emilio Bonifacio. Ian Desmond out at 2nd. Roger Bernadina to 1st. 161259 1.317241e+12 435622 NA NA 125.32
707981 Jayson Werth strikes out swinging. 161351 1.317241e+12 465668 NA NA 96.14
707982 Jayson Werth strikes out swinging. 161433 1.317241e+12 465668 NA NA 100.43

  y start_speed end_speed sz_top sz_bot pfx_x pfx_z px pz x0 y0 z0 vx0 vy0 vz0 ax ay az break_y break_angle break_length zone nasty spin_dir spin_rate
707977 129.52 91.8 84.1 3.34 1.66 -3.88 6.44 -0.488 3.218 -2.318 50 6.372 6.174 -134.489 -4.494 -7.043 31.310 -20.391 23.8 14.8 5.0 1 50 210.867 1480.831
707978 170.10 90.5 82.9 3.34 1.67 -5.65 10.07 2.164 1.488 -1.937 50 6.210 12.546 -131.850 -9.470 -9.875 29.738 -14.481 23.8 23.4 4.2 14 43 209.166 2229.509
707979 164.06 92.5 85.5 3.50 1.70 -8.10 6.26 -0.925 1.730 -2.434 50 6.194 6.848 -135.317 -8.101 -15.042 29.260 -20.475 23.8 31.6 5.7 13 78 232.125 2043.054
707980 162.33 92.6 83.8 3.61 1.70 -10.90 3.43 -0.748 1.812 -2.277 50 6.274 7.779 -135.353 -6.919 -19.752 35.900 -25.879 23.7 32.8 7.4 13 65 252.322 2222.039
707981 154.56 92.2 84.9 3.61 1.72 -6.71 5.79 0.172 2.156 -2.211 50 6.266 8.655 -134.833 -6.894 -12.329 29.929 -21.466 23.8 24.6 5.6 8 47 229.024 1757.072
707982 159.74 92.6 85.1 3.46 1.70 -7.12 4.14 -0.004 1.848 -2.033 50 6.320 7.874 -135.387 -7.340 -13.138 31.192 -24.454 23.8 23.7 6.3 8 38 239.560 1632.907

  home_team_runs away_team_runs sv_id cc mt rb_upper b_name b_sz_top_mn
707977 0 0 110928_161150 NA 4.408430 Desmond, Ian 3.419157
707978 0 0 110928_161204 NA 4.408430 Desmond, Ian 3.419157
707979 0 0 110928_161240 NA 4.408430 Bernadina, Roger 3.338457
707980 0 0 110928_161259 NA 4.408430 Bernadina, Roger 3.338457
707981 0 0 110928_161351 NA 4.587151 Werth, Jayson 3.577764
707982 0 0 110928_161433 NA 4.587151 Werth, Jayson 3.577764
> |
```



- Before 1907
  - Batter's could request location (high, low, fair)
  - Umpire's role minimal
- 1907
  - Traditional pitch count began (4/3)
  - Strike zone standardized
    - “. . .any portion of the home base **between the batsman's shoulder and knees. . .**”



Honus Wagner  
Off. WAR: 9.5



## Evolution of the Strike Zone

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- 1950
  - “. . .that space over home plate, which is **between the batter's armpits and the top of his knees** when he assumes his natural stance. . .”
- 1963
  - “. . . that space over home plate, which is **between the top of the batter's shoulders and the top of his knees** when he assumes a natural stance. . .”

Stan Musial  
Off. WAR: 7.3



Hank Aaron  
Off. WAR: 9.2

## Evolution of the Strike Zone

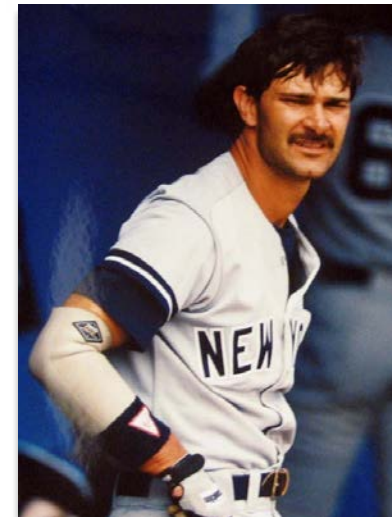
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- 1969
  - “. . . that space over home plate, which is **between the batter's armpits and the top of his knees** when he assumes his natural stance. . . .”
- 1988
  - “. . . that area over home plate the upper limit of which is a horizontal line at the **midpoint between the top of the shoulders and the top of the uniform pants**, and the lower level is a line at the top of the knees . . . .”

Willie McCovey  
Off. WAR: 8.6



Don Mattingly\*  
\*Did not lead in  
WAR, but should have

- 1996
  - Lower limit of the strike zone expanded
  - From the **top of the knees** to the **bottom of the knees**

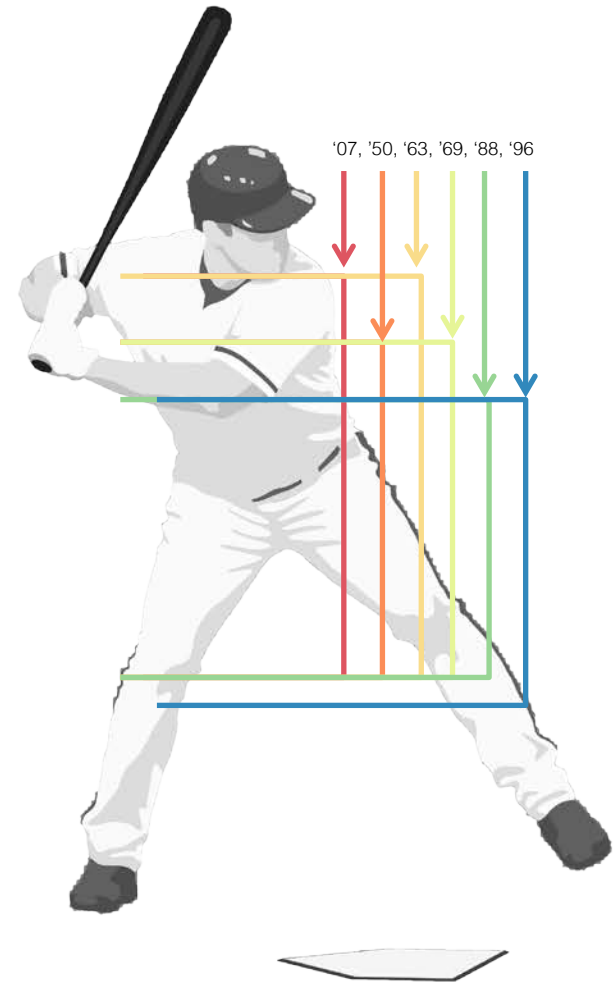
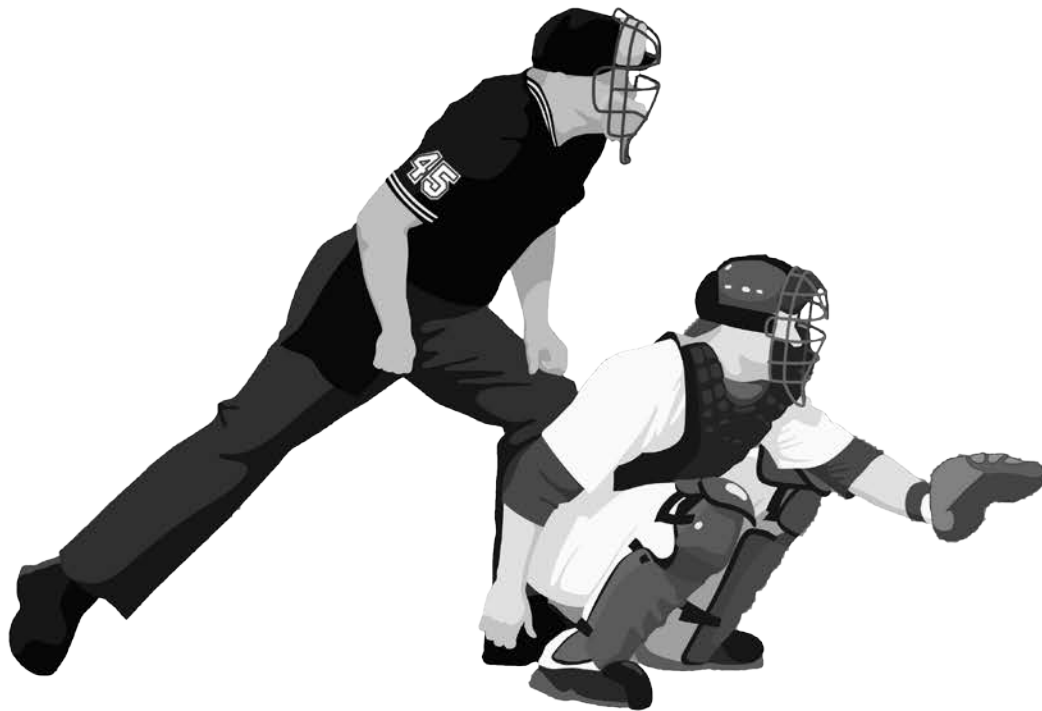


Barry Bonds  
Off. WAR: 8.6

# Evolution of the Strike Zone



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- Most analysis is done based on a typical strike zone
- Prevents meaningful analysis
- Negates rule book zone
- Account for batter height
- Variability in PITCHf/x operators

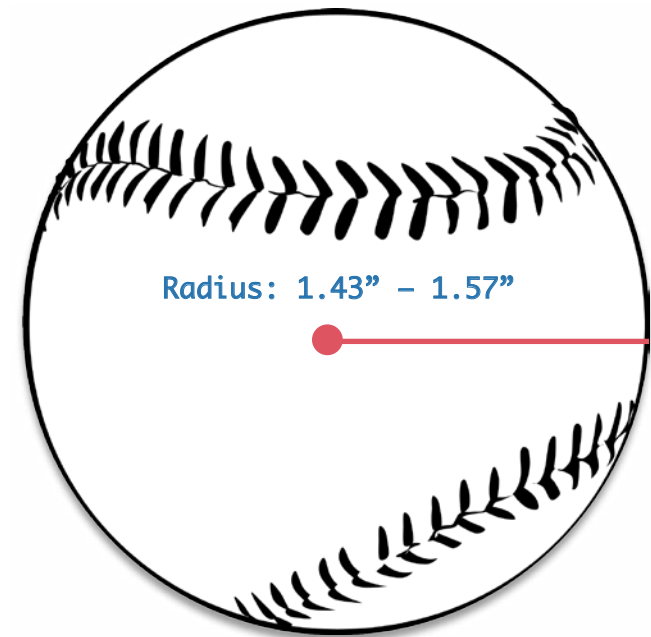


- Most analysis is done based on a typical strike zone
- Prevents meaningful analysis
- Negates rule book zone



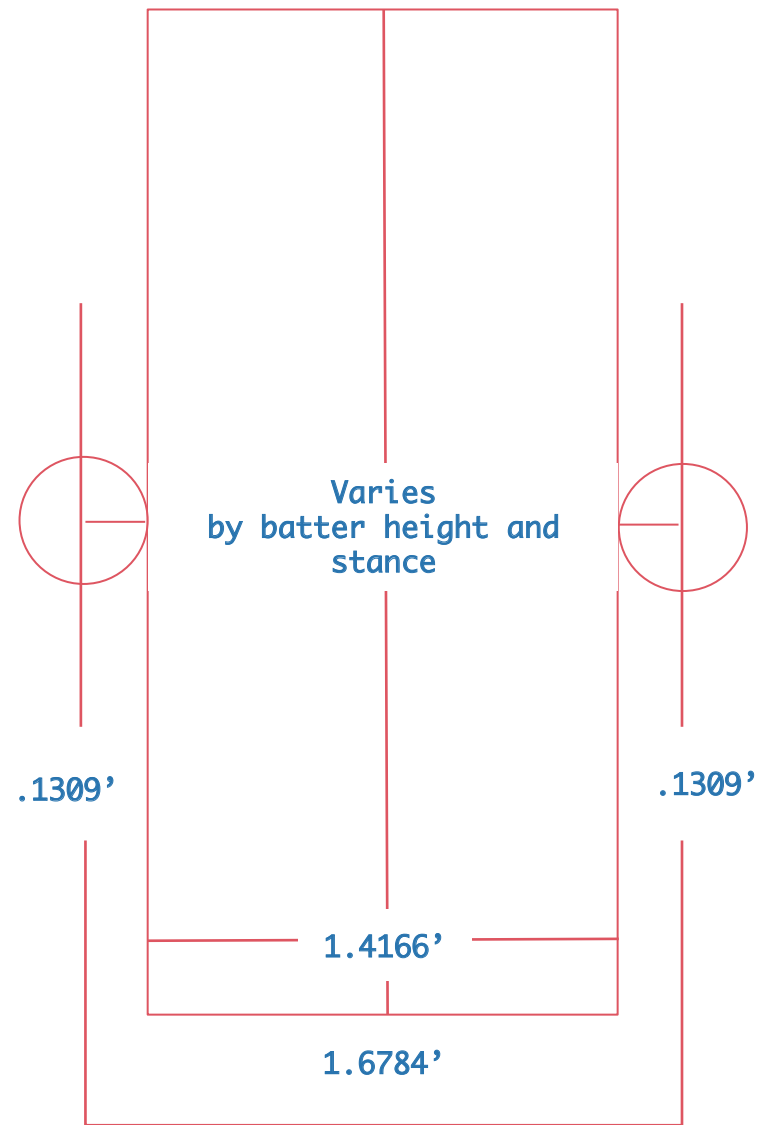
- Account for batter height
- Variability in PITCHf/x operators
- Length is variable
- Width is exact
- Start with the baseball

- Dimensions are standardized (Rule 1.09)
  - Weight:  $\geq 5 \leq 5.25$
  - Circumference:  $\geq 9 \leq 9.25$
  - Diameter:  $\geq 2.864 \leq 3.142$
  - Radius:  $\geq 1.43 \leq 1.57$





# The Actual Strike Zone



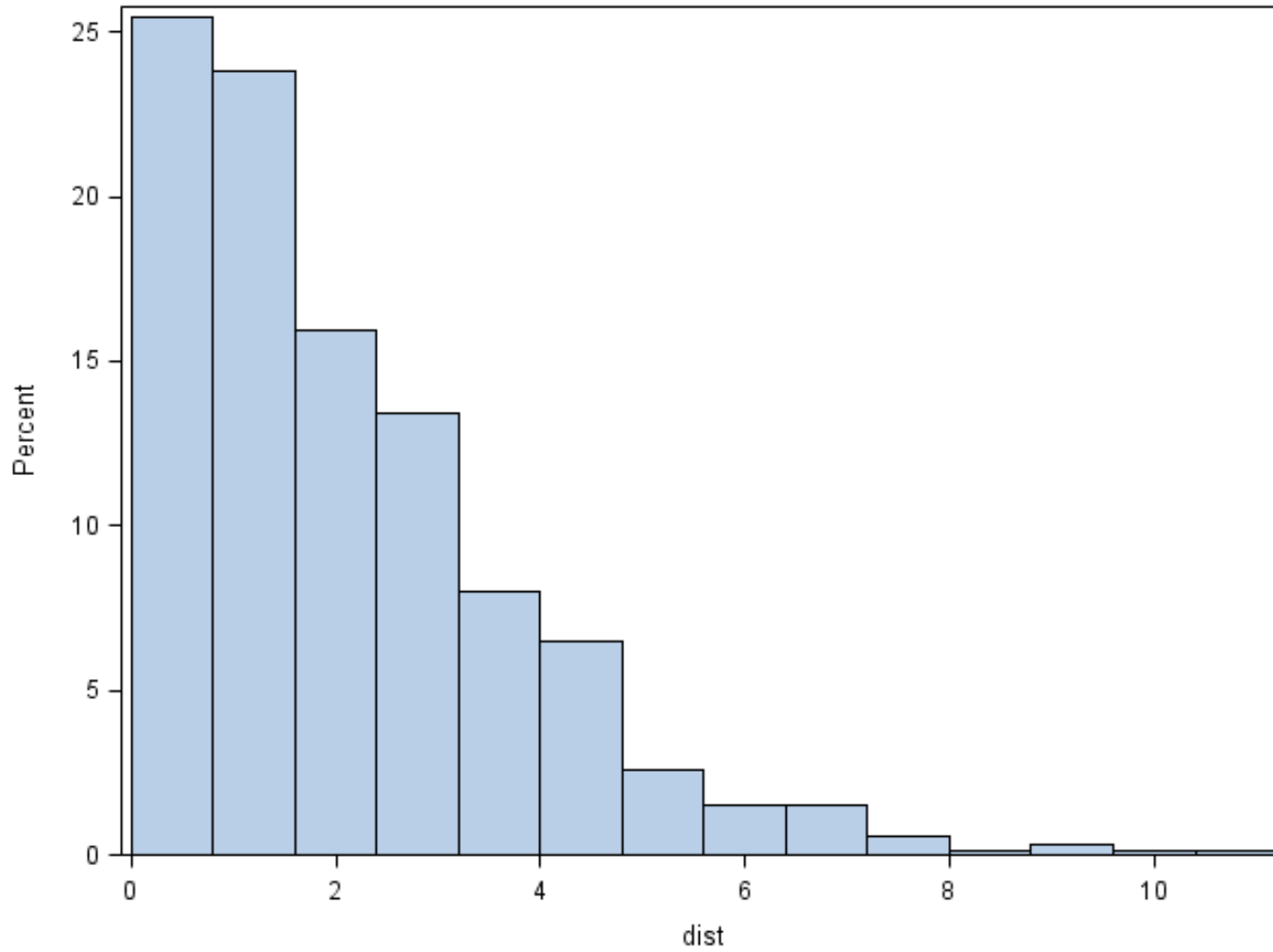


- Calculated the minimum distance each pitch was from the nearest edge of the strike zone
- To determine at what point umpires begin to demonstrate accuracy in judgment
- 85% - 91% accurate

# Accuracy Inside & Outside



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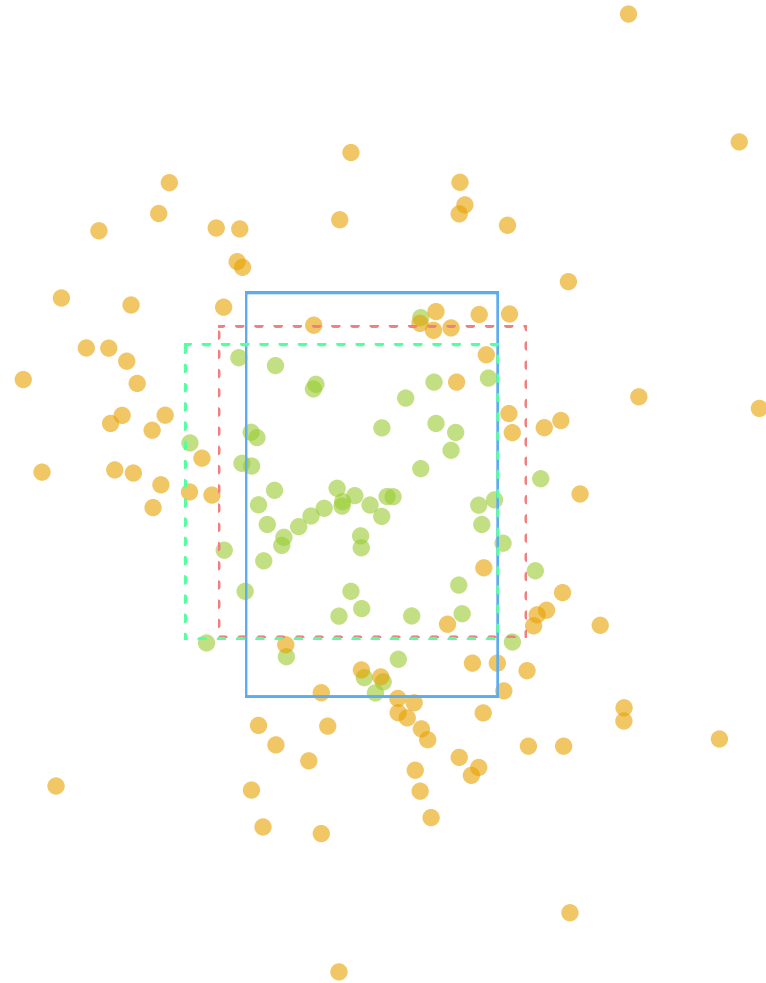


# General Accuracy

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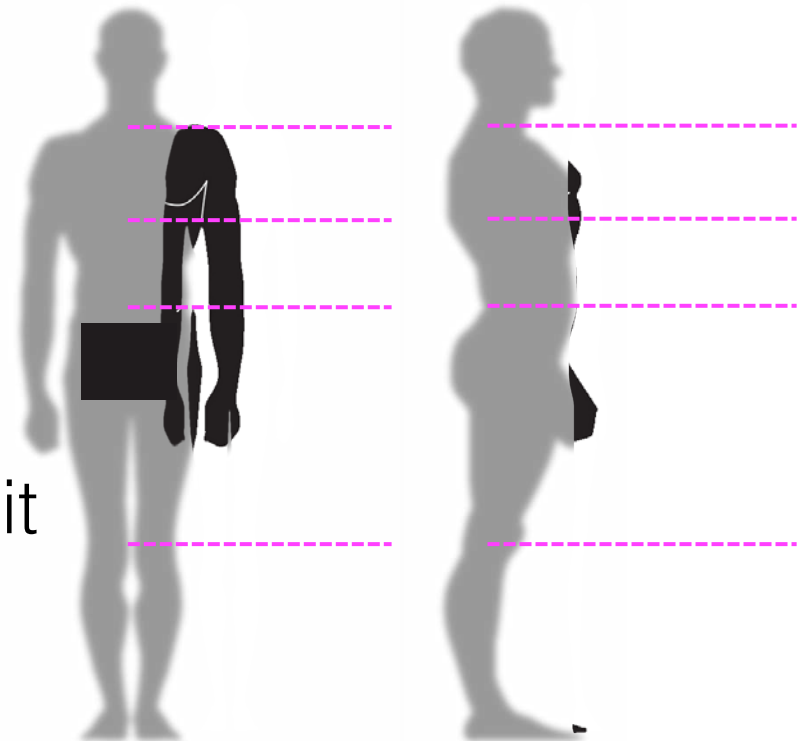


## Estimating Strike Zone Length



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- U.S. Army anthropometric measures
  - 25,000+ individuals
  - 5'1" – 6'10"
  - Shoulder height
  - Waist height
  - Suprasternal
  - Difference = upper limit
  - 6'0": 51.46"/4.288'





- Judgment and decision-making susceptible to bias
  - Catcher framing
  - Team/player retaliation
  - Pitch velocity (90+ MPH .485 - .385ms)
- Perceived and experienced anxiety/stress
  - Injuries
  - Catcher confrontations

## **Umpire Injuries**

<http://goo.gl/OVc2N>

## **Umpire confronts catcher**

<http://goo.gl/NX6EG>



- Continue strike zone analysis in order to better understand umpire accuracy
- Apply more robust statistical procedures to data
- Field testing



Thank you!

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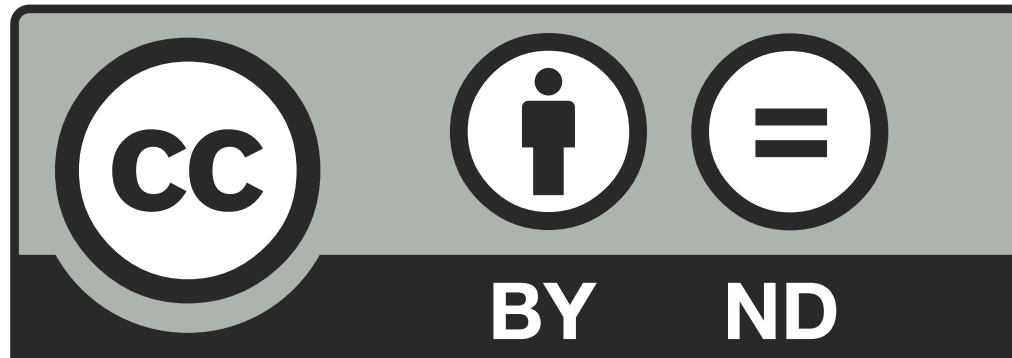
# References

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- Abernethy, B., Maxwell, J.P., Masters, R.S.W., van der Kamp, J., & Jackson, R.C. (2007). Attentional processes in skill learning and expert performance. In Tenenbaum, G. & Eklund, R.C. (Eds.). *Handbook of sport psychology*. San Francisco: John Wiley & Sons, Inc.
- Ericsson, K.A. (2006). The influence of experience and deliberate practice on the development of superior expert performance. In K. A. Ericsson, N. Charness, P. Feltovich, and R. R. Hoffman, R. R. (Eds.). *Cambridge handbook of expertise and expert performance* (pp. 685-706). Cambridge, UK: Cambridge University Press.
- Fadde, P.J. (2006). Interactive video training of perceptual decision-making in the sport of baseball. *Technology, Instruction, Cognition, and Learning*, 4, 237-255.
- Ghasemi, A. Momeni, M., Jafarzadehpur, E., Rezaee, M., & Taheri, H. (2011). Visual skills involved in decision making by expert referees. *Perceptual and Motor Skills*, 112(1), 161-171.
- Moran, A. (2009). Cognitive psychology in sport: Progress and prospects (In press). *Psychology of Sport and Exercise*, 1-7.
- The Office of the Commissioner of Baseball (2012). *Official baseball rules*. New York: Major League Baseball. Retrieved from [http://mlb.mlb.com/mlb/downloads/y2012/Official\\_Baseball\\_Rules.pdf](http://mlb.mlb.com/mlb/downloads/y2012/Official_Baseball_Rules.pdf)
- Paull, G. & Glencross, D. (1997). Expert perception and decision making in baseball. *International Journal of Sport Psychology*, 28(1), 35-56.
- Takeuchi, T. & Inomata, K. (2009). Visual search strategies and decision making in baseball batting. *Perceptual and Motor Skills*, 108(3), 971-980.
- Williams, A.M. & Ward, P. (2007). Anticipation and decision making: Exploring new horizons. In Tenenbaum, G. & Eklund, R.C. (Eds.). *Handbook of sport psychology*. San Francisco: John Wiley & Sons, Inc.
- Williams, A.M., Ward, P., & Smeeton, N.J. (2004). Perceptual and cognitive expertise in sport: Implications for skill acquisition and performance enhancement. In Williams, A.M. & Hodges, N.J. (Eds.). *Skill acquisition in sport: research, theory and practice*. Routledge: London.



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