

## BoRK or BT? An Analysis for Vayne Players in League of Legends

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### Abstract

Since the Blade of the Ruined King (BoRK) received significant stat decreases on League of Legends, Vayne players have increasingly begun to purchase the Bloodthirster (BT) instead. This paper aims to address when buying one item over the other is optimal through finding the difference between kill times on targets with varying health and armour in a plausible mid-game scenario with each item.

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### Introduction

League of Legends (LoL) is a multiplayer game published by Riot Games. Players control a character known as a champion and work in teams of five to take down the structure of an opposing team known as the "Nexus" [1].

One currently popular champion is Vayne, who is played in 18.23% of all games [2]. In August of 2013, an item universally utilized by Vayne players known as the "Blade of the Ruined King" (BoRK) received stat decreases [3]. This raised the question of whether the item should be purchased anymore over the "Bloodthirster" (BT), a similar alternative.

This article aims to identify when purchasing one item over the other is preferable by modelling a plausible mid-game scenario: at 16 minutes, a fight has broken out around dragon. By creating surface functions for kill times on targets with varying armour and health for each item and subtracting the two functions, the effectiveness of each item can be determined.

### Defensive Stats

We will first consider the stats that govern a target's survivability. While there are many such stats in LoL, only two are relevant to our model: hit points (HP) and armour (AR).

HP is the amount of damage a target can receive before dying.

AR reduces incoming physical damage by a multiplier ( $AR_{red}$ ) [4]:

$$AR_{red} = \frac{100}{100 + AR}$$

AR is affected by attacker armour penetration (APen), which ignores a percentage of a target's AR. Taken together, physical damage on a per hit basis is multiplied by [4]:

$$AR_{red} = \frac{100}{100 + (1 - Apen)AR}$$

We will consider two types of damage for our calculations: physical damage, which is mitigated by armour, and true damage, which is not.

### Offensive Stats

We will now review the stats that affect Vayne's damage per second (DPS). Although there are many factors affecting DPS, we will only consider attack damage (AD), attack speed (AS), and "Silver Bolts". AD is the physical damage inflicted per hit [5] and AS is the number of attacks per second [6]. With this in mind, DPS is:

$$DPS = AS \times AD$$

By accounting for decreases in physical damage due to armour, the DPS formula becomes:

$$DPS = AS(AR_{red} \times AD)$$

Vayne deals true damage on every third consecutive hit through an ability known as "Silver Bolts"; the damage is dependent on the number of "points" invested in the skill. In the scenario given, this value is 30 + 5% of a target's maximum health ( $HP_{max}$ ) [7]. For simplicity, we will incorporate this into our model by dividing the damage dealt by three and applying it to every hit. Accounting for silver bolts, the DPS formula becomes:

$$DPS = AS(AR_{red} \times AD + 10 + \frac{HP_{max}}{60})$$

Finally, the time to kill a target in seconds ( $k_t$ ) may be determined by dividing the maximum

health ( $HP_{max}$ ) by the DPS:

$$k_t = \frac{HP_{max}}{DPS}$$

While Vayne has additional damage increasing skills, we will not incorporate them into our model. In addition, all champions have health regeneration (which decreases effective DPS); for the sake of simplicity, we will also ignore this.

### Offensive Statistical Modifiers

There are many methods by which a Vayne player may increase their AD and AS. These may be divided into pregame and in-game modifiers.

Pregame modifiers consist of runes and masteries, which give a persistent bonus to AD and AS. To determine the effects of runes and masteries on our model, we will examine a Vayne game played by a professional LoL player in February 2014. The net effect of his runes and masteries were: +14.76 AD, +0.55 AD/level, +5% bonus AD, +0.0329 AS, +6% Apen, +4.5% physical damage, and +5% physical damage to champions below 50% HP. For simplicity, we will model the physical damage increase to champions below 50% HP as a consistent 2.5% bonus [8].

In-game modifiers consist of levelling up and purchasing items. Levelling up is accomplished by performing in game actions such as participating in enemy champion kills. Vayne begins the game with 50 AD and 0.568 AS, and gains 3.25 AD and 0.0204 AS per level [7].

Items are purchased with gold earned in game. For our model, we will assume that Vayne has bought a Berserker's Greaves, which grants +0.132 AS [6], and either a BoRK or a BT. A Bloodthirster grants +100 AD, while a BoRK provides + 25 AD, 0.263 AS, and deals bonus physical damage equal to 5% of a target's current health on each hit [5]. For simplicity, we will assume that this is instead consistently 2.5% of a target's  $HP_{max}$ .

For our scenario, in which we assume Vayne to be level 9, the cumulative effect of all statistical modifiers except for a BoRK or a BT is 100 AD, 1.01 AS, 6% Apen, and +7% physical damage. By adding these values to the  $k_t$  formula, we arrive at

$$k_t = \frac{HP_{max}}{1.01(1.07 \times AR_{red} \times 100 + 10 + \frac{HP_{max}}{60})}$$

Where  $AR_{red}$  is

$$AR_{red} = \frac{100}{100 + (1 - 0.06)AR}$$

### Surface Functions

Accounting for the stats given by a BT, the kill time function becomes:

$$k_{tBT} = \frac{HP_{max}}{1.01(1.07 \times AR_{red} \times 205 + 10 + \frac{HP_{max}}{60})}$$

Accounting for the stats given by a BoRK, the kill time function becomes:

$$k_{tBoRK} = \frac{1}{1.27(1.07 \times AR_{red} \times (126 + \frac{HP_{max}}{40}) + 10 + \frac{HP_{max}}{60})}$$

By subtracting the  $k_t$  functions, we form a surface function displaying when each item is more effective against a target (figure 1).

$$\Delta k_t = k_{tBT} - k_{tBoRK}$$

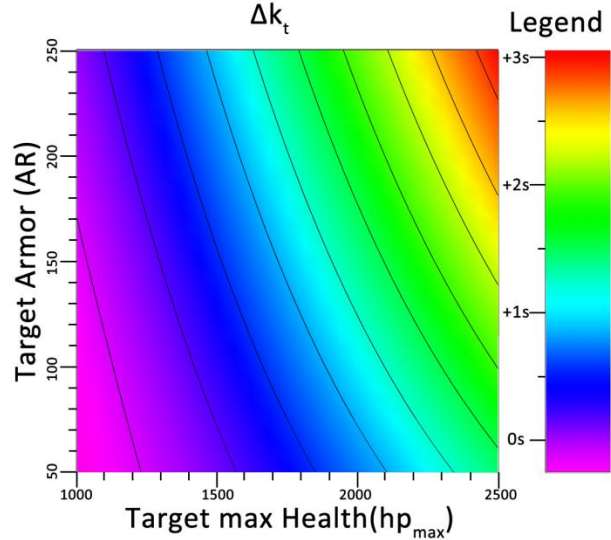


Figure 1 –  $\Delta k_t$  as a function of AR and  $HP_{max}$ . Warmer coloured areas indicate that BT has a higher kill time than BoRK, and is therefore less effective. Contours are 1/3 s apart. The bounds were set to values that seem reasonable for the scenario.

### Analysis

Purchasing a BT is more effective on targets entering a fight with low  $HP_{max}$  ( $< \sim 1250$ ) and AR, while buying a BoRK is more efficient on targets with high  $HP_{max}$  and AR. This makes sense, as BoRK deals percentage health damage and makes silver bolts more effective due to the AS it grants. However, the difference in  $k_t$  for each item does not appear to be significant, with a maximum difference of about 3.0s between the ideal BT case and the ideal BoRK case.

### Conclusion

The difference between building a BT and BoRK does not seem to be appreciable for the scenario described, with a maximum difference of 3 seconds. However, the differences may be more appreciable with more items and levels, and with different runes and masteries.

## References

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