Gerrymandering in the Laboratory

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Abstract

Gerrymandering, the act of drawing political boundaries for electoral advantage, is a hot button political topic. Previous theoretical work has treated gerrymandering as a one-stage strategic game against nature, but this paper treats drawing districts as the first stage in a two stage game in which parties subsequently compete within districts for undecided voters. In a controlled laboratory experiment, subjects overwhelmingly engage in gerrymandering, which is optimal in terms of maximizing the probability of winning a majority of the districts and maximizing the expected payoff of the party drawing the districts. Engaging in gerrymandering occurs despite the fact that subjects report being opposed to the practice and regardless of their own political views. However, when forced to select the electoral map behind a veil of ignorance, our subjects indicate a clear preference for symmetric fair maps although not the theoretically socially efficient map. Additionally, consistent with past Tullock contest experiments, the subjects overspend at the second stage although average spending across electoral maps is largely consistent with the theoretical comparative static predictions.

Keywords: Gerrymandering, Contests, Laboratory Experiment

1 Introduction

Gerrymandering is the act of strategically determining the boundaries of an electoral district in an attempt to influence the outcome of an election. The term was introduced in 1812 to criticise Massachusetts Governor Elbridge Gerry, who authorized a state senate district thought by some to resemble a salamander. Today, gerrymandering is perhaps most associated with the United States House of Representatives with districts know as the earmuffs (Illinois' 4^{th} District), the duck (Ohio's 4^{th} District), and Goofy kicking Donald (Pennsylvania's 7^{th} District) all based on their geographic shape. Redrawing Congressional districts has become a data science driven endeavor Newkirk (2017), so it is little wonder that the practice continues to receive considerable political attention. For example, in September 2021 Democrats in Indiana accused Republican lawmakers of cracking apart democratic voters in the state to create districts that favor Republicans. That same month, Oregon's state legislature put forward a plan that Republicans claim favors Democrats in five of the state's six Congressional districts. Also in September 2021, a case was filed in federal court claiming that Alabama's congressional districts are racially motivated and pack many black voters into one district to minimize the impact of that community in other districts. Concern with gerrymandering has led some states to form non-partisan groups to draw Congressional Districts; for example, in September 2021, Michigan's Independent Citizens Redistricting Commission provided a draft map of its proposed districts. However, in the 2019 case Rucho, et al v. Common Cause, the United States Supreme Court ruled that claims of partisan gerrymandering are not justiciable leaving the practice in play.[1]

Previous economic research on gerrymandering has primarily fallen into two categories. The first examines the effects of redistricting on voter participation Hayes and McKee (2009), policy choices (Shots 2002, Besley and Preston (2007), and polarization McCarty et al. (2009). The second category focuses on gerrymandering as a strategic problem (from the perspective of the gerrymanderer). Owen and Grofman (1988) introduce a model where the party drawing districts has an aggregate level of support but can partition that support among a fixed number of districts. They show that a gerrymanderer who wishes to either maximize the expected number of districts won or to maximize the chance of winning a majority of districts should pack rival's supporters into some districts and fragment own supporters across the other districts. Known as packing and cracking, respectively, these two strategies have become a cornerstone of partisans seeking to gain a political advantage. Gilligan and Matsusaka (1999) consider a setting in which the preferences of each voter are observable and show that constructing districts that maximize homogeneity within districts can effectively eliminate bias whereas randomly generated districts will not eliminate bias in general. More recent work by Friedman and Holden (2008), Gul and Pesendorfer (2010) and Kolotilin and Wolitzky (2020) has focused on voters with unobservable types.

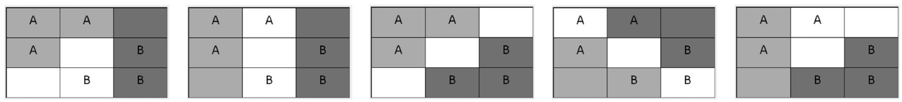
[1] Cases involving racial discrimination, such as that alleged against the State of Alabama, can be reviewed by the courts and are subject to the Voting Rights Act of 1965.

Our paper contributes to the strategic gerrymandering literature in two ways. First, the prior papers in this area have treated districting as a one stage game against nature, whereas in practice districting is only the first stage in a two stage game against another party. Therefore, we combine the notion of districting with a second stage Tullock style electoral competition within each district. Specifically, we assume that there are two types of voters: partisan voters who will vote for their favored party and undecided voters who can be influenced by the campaign efforts of the candidates. In our setting, optimal gerrymandering involves packing (rival partisans) and cracking (own partisans and undecided voters). Theoretically, gerrymandering yields a higher expected payoff and a greater probability of winning than the other possible ways district maps could be drawn. Second, we conduct a controlled laboratory experiment to examine not only what districts are chosen, but also how people compete in those districts. We find that conditional on the electoral map, subjects tend to overspend relative to the theoretical predictions, but spending across electoral maps is largely consistent with the predicted comparative statics of the model. Additionally, we find that subjects overwhelmingly engage in self-interested gerrymandering when given the opportunity to do so and this pattern holds regardless of the subjects own political leanings. This pattern also holds despite the nearly unanimous claim among the subjects that they do not support gerrymandering. However, when our subjects are forced to draw electoral boundaries behind a veil of ignorance, they are far more likely to choose an unbiased map although not the one that theoretically yields the greatest expected profit.

2 Model

We consider an election game with two players (A and B) and 9 zones arranged in a 3x3 grid. The players compete for a fixed a prize, V. To win the prize, a player must win at least two of the three districts. For simplicity we refer to the districts as (W)hite, (L)ight Gray, and Dark (G)ray. Each district is comprised of 3 zones and to win a district a player must claim at least two of the three zones in the district. The players represent political parties competing for majority control of a representative legislature and the zones represent individual voters. To capture the notion that some voters are party loyalists while others are influenced by political campaign, some zones are preassigned to a specific player while other zones are not. We assume that one-third of zones are preassigned to A, one-third are preassigned to B, and one third are not preassigned. We refer to a specific assignment of the 9 zones to three equally sized districts as a map. Figure 1 shows five distinct maps. Any other map that could be constructed with three zones of three districts each where one third of the zones are not preassigned and the other districts are equally split between the two players is strategically equivalent to one of these five maps.

The players compete via simultaneous independent Tullock contests for each non-preassigned zone; however, expenditure decisions are made at the district level reflecting the practical reality of electioneering. Specifically, given Map M,



(a) $Gerry_B$ (b) $Sym_{1,1}$ (c) $Sym_{1,3}$ (d) $Sym_{3,1}$ (e) $Gerry_A$

Figure 1: Map Structures

Player $i \in \{A, B\}$ selects an expenditure triple $(e_{i,W|M}, e_{i,L|M}, e_{i,G|M})$ where $e_{i,d|M}$ denotes the player's expenditure in district $d \in \{W, L, G\}$. When there is no ambiguity with regard to the map being referenced, we drop $|M$ from the notation. The probability that player i wins a non-preassigned zone in district d of map M is $\frac{(e_{i,d|M})}{(e_{i,d|M})+(e_{j,d|M})}$ with $i \neq j$. Player i's expected payoff is $E\pi_i = \rho_i V - \sum_d e_{i,d|M}$ where ρ_i is the probability that player i claims a majority of the zones in a majority of the districts given the choices of both players.

We now consider each Map shown in Figure 1. Three of these maps are symmetric in the sense that the objective function of the two players are symmetric and the resulting equilibrium strategy is symmetric. We refer to these maps as $Sym_{D,Z}$ as there are D districts in the map that either player could win and there are Z zones in each of those competitive districts that are not preassigned. For example, in $Sym_{1,1}$ there is only one district that is competitive and there is a single zone in that district that is in play. The other two districts each have 2 zones preassigned to a single player and thus that player is guaranteed to win those districts. Specifically, player $A(B)$ is guaranteed to win district $L(G)$. Therefore $e^*_{A,L} = e^*_{B,L} = e^*_{A,G} = e^*_{B,G} = 0$ as expenditures in these districts cannot influence which player wins those districts. For $Sym_{1,1}$, whichever player claims the non-preassigned zone in district W wins the map. Thus, $\rho_i = \frac{e_{i,W}}{(e_{i,W}+e_{j,W})}$ for $Sym_{1,1}$ and the competition reduces to a standard Tullock contest with the optimal expenditure from both players being $e^*_{A,W} = e^*_{B,W} = \frac{V}{4}$, giving each player a 50% chance of wining and an expected profit of $\frac{V}{4}$.

In $Sym_{3,1}$, no player has a guaranteed victory in any district. Further, because each player has one preassigned zone in each district the player who wins the non-preassigned zone in a district will win that district. Thus, the two parties are playing a simultaneous best of three Tullock contest where each contest is independent. For $Sym_{3,1}$,

$$\rho_i = \frac{e_{i,W}}{e_{i,W}+e_{j,W}}\frac{e_{i,L}}{e_{i,L}+e_{j,L}}\frac{e_{i,G}}{e_{i,G}+e_{j,G}} + \frac{e_{i,W}}{e_{i,W}+e_{j,W}}\frac{e_{i,L}}{e_{i,L}+e_{j,L}}\frac{e_{j,G}}{e_{i,G}+e_{j,G}} + \frac{e_{i,W}}{e_{i,W}+e_{j,W}}\frac{e_{j,L}}{e_{i,L}+e_{j,L}}\frac{e_{i,G}}{e_{i,G}+e_{j,G}} + \frac{e_{j,W}}{e_{i,W}+e_{j,W}}\frac{e_{i,L}}{e_{i,L}+e_{j,L}}\frac{e_{i,G}}{e_{i,G}+e_{j,G}} \quad (1)$$

The equilibrium expenditure for each district for Player i is $(e^*_{i,W}, e^*_{i,L}, e^*_{i,G}) =$

$(\frac{V}{8}, \frac{V}{8}, \frac{V}{8})$. Each player wins with a 50% chance and has an expected profit of $\frac{V}{8}$.

In $Sym_{1,3}$, Player $A(B)$ is guaranteed to win district $L(G)$ and thus both players should spend zero in these two districts. District W has three zones that are in play and whichever player wins at least two of those zones will win the overall contest. Again, the contest reduces to a best of three competition, but for this map both players are constrained to make a single expenditure that applies to all three competitive zones. Thus, for $Sym_{1,3}$

$$\rho_i = \left(\frac{e_{i,W}}{e_{i,W} + e_{j,W}}\right)^3 + 3\frac{e_{i,W}^2 e_{j,W}}{(e_{i,W} + e_{j,W})^3} \tag{2}$$

The equilibrium expenditure for District W in $Sym_{1,3}$ for player i is $e^*_{i,W} = \frac{3V}{8}$ and the expected profit is $\frac{V}{8}$. Thus, of the three symmetric maps $Sym_{1,1}$ is socially optimal and yields the greatest expected profit to the players.

We now turn to the two asymmetric maps. In $Gerry_A$, all of the zones preassigned to Player B are packed into District G. However, the zones preassigned to Player A are cracked and split between Districts L and W in such a way that Player A is guaranteed to win District L and that Player A has a one zone advantage in District W. Because the outcomes in Districts L and G are guaranteed, $e^*_{A,L} = e^*_{B,L} = e^*_{A,G} = e^*_{B,G} = 0$. While either player can win the contest, Player A only needs to win one of the two non-preassigned zones in District W while Player B must win both non-preassigned zones in District W. Thus, the game effectively becomes a weak-link contest. In $Gerry_A$,

$$\rho_A = 1 - \left(\frac{e_{B,W}}{e_{A,W} + e_{B,W}}\right)^2 \tag{3}$$

In equilibrium, $e^*_{A,W} = e^*_{B,W} = \frac{V}{4}$, giving Player A 75% chance of winning the contest and an expected profit of $\frac{V}{2}$ while Player B has a 25% chance of winning the contest and en expected profit of 0. $Gerry_B$ is similar to $Gerry_A$ except that the advantage and equilibrium favor Player B.

Table 1 summarizes the equilibrium predictions for each of the 5 maps in Figure 1. From this table it is clear that Player A would prefer to compete on $Gerry_A$ while Player B would prefer to compete on $Gerry_B$. That is, players find it optimal to engage in gerrymandering if given the opportunity.

3 Experimental Design

To test the theoretical predictions developed in the previous section we conducted a controlled laboratory experiment using a within subjects design. While the choice of V is somewhat arbitrary, given the predictions in Table 1 we set $V = 80$. The experiment progressed in 3 main stages.

Stage 1 consisted of ten decision periods with random and anonymous rematching each period. Participants were informed of their role as Player A or

Table 1: Summary of Theoretic Results

	$Sym_{1,1}$	$Sym_{3,1}$	$Sym_{1,3}$	$Gerry_A$	$Gerry_B$
$(e^*_{A,W}, e^*_{A,L}, e^*_{A,G})$	$(\frac{V}{4}, 0, 0)$	$(\frac{V}{8}, \frac{V}{8}, \frac{V}{8})$	$(\frac{3V}{8}, 0, 0)$	$(\frac{V}{4}, 0, 0)$	$(\frac{V}{4}, 0, 0)$
$(e^*_{B,W}, e^*_{B,L}, e^*_{B,G})$	$(\frac{V}{4}, 0, 0)$	$(\frac{V}{8}, \frac{V}{8}, \frac{V}{8})$	$(\frac{3V}{8}, 0, 0)$	$(\frac{V}{4}, 0, 0)$	$(\frac{V}{4}, 0, 0)$
ρ_A	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{4}$
ρ_B	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{4}$
$E\pi_A$	$\frac{V}{4}$	$\frac{V}{8}$	$\frac{V}{8}$	$\frac{V}{2}$	0
$E\pi_B$	$\frac{V}{4}$	$\frac{V}{8}$	$\frac{V}{8}$	0	$\frac{V}{2}$

Player B and shown all 5 maps simultaneously. As explained to the participants, one map would be selected at random after both players made all of their decisions and it was the result for the randomly selected map that would determine the actual outcome for that period. That is, the strategy method was used so that participants had an incentive to faithfully report their preferred choices for all 3 district on all 5 maps each period. After both players made their decisions, participants received feedback that included the other player's choices, the probability they themselves would win each district, the probability they would win the map, a realization of the outcome for the map and the resulting payoff. The map that was randomly selected to determine the outcome was highlighted on the participant's screen. Figure 2 provides an example of the period end feedback.

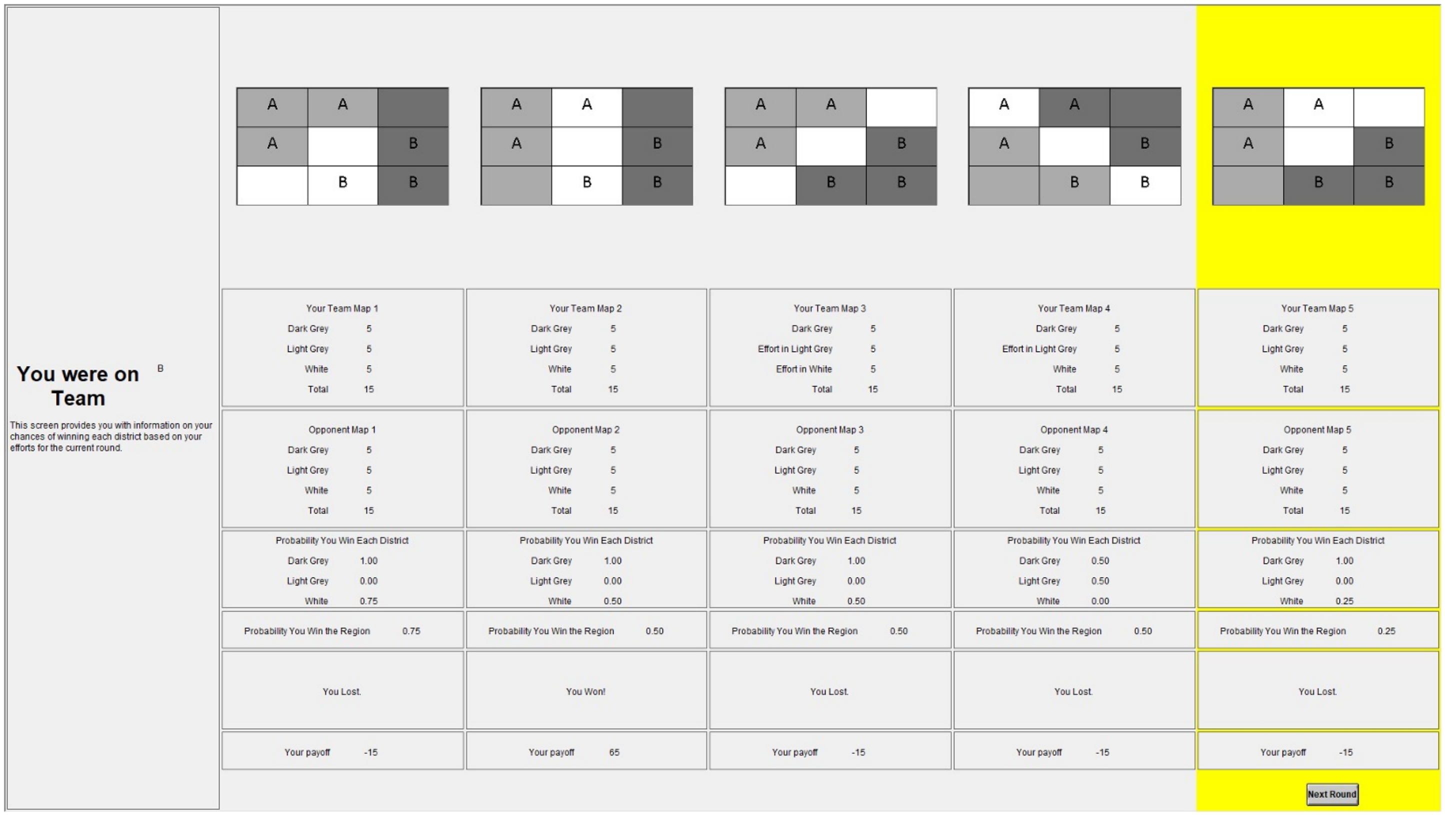


Figure 2: Subject Feedback

Stage 2 consisted of three decision periods with random and anonymous rematching each period. The only distinction between Stage 2 and Stage 1 is that in Stage 2 participants were first asked what map they would prefer to use to determine the outcome for that period. Both Player A and Player B privately indicated their preferred maps, but this information was not revealed until after the period was over. What participants did know was that the computer would randomly pick one of the maps selected by the two players. But because a player did not know which map would be selected, both players had an incentive to make choices on each map as though it would be the one that determined the outcome. The feedback received in Stage 2 was the same as the feedback received in Stage 1.

Stage 3 consisted of a single decision period with random and anonymous rematching. The only difference between Stage 3 and Stage 2 is that a participant was asked to select the map that he or she preferred to use prior to learning if he or she would be in the role of Player A or Player B. That is, in Stage 3 each participant selected a map behind a veil of ignorance. Once both people in the contest made their selections, roles were revealed. But which map would be used that period was not revealed and thus both players again had to make choices on each map as if it were the map that would determine the outcome. The feedback received in Stage 3 was the same as the feedback received in the other two stages.

In each session, eight participants entered the laboratory. Each person was seated at a private workstation where they read instructions and went through several practice contests. To minimize experimenter demand effects or other implications of loaded language, no mention of elections or gerrymandering were used in the instructions or during the three stages of the experiment. Copies of the instructions are available in Appendix A. After everyone completed the initial set of instructions, Stage 1 of the study was conducted. After Stage 1 was completed, instructions regarding Stage 2 were displayed and then Stage 2 was completed. After Stage 2 was completed, instructions for Stage 3 were displayed and then Stage 3 was completed. After Stage 3 was completed, an anonymous survey that collected information about gender, political leaning, and attitude towards gerrymandering was administered. The entire experiment was programmed using ztree Fischbacher (2007). Once everyone in the session completed the experiment, a die was rolled in front of the participants to determine which single period from across all 3 stages would determine the participants' actual payments.

A total of 8 sessions were conducted at The University of Alabama's TIDE Lab. All of the participants were undergraduate students at that university who had registered in the lab's standing pool of volunteers. Each participant received \$5 plus their salient earnings, which averaged \$19.13. As explained to participants in the instructions, all monetary amounts in the experiment were denoted in Lab Dollars that were converted at the rate 4 Lab Dollars = 1\$US. To avoid the loss of experimenter control associated with negative earnings, each participant received an endowment of 80 Lab Dollars and was not allowed to spend more than this on any map in any period.

4 Results

We present the analysis separately for each stage. In our analysis, we combine data for Player A and Player B in equivalent strategic positions.[2] For the maps with gerrymandering, we combine Player A data from a district in $Gerry_A$ with Player B data from the corresponding district d in $Gerry_B$ and refer to this as *Advantaged* and we combine Player A data from a district in $Gerry_B$ with Player B data from the corresponding district in $Gerry_A$ and refer to this as *Disadvantaged*. In the remainder of the paper, districts are referred to from the perspective of Player A.

4.1 Stage 1

Our data includes 9,600 Stage 1 decisions with 640 decisions per district. Table 2 provides a summary of the observed behavior. Several patterns are readily apparent from this table. First, the participants are far more likely to make positive expenditures in districts where the the equilibrium prediction is positive than in districts where the equilibrium prediction is zero. However, some participants do make positive expenditures in districts that have no strategic value, a common pattern in the experimental contest literature (see for example Sheremeta (2010)). On the other hand, participants do not always make positive expenditures in districts when they are predicted to do so. This is most notable in $Sym_{3,1}$, something we return to later. Another pattern readily apparent from Table 2 is that on average participants expend more than the predicted level. Of the seven situations in which the equilibrium expenditure is positive, the average expenditure exceeded the predicted level in each of them. This overbidding is typical in the experimental contest literature Sheremeta (2013).

Figure 3 plots average bid by district by period. Behavior in districts with positive equilibrium expenditures is fairly stable across Stage 1. However, the amount expended in districts that have no strategic value tends to fall over the first part of the study. Therefore, to compare behavior across treatments we do so using all of the Stage 1 data as well as only using data from the last half of the stage. Specifically, to compare total expenditures we rely on the regression analysis in Table 3 that includes subject fixed effects and standard errors clustered at the session level. The omitted treatment is $Sym_{1,1}$, which is theoretically equivalent to a standard Tullock game, and thus the coefficients for the other treatments can be viewed as deviations from that baseline.

Theoretically, both the advantaged and the disadvantaged player in a gerrymandered map should exert the same total expenditure as each other and that level should equal that of a player in $Sym_{1,1}$. The lack of significance for $\beta_{Advantaged}$ in Table 3 is consistent with the theoretical prediction. But the

[2] Appendix B evaluates the effect that being labeled Player A or Player B has on behavior. In most situations there is no statistical differences although there are cases where there is a small but significant difference.

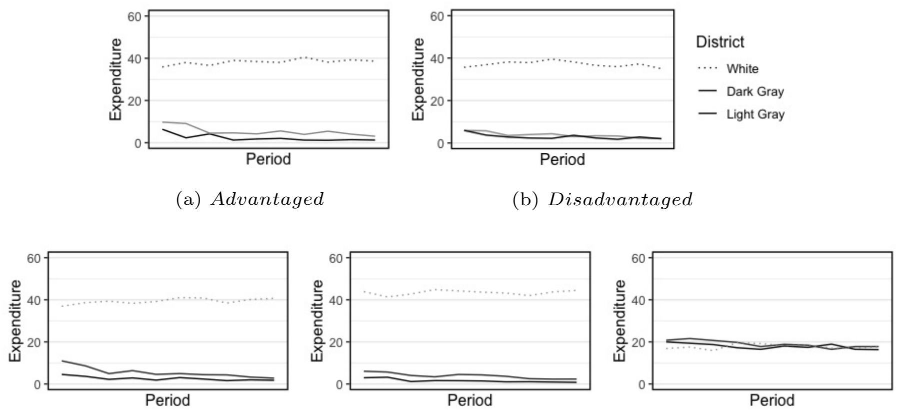
Table 2: District Statistics

Map	District	Percent Bidding Zero	Average Expenditure	Equilibrium Expenditure
Advantaged	White	2%	38	20
Advantaged	Light Gray	74%	5	0
Advantaged	Dark Gray	86%	2	0
Disadvantaged	White	10%	37	20
Disadvantaged	Light Gray	82%	4	0
Disadvantaged	Dark Gray	82%	3	0
$Sym_{1,1}$	White	3%	39	20
$Sym_{1,1}$	Light Gray	74%	5	0
$Sym_{1,1}$	Dark Gray	82%	3	0
$Sym_{1,3}$	White	3%	43	30
$Sym_{1,3}$	Light Gray	83%	4	0
$Sym_{1,3}$	Dark Gray	88%	2	0
$Sym_{3,1}$	White	13%	18	10
$Sym_{3,1}$	Light Gray	15%	19	10
$Sym_{3,1}$	Dark Gray	13%	18	10

Table 3: Comparison of Total Expenditure Across Maps

	Dependent Variable: Total Expenditure	
	Periods 1 - 10	Periods 6 - 10
	(1)	(2)
$\beta_{Advantaged}$	-1.470 (1.225)	-1.547 (1.592)
$\beta_{Disadvantaged}$	-3.656^{**} (1.730)	-4.425^{***} (1.517)
$\beta_{Sym_{13}}$	1.417^{**} (0.656)	1.172 (0.788)
$\beta_{Sym_{31}}$	7.189^{***} (2.272)	6.666^{***} (2.262)
β_0	40.704^{***} (0.881)	30.147^{***} (0.786)
Observations	3200	1600
Null Hypothesis	p-value	p-value
$\beta_{Advantaged} = \beta_{Disadvantaged}$	0.326	0.082^{*}
$\beta_{Sym_{13}} = 10$	$<0.001^{***}$	$<0.001^{***}$
$\beta_{Sym_{31}} = 10$	0.216	0.044^{**}
$\beta_{Sym_{13}} = \beta_{Sym_{31}}$	0.001^{**}	$<0.001^{***}$

Notes: Clustered standard errors in parentheses. Subject fixed effects suppressed for brevity. *p<0.1; **p<0.05; ***p<0.01



(a) *Advantaged* (b) *Disadvantaged*

(c) $Sym_{1,1}$ (d) $Sym_{1,3}$ (e) $Sym_{3,1}$

Figure 3: Average Expenditure by District in Stage 1

negative and significant coefficient for $\beta_{Disadvantaged}$ is not consistent with the prediction. Further, as shown in the lower portion of Table 3, the coefficients on $\beta_{Advantaged}$ and $\beta_{Disadvantaged}$ are marginally statistically different; contrary to the theoretical prediction of equal expenditures, disadvantaged players expend less than advantaged players on average. The coefficient for $Sym_{1,3}$ is predicted to be ten, but it is not statistically different from zero and is statistically different from ten. Thus, while $Sym_{1,3}$ is predicted to lead to greater expenditure than $Sym_{1,1}$, it does not. $Sym_{3,1}$ is also predicted to lead to an increase in expenditure relative to $Sym_{1,1}$, which it does as evidence by the positive and significant value for $\beta_{Sym_{31}}$ in Table 3. However, the effect is less than the predicted change of ten, as shown in the lower portion of the table. We also note that, although $Sym_{1,3}$ and $Sym_{3,1}$ are predicted to generate equal expenditures, they do not as shown in the lower portion of Table 3.

Before continuing to Stage 2, we highlight two additional patterns of behavior that we observe in our data. First, Table 2 shows that participants are less likely to make positive expenditures in districts where the equilibrium is positive when competing on $Sym_{3,1}$ than when competing on other maps. One difference between this map and the others is that here players should make positive expenditures on all three districts whereas for the other maps the players should focus on a single district. Further, on $Sym_{3,1}$ the benefit of winning a district depends on the outcome for the other districts. Deck et al. (2017) report that participants in a related situation often focus on forming a minimum winning combination and ignore other elements. In our setting, a minimum winning combination would consist of two of three districts. Further, Deck et al. (2017) report that participants often make nearly equal expenditures across the components of a given minimum winning combination. Our participants also exhibit similar behavior at least to some degree. Nearly one fifth of the time participants make positive expenditures in exactly two of the districts.[3] Further, even when they do make positive expenditures in all three districts, the amount spent in one of the districts is often minimal in comparison to what is expended in the other two districts. These patterns can be seen in Figure 4, which is a scatter-plot of the median district expenditure relative to total expenditure versus the maximum district expenditure relative to total expenditure.[4] Observations near $(0.5, 0.5)$ are evidence of participants pursuing a minimal winning combination. The cluster located at $(0.3\overline{3}, 0.3\overline{3})$ are observations that are consistent with equilibrium behavior, at least in terms of the relative expenditures across districts.

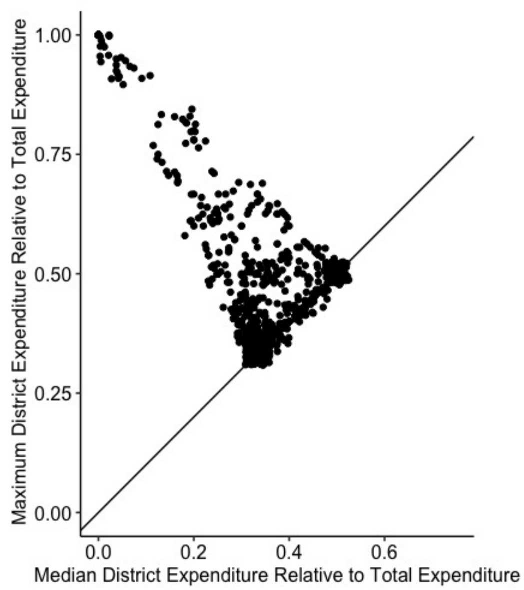


Figure 4: Scatter-Plot of Relative District Level Expenditures in $Sym_{3,1}$

Finally, based on the average observed expenditure by the advantaged and disadvantaged player in the White district as reported in Table 2, one would expect the advantaged player to win 76% of the time. This number is virtually identical to the predicted result that the advantaged player has a 75% chance of winning the overall contest. However, we actually observe the advantaged player only winning 55% of the time. This is because the disadvantaged player is both more likely to make a very low expenditure in the White district and more likely to make a very large expenditure in the White district. That the distribution of expenditure by the advantaged player second order stochastically

[3]Only three percent of the time do participants make positive expenditures in only one of three districts in $Sym_{3,1}$ and only eight percent of the time do participants make zero expenditure on all three districts in $Sym_{3,1}$.

[4]Because of the large number observations at both $(0.3\overline{3}, 0.3\overline{3})$ and $(0.5, 0.5)$, the plot includes jitter with a parameter of 0.01.

dominates the the distribution of expenditure by the disadvantaged player as shown in Figure 5. A Kolmogorov-Smirnov test indicates confirms that these two distributions differ (p-value < 0.001).

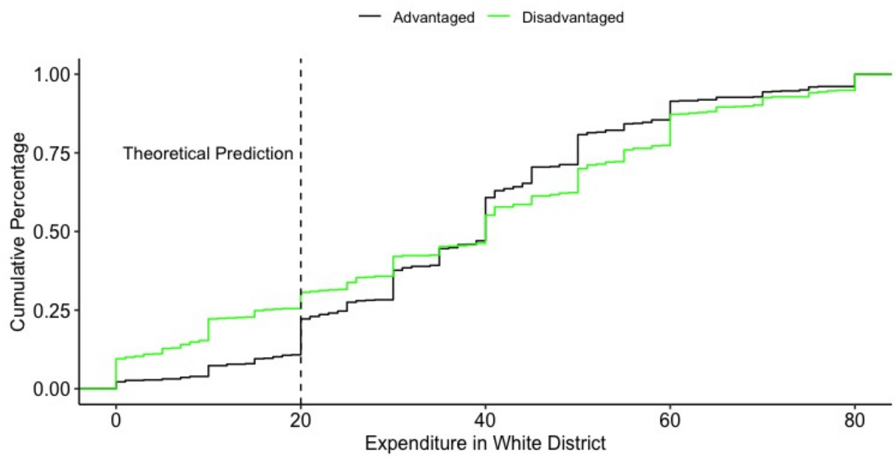


Figure 5: Expenditure Distribution in Competitive District of Gerrymandered Map

4.2 Stage 2

The focus of Stage 2 is to identify what maps participants prefer.[5] As subjects faced the decision three times in Stage 2, we assume a subject's modal response indicates their preferred map.[6] As revealed in Figure 6 over 60% of the participants favored a map that was gerrymandered to provide an advantage in their own favor. Statistically, map preferences are not random (p-value for chi-squared test < 0.001).

Despite a clear willingness by most participants to engage in gerrymandering, in the post-study survey over 95% of the participants indicated they were opposed to gerrymandering. In fact, professed opposition to gerrymandering and willingness to gerrymander are independent (p-value for chi-squared test $= 0.984$). The post study survey also asked participants to self-identify their political leanings on a 9-point scale from far left ($= 1$) to far right ($= 9$). Figure 7 shows both the political leanings and support for gerrymandering among those participants who did and those who did not engage in gerrymandering. From this figure there is suggestive evidence that professed opposition to gerrymandering might vary with political leanings with those on the right being relatively

[5]Appendix B provides analysis of expenditures on maps during Stage 2. The relative patterns between maps are similar to those reported for Stage 1.

[6]Eleven subjects did not select a map at least twice in Stage 2 and thus did not have a unique modal response. For these subjects we assume the map selected in the last period of the stage was their preferred map.

more supportive. However, this relationship is not significant (p-value for chi-square test = 0.108).[7] What is clear from Figure 7 is that one's willingness to actually engage in gerrymandering does not depend on one's political leanings (p-value for chi-square test = 0.311).

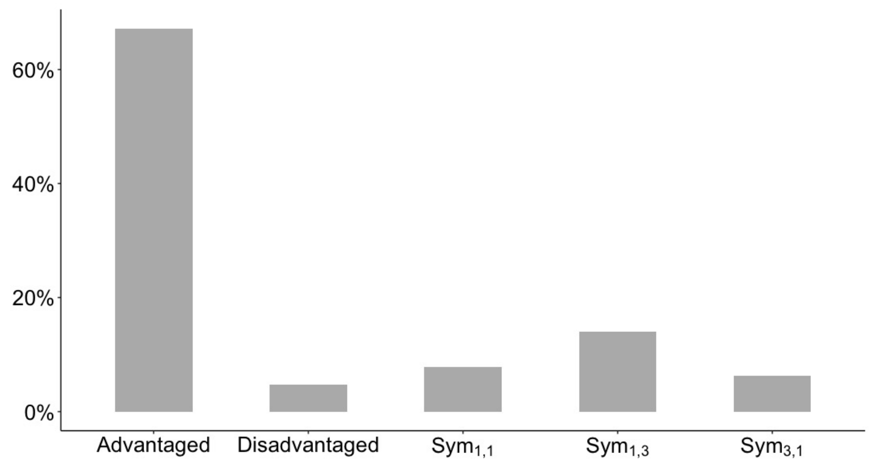


Figure 6: Map Preference in Stage 2

4.3 Stage 3

Stage 3 consists of a single period and differs from Stage 2 only in that participants are asked to indicate a map preference before learning if they were going to be Player A or Player B. That is, map selection occurred behind a veil of ignorance. In a reversal from Stage 2, in Stage 3 about three-quarters of the participants indicate a preference for a symmetric map, see Figure 8.[8] We also note that map selection in Stage 3 is not random (p-value for chis-squared test = 0.026). Interestingly, the most commonly preferred map in Stage 3 was $Sym_{1,3}$ rather than $Sym_{1,1}$, which theoretically yields the largest expected payoff among the symmetric maps. However, as noted when discussing Stage 1 behavior, total expenditures did not differ substantially between $Sym_{1,3}$ and $Sym_{1,3}$ making these choices empirically equally profitable. It is also worth recalling that a gerrymandered maps result in lower average expenditures (see Table 2) and thus empirically has the greatest expected payoff *a priori*, which may explain why some people continue to prefer it in Stage 3.

[7] One should be cautious in interpreting the results of this test as there are only three participants who report supporting gerrymandering.

[8] One subject did not indicate a preference for a map in Stage 3 because this subject left the lab to use the restroom.

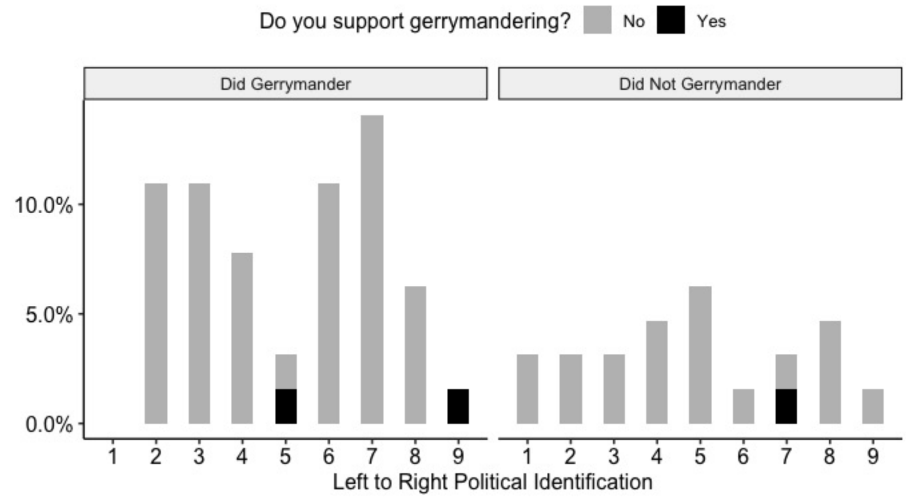


Figure 7: Political Leaning and Gerrymandering

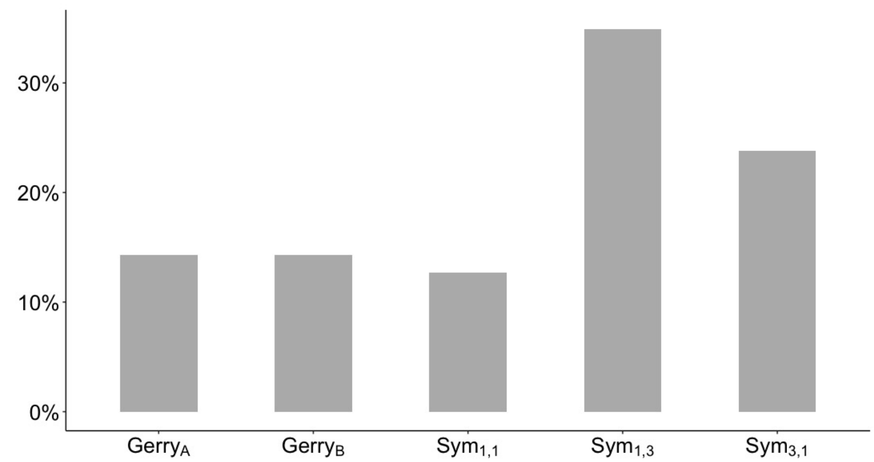


Figure 8: Map Preference in Stage 3

5 Conclusion

Gerrymandering has received considerable attention in the popular press, but far less attention in the economics literature. Our work builds on the relatively literature that views gerrymandering as a strategic decision. However, unlike most of previous models that view gerrymandering as a game against nature, we consider mapping of political boundaries as the first stage in a two stage game against another player. Specifically, we assume that after boundaries are drawn the parties compete using a winner-take-all proportional contest success function for the undecided voters within a district while attempting to claim the most districts. Depending on how the political map is drawn determines if the second stage becomes a standard Tullock contest, a best-of contest, or a weak-link contest. We find the familiar result that a player's preferred map involves packing rival partisans and cracking one's own partisans.

In our controlled laboratory experiment, our participants overwhelmingly attempt to engage in shaping a contest in a self-interested manner despite claims that they do not support gerrymandering. The lack of stated support for gerrymandering and the willingness to engage in it do not depend on political leanings. However, when operating behind a veil of ignorance our participants are far more likely to prefer symmetric maps that do not offer a systematic advantage to any player. While the stakes of our experiment are dramatically different from those in political elections and our subject pool differs from the population of people who draw political districts, our results do highlight the inherent reluctance of those in power to willingly giving up an advantage. As such, gerrymandering is likely to remain a staple of electioneering. But our hope is that our work leads to further behavioral research into the strategic aspects of drawing political boundaries and how this impacts subsequent campaign behavior. That we observe such high levels of endogenous gerrymandering in the lab, suggests the lab offers an appropriate test-bed for policies or practices meant to discourage the practice. More generally, we hope our paper encourages more research that considers how players strategically shape the structure of contests in which they will subsequently participate.

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6 Appendix A: Subject Instructions

This appendix provides the instructions shown to the subjects.

The following pages of instructions was displayed before Stage 3 began.

The following page of instructions was displayed before Stage 2 began. The following page of instructions was displayed before Stage 3 began.

This is a study on the economics of decision making.

In each round of the study you will be randomly matched with another person. No one will ever know the identity of the person with whom they are matched.

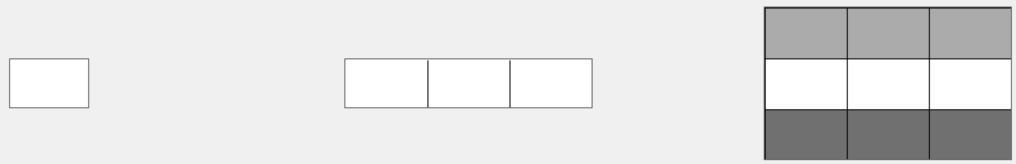
You and the person you are matched with will be competing in a contest for a prize of 80 lab dollars. You will either be Player A or Player B and the person you are matched with (your opponent) will be the other player.

At the end of the study one round will be randomly selected and you will be paid in cash based on your earnings for that round. Lab dollars will be converted into USD at the rate of 4 lab dollars = 1 USD.

You will be given an endowment of 80 lab dollars. Any amount that you spend in the contest will be deducted from this amount and any prize you earn will be added to this amount. One unit of effort will cost 1 lab dollar.

If you have a question at any point please raise your hand and someone will be with you shortly.

Continue



In this study, you will be assigned as Player A or Player B with equal chance.

Players will compete for zones. A **zone** is shown in the top left of the screen. The probability you will win a zone will be determined by the effort you put into the contest, divided by the total effort you and your opponent.

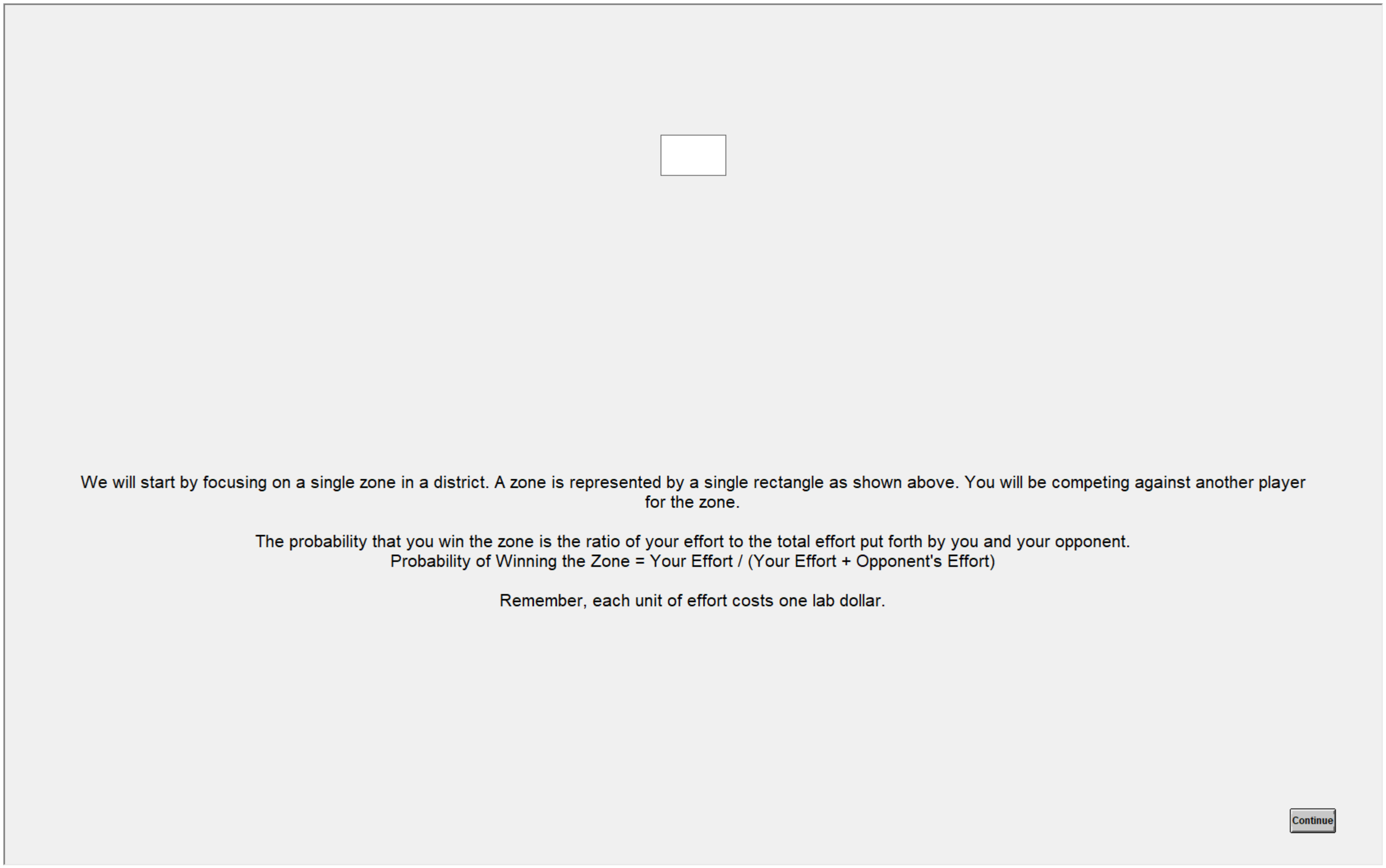
Three zones grouped together make up a **district**, as shown in the top middle of the screen. You will be competing with the other player to win the most districts. To win a district you must win at least 2 out of the 3 zones in that district.

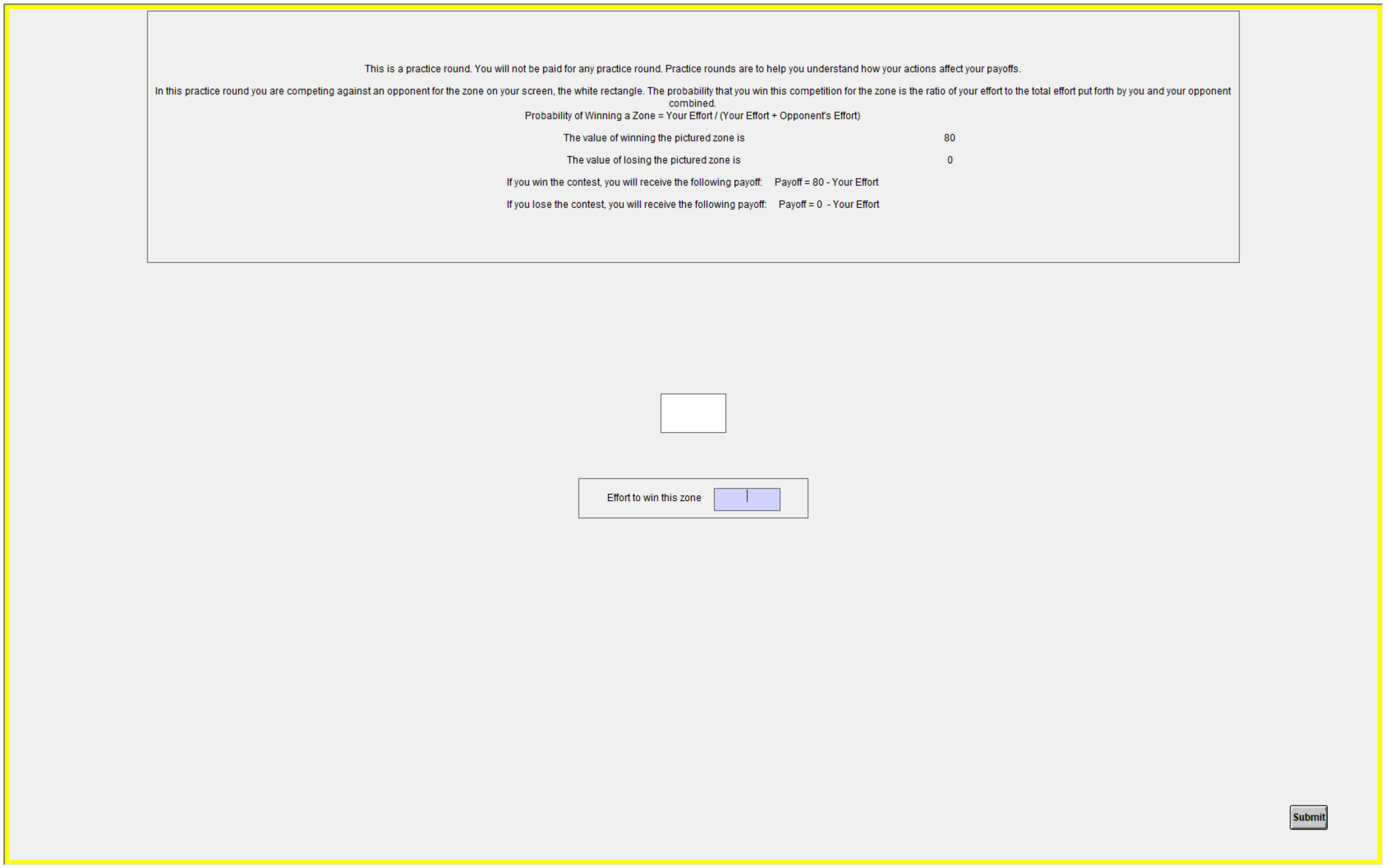
Three districts grouped together make up a **region**, as shown in the top right of the screen. To win the region you must win at least 2 out of the 3 districts.

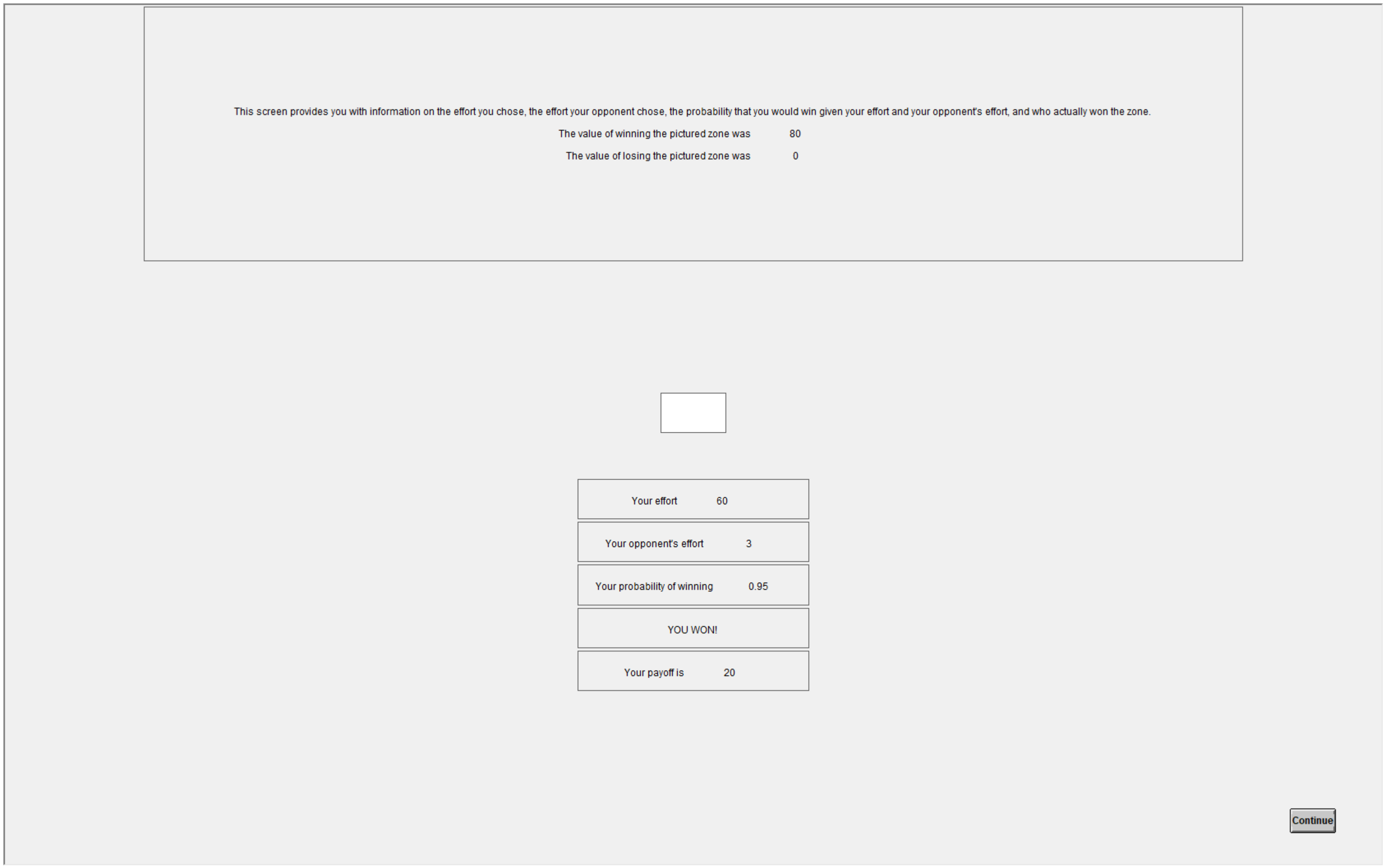
Whichever player wins at least 2 out of the 3 districts in a region will win the prize of 80 lab dollars.

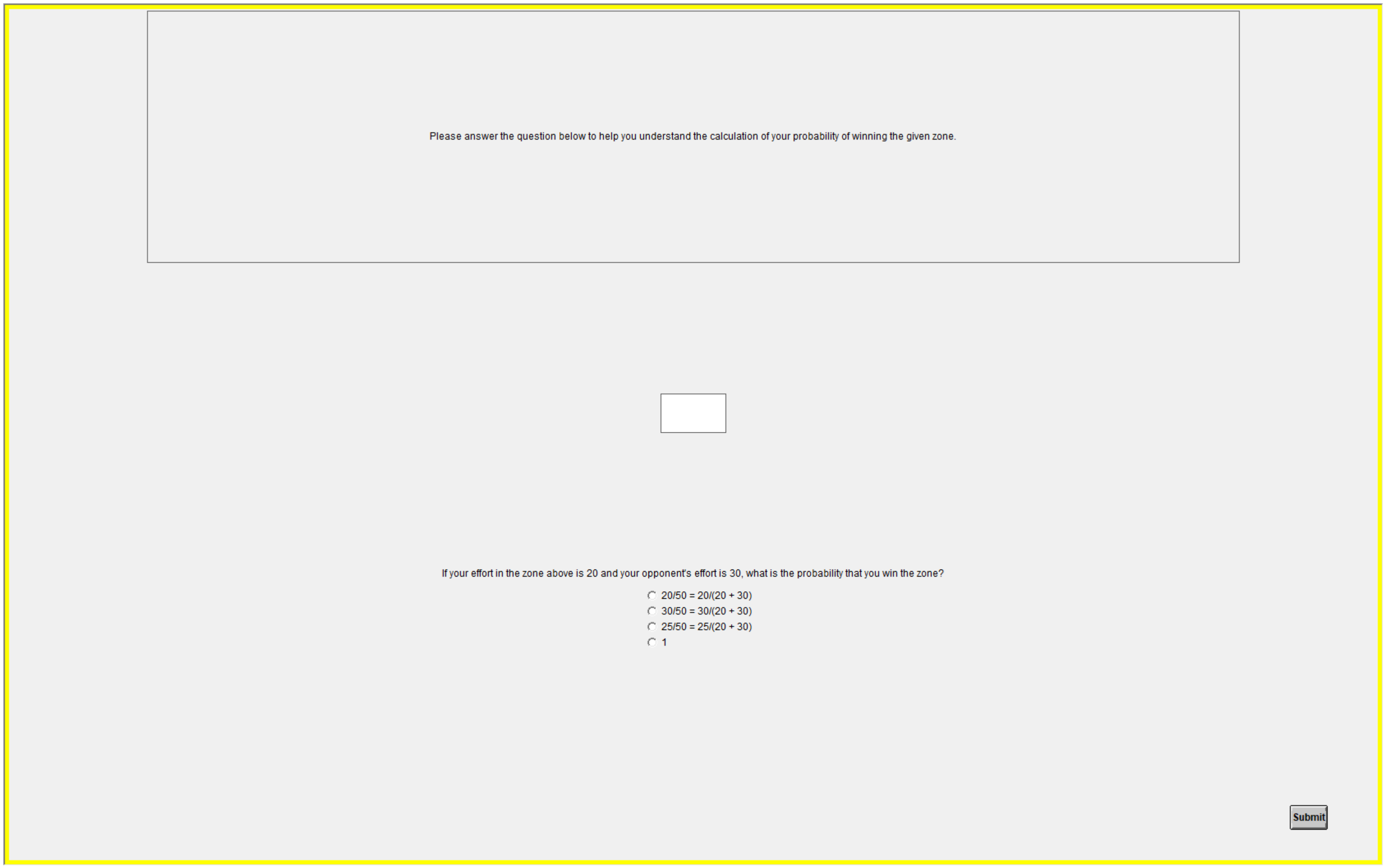
The next few screens will focus on explaining how to win a zone.

Continue


We will start by focusing on a single zone in a district. A zone is represented by a single rectangle as shown above. You will be competing against another player for the zone.
The probability that you win the zone is the ratio of your effort to the total effort put forth by you and your opponent.
Probability of Winning the Zone = Your Effort / (Your Effort + Opponent's Effort)
Remember, each unit of effort costs one lab dollar.
Continue


This is a practice round. You will not be paid for any practice round. Practice rounds are to help you understand how your actions affect your payoffs.
In this practice round you are competing against an opponent for the zone on your screen, the white rectangle. The probability that you win this competition for the zone is the ratio of your effort to the total effort put forth by you and your opponent combined.
Probability of Winning a Zone = Your Effort / (Your Effort + Opponent's Effort)
The value of winning the pictured zone is 80
The value of losing the pictured zone is 0
If you win the contest, you will receive the following payoff: Payoff = 80 - Your Effort
If you lose the contest, you will receive the following payoff: Payoff = 0 - Your Effort
Effort to win this zone
Submit


This screen provides you with information on the effort you chose, the effort your opponent chose, the probability that you would win given your effort and your opponent's effort, and who actually won the zone.
The value of winning the pictured zone was 80
The value of losing the pictured zone was 0
Your effort 60
Your opponent's effort 3
Your probability of winning 0.95
YOU WON!
Your payoff is 20
Continue


Please answer the question below to help you understand the calculation of your probability of winning the given zone.
If your effort in the zone above is 20 and your opponent's effort is 30, what is the probability that you win the zone?
20/50 = 20/(20 + 30)
30/50 = 30/(20 + 30)
25/50 = 25/(20 + 30)
1
Submit

Now we will focus on a single **district**. Note, a single district is made up of 3 zones, as shown above.

In order to win a district, you must win at least 2 of the 3 zones in that district.

The effort you choose for the district will be applied to each of the zones in the district. The winner of each zone is determined as described previously. Each outcome of each zone in the district is independent.

Remember, the probability that you win a zone in the district is
Probability of Winning a Zone in the District = (Your Effort for the District) / (Your Effort for the District + Opponent's Effort for the District)

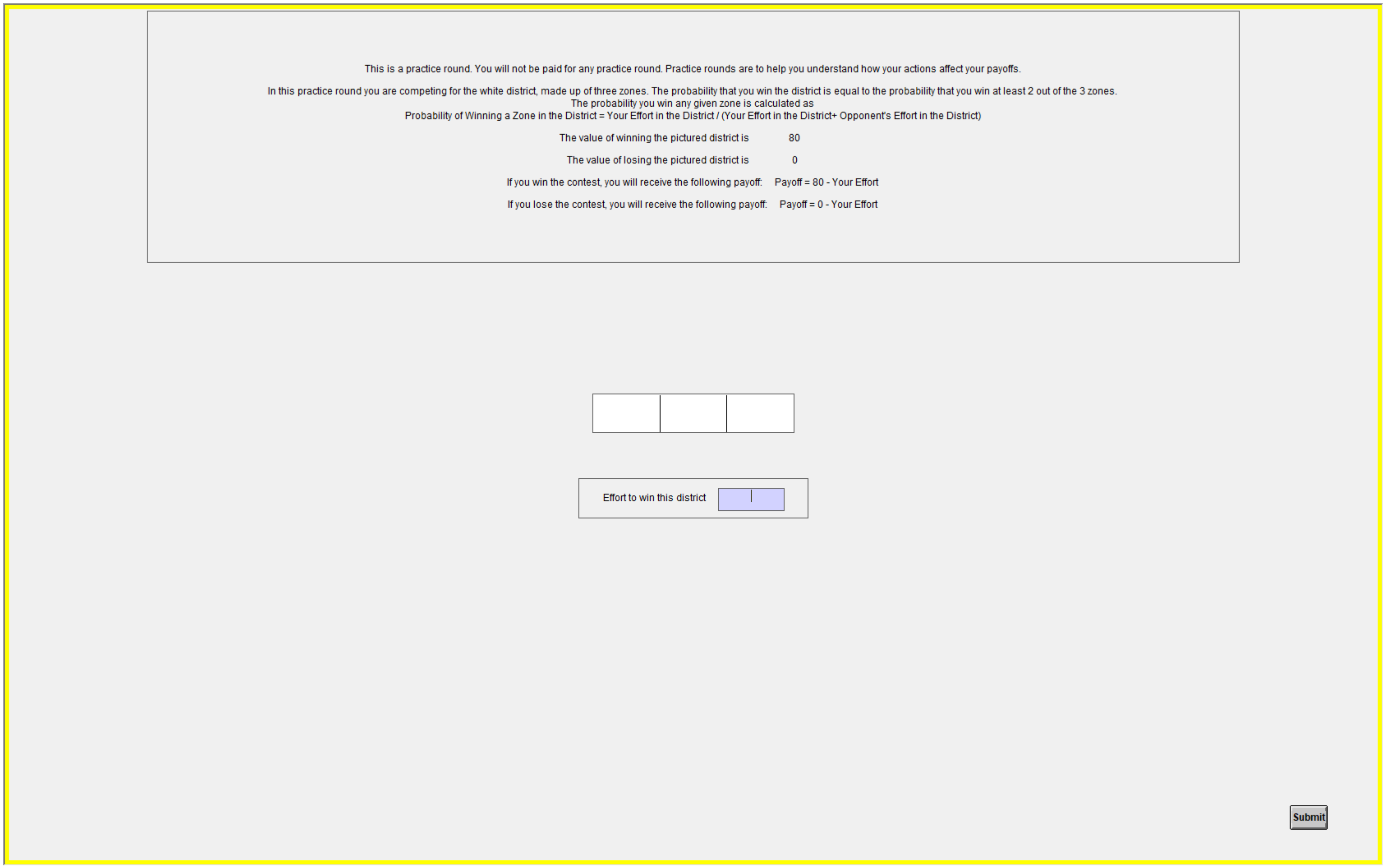
Recall, each unit of effort costs one lab dollar. Your cost depends on the effort you choose for the district. So, if you choose an effort of 50 for the district, that will cost you 50 lab dollars. You do not pay the effort cost for each zone separately.

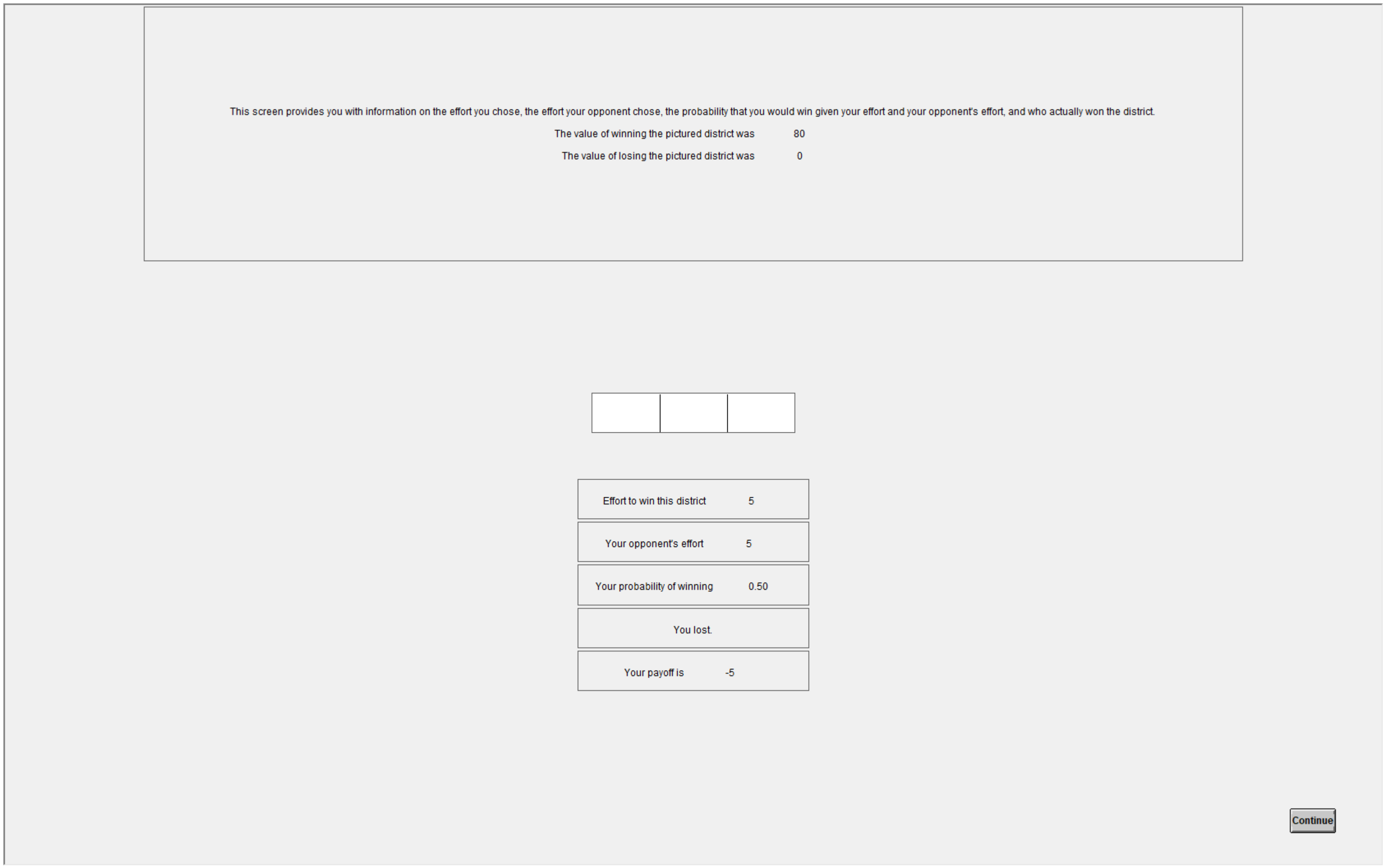
Continue

To help you understand how districts are won, consider the following scenarios depicted below. Each district is a different scenario in which zones have already been won by either Player A or Player B.

A	A	A	Player A won at least 2 zones so they win the district
A	A	B	Player A won at least 2 zones so they win the district
A	B	B	Player B won at least 2 zones so they win the district
B	B	B	Player B won at least 2 zones so they win the district
B	A	B	Player B won at least 2 zones so they win the district
A	B	A	Player A won at least 2 zones so they win the district
B	B	A	Player B won at least 2 zones so they win the district
B	A	A	Player A won at least 2 zones so they win the district

Continue


This is a practice round. You will not be paid for any practice round. Practice rounds are to help you understand how your actions affect your payoffs.
In this practice round you are competing for the white district, made up of three zones. The probability that you win the district is equal to the probability that you win at least 2 out of the 3 zones.
The probability you win any given zone is calculated as
Probability of Winning a Zone in the District = Your Effort in the District / (Your Effort in the District+ Opponent's Effort in the District)
The value of winning the pictured district is 80
The value of losing the pictured district is 0
If you win the contest, you will receive the following payoff: Payoff = 80 - Your Effort
If you lose the contest, you will receive the following payoff: Payoff = 0 - Your Effort
Effort to win this district
Submit

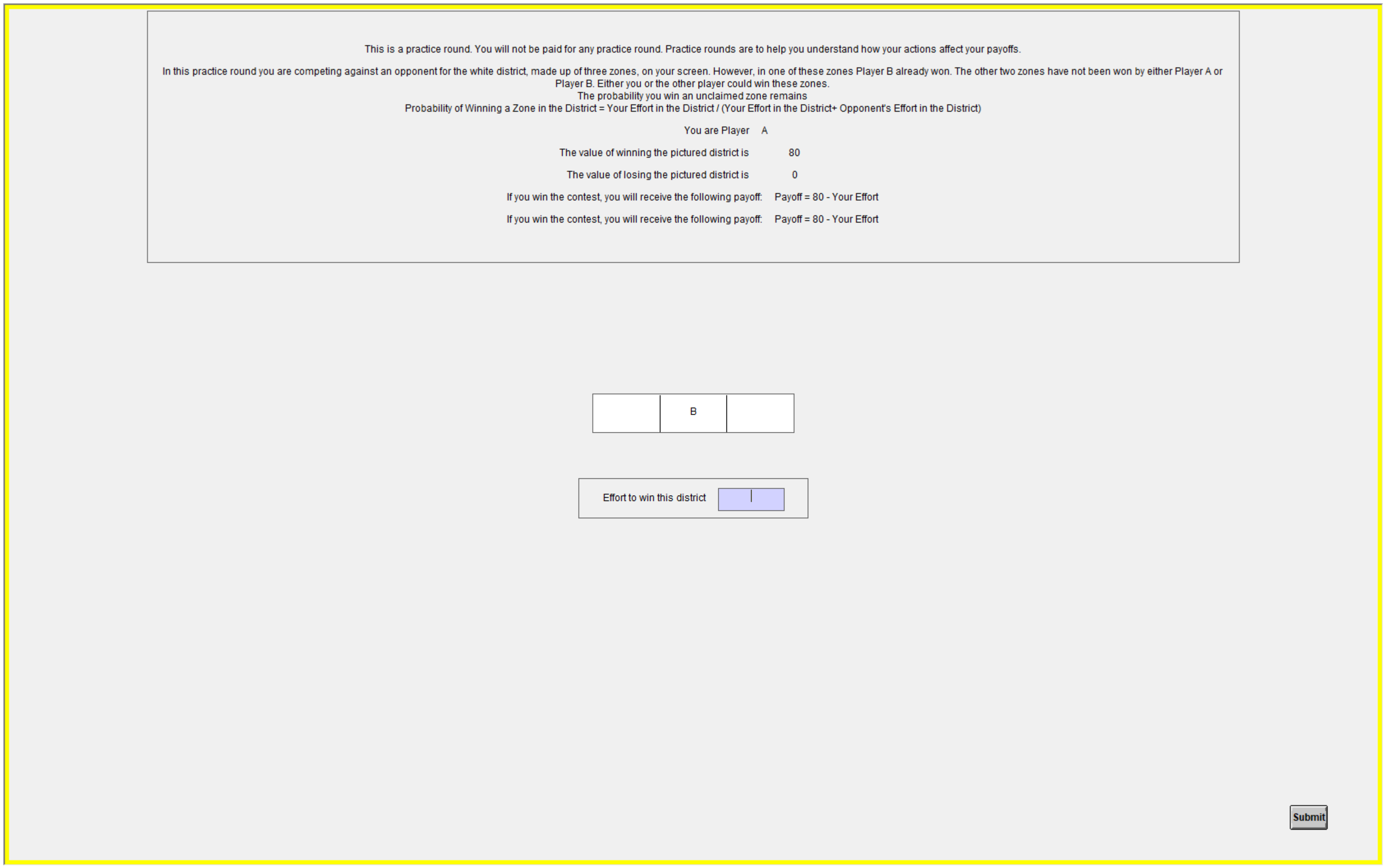

This screen provides you with information on the effort you chose, the effort your opponent chose, the probability that you would win given your effort and your opponent's effort, and who actually won the district.
The value of winning the pictured district was 80
The value of losing the pictured district was 0
Effort to win this district 5
Your opponent's effort 5
Your probability of winning 0.50
You lost.
Your payoff is -5
Continue

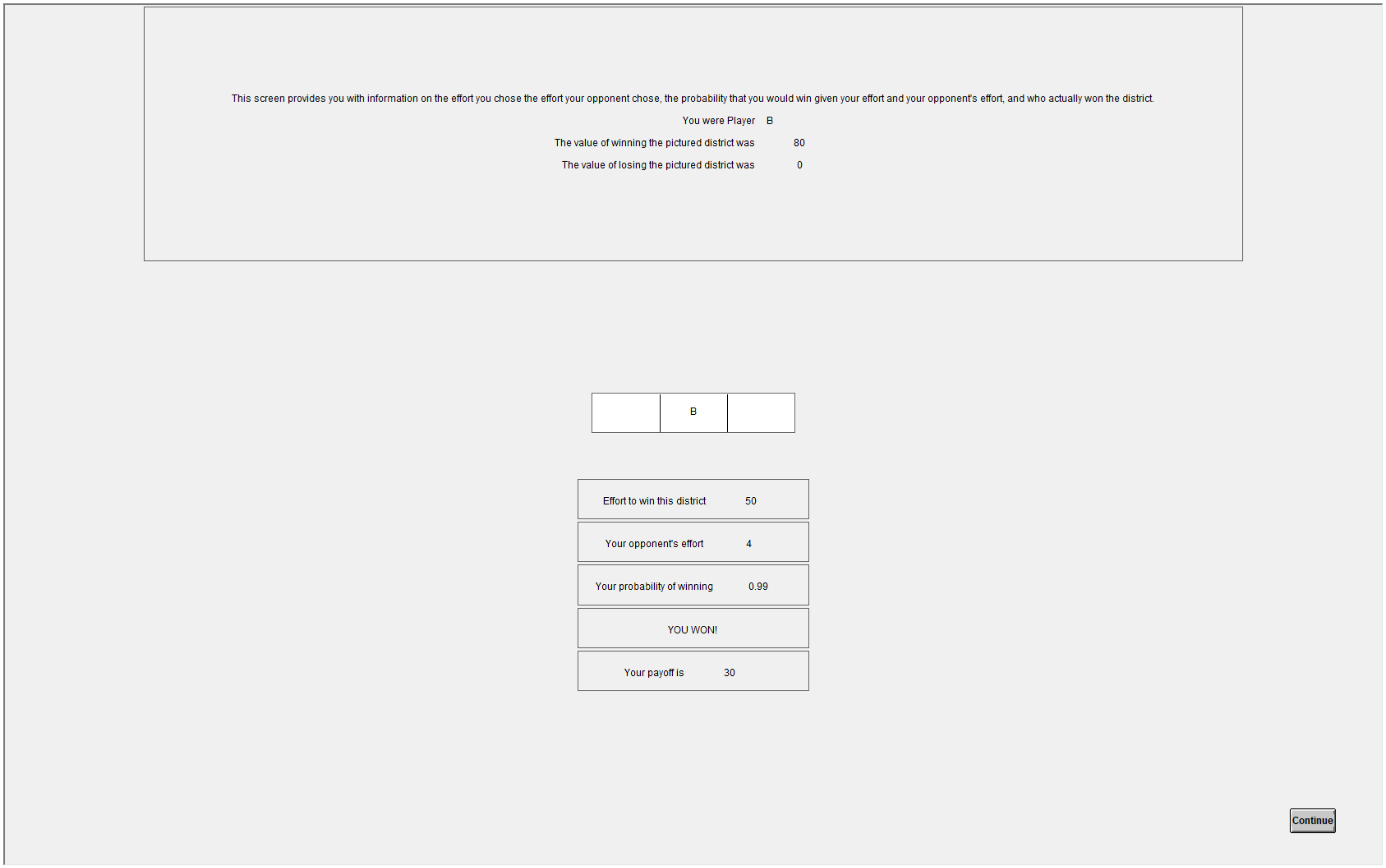
Please answer the question below to help you understand the calculation of your probability of winning the white district. The probability that you win the contest for the district is equal to the probability that you win at least 2 out of the 3 zones.

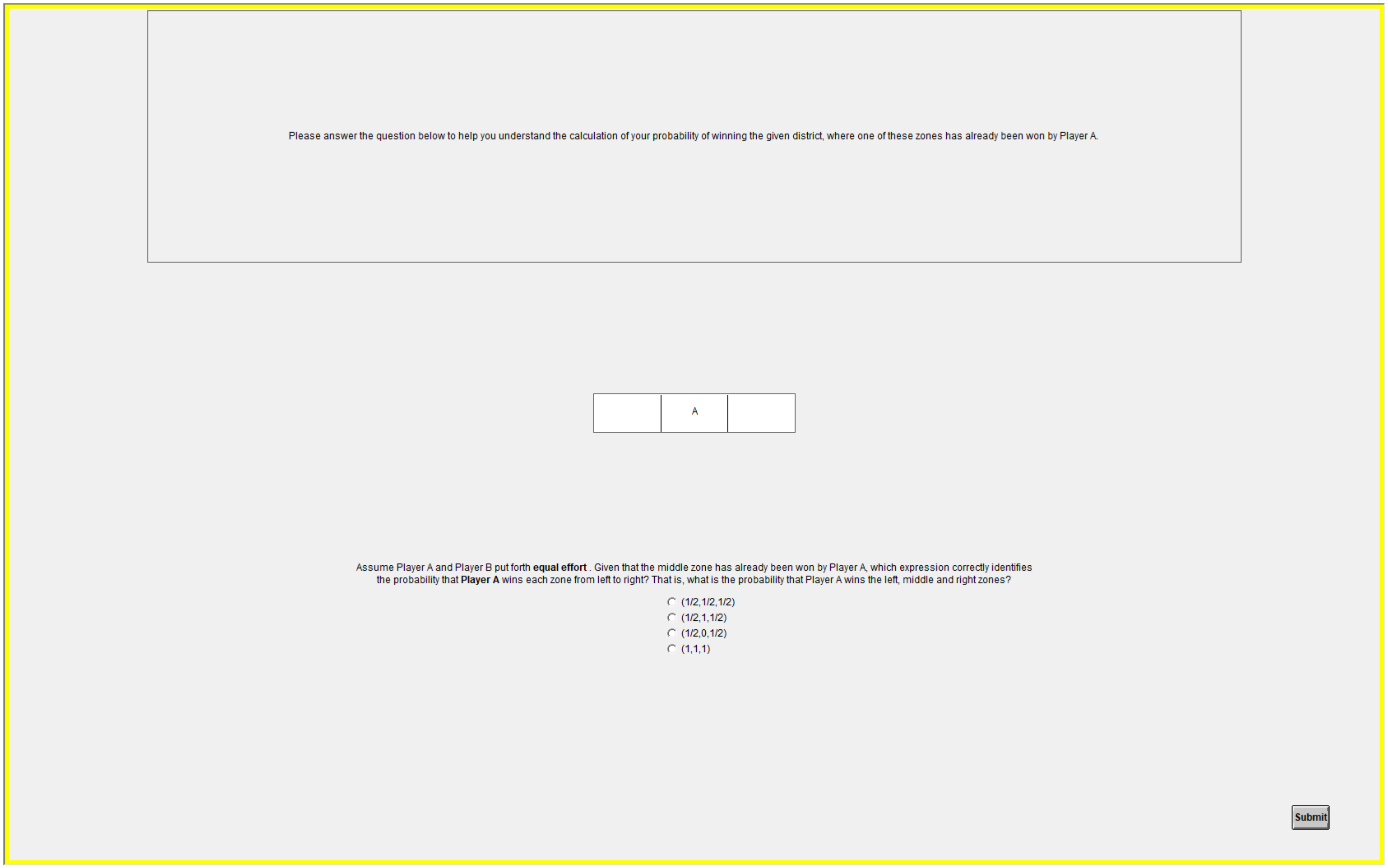
If your effort in the white district above is 10 and your opponent's effort is 40, which expression correctly identifies the probability that you win each individual zone within the district?

- ○ 40/50 = 40/(10 + 40)
- ○ 10/50 = 10/(10 + 40)
- ○ 30/50 = 30/(10 + 40)
- ○ 1

Submit


This is a practice round. You will not be paid for any practice round. Practice rounds are to help you understand how your actions affect your payoffs.
In this practice round you are competing against an opponent for the white district, made up of three zones, on your screen. However, in one of these zones Player B already won. The other two zones have not been won by either Player A or Player B. Either you or the other player could win these zones.
The probability you win an unclaimed zone remains
Probability of Winning a Zone in the District = Your Effort in the District / (Your Effort in the District+ Opponent's Effort in the District)
You are Player A
The value of winning the pictured district is 80
The value of losing the pictured district is 0
If you win the contest, you will receive the following payoff: Payoff = 80 - Your Effort
If you win the contest, you will receive the following payoff: Payoff = 80 - Your Effort
B
Effort to win this district
Submit


This screen provides you with information on the effort you chose the effort your opponent chose, the probability that you would win given your effort and your opponent's effort, and who actually won the district.
You were Player B
The value of winning the pictured district was 80
The value of losing the pictured district was 0
B
Effort to win this district 50
Your opponent's effort 4
Your probability of winning 0.99
YOU WON!
Your payoff is 30
Continue



Please answer the question below to help you understand the calculation of your probability of winning the given district, where one of these zones has already been won by Player A.
A
Assume Player A and Player B put forth **equal effort** . Given that the middle zone has already been won by Player A, which expression correctly identifies the probability that **Player A** wins each zone from left to right? That is, what is the probability that Player A wins the left, middle and right zones?
(1/2,1/2,1/2)
(1/2,1,1/2)
(1/2,0,1/2)
(1,1,1)
Submit

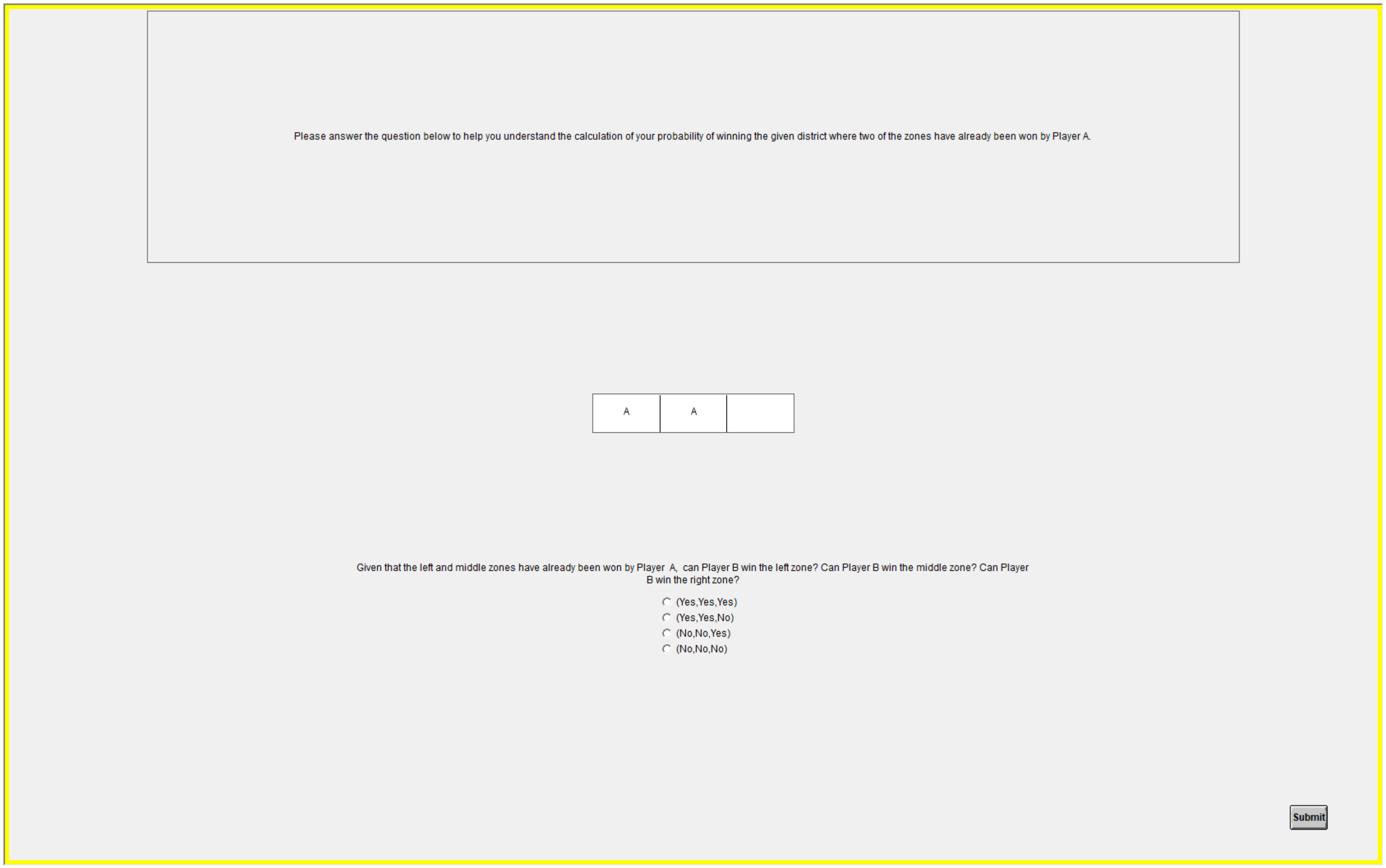
Please answer the question below to help you understand the calculation of your probability of winning the given district, where one of these zones has already been won by Player B.

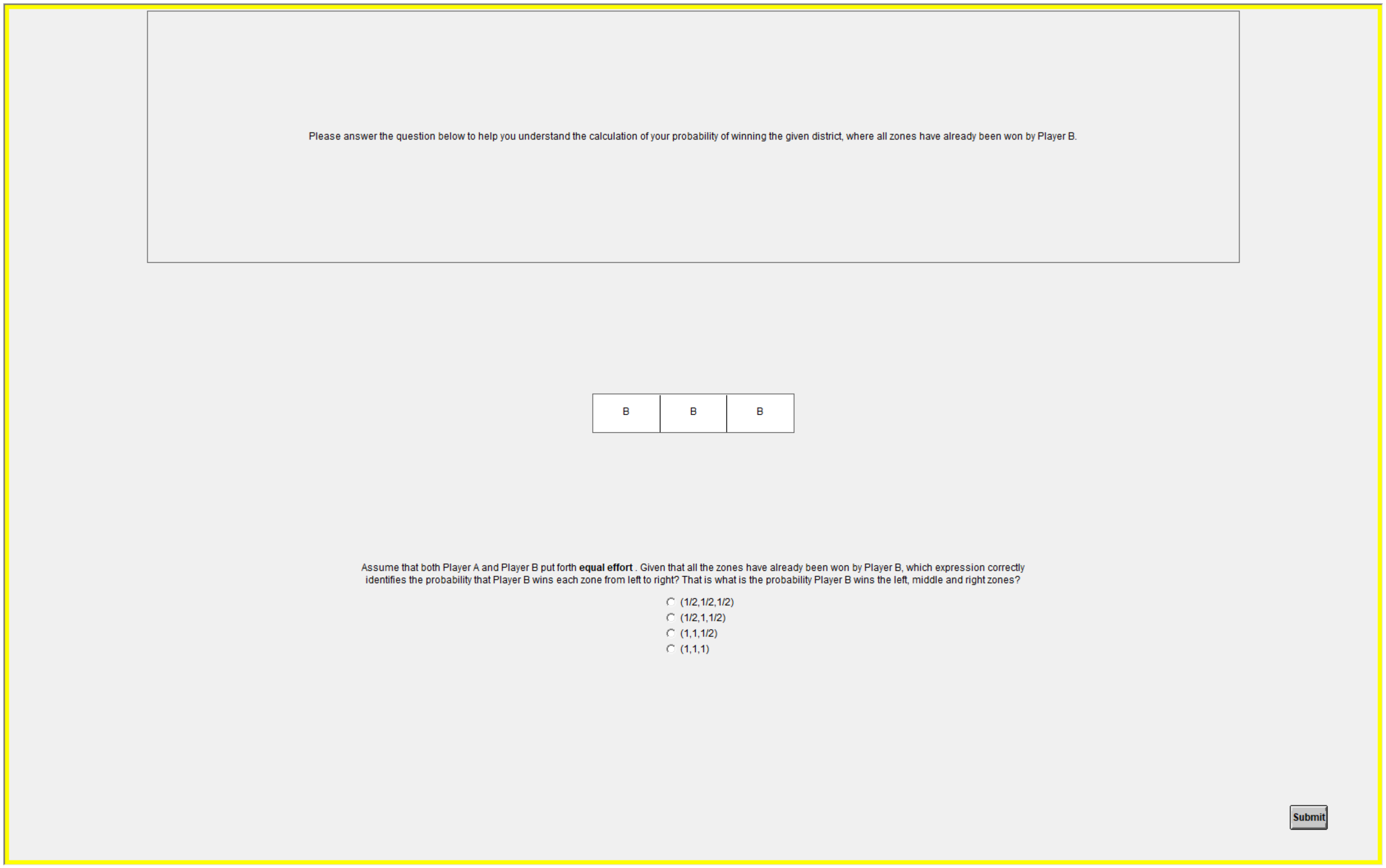
	B	

If both Player A and Player B put forth efforts of 5, which player has the greater probability of winning the district?

- Player A
- Player B
- Both are equally likely to win

Submit


Please answer the question below to help you understand the calculation of your probability of winning the given district where two of the zones have already been won by Player A.
A
A
Given that the left and middle zones have already been won by Player A, can Player B win the left zone? Can Player B win the middle zone? Can Player B win the right zone?
(Yes,Yes,Yes)
(Yes,Yes,No)
(No,No,Yes)
(No,No,No)
Submit


Please answer the question below to help you understand the calculation of your probability of winning the given district, where all zones have already been won by Player B.
B
B
B
Assume that both Player A and Player B put forth **equal effort** . Given that all the zones have already been won by Player B, which expression correctly identifies the probability that Player B wins each zone from left to right? That is what is the probability Player B wins the left, middle and right zones?
(1/2,1/2,1/2)
(1/2,1,1/2)
(1,1,1/2)
(1,1,1)
Submit

A	A	
A		B
	B	B

Now we will focus on **regions**. Note, the region is made up of 3 districts as shown above. The 3 districts are Light Grey, White, and Dark Grey.

In order to win the region you must win at least 2 of the 3 districts in the region. You and your opponent will each choose effort for the Light Grey district, for the White district, and for the Dark Grey district. Your effort can be different for each district, but the sum of those efforts cannot exceed the 80 lab dollar prize. Keep in mind that whatever effort you select for a district, that amount will be deducted from your endowment regardless of whether you win the region or not.

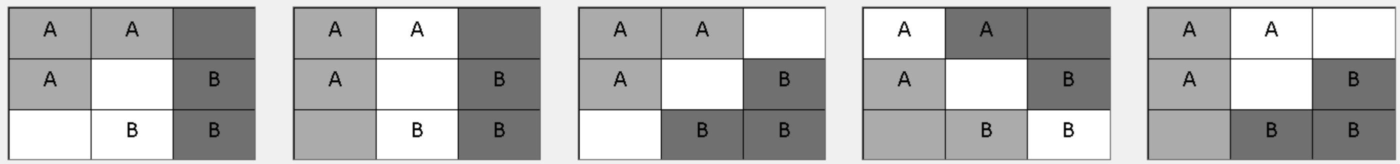
Continue

A	A	
A		B
	B	B

What is the minimum number of districts you must win in order to win the region?

- 0
- 1
- 2
- 3

Continue



There are many different ways to divide up the region. These different ways to divide the region are referred to as **maps**.

The maps shown differ based on how the districts are drawn. Please note that the number of zones already won by either Player A or Player B may not be equivalent in each district depending on which map you are considering.

You will be asked to choose effort for each district for all five maps shown above. One map will be selected at random, with each map being equally likely to be chosen, and the outcome for that randomly selected map will be the one that counts as your payoff. The randomly selected round will be highlighted in yellow when you see the results of the contest. It is important that you choose your effort carefully for all 3 districts for all 5 maps since you do not know which map will actually be used to determine your payoff.

Continue

The remaining rounds may count towards your payoff. One round will be chosen at random and you will receive that payoff for that round. Any round is equally likely to be chosen as the paid round.

Each round, you and your opponent will be given an endowment of 80 for each map to use as effort in each contest. Endowments do not carry over to other rounds. Endowments are exclusive to each map. Therefore, the maximum effort you may put forth in any one map is 80. Each unit of effort costs 1 lab dollar.

Continue

In the subsequent rounds, you and your opponent will have to choose efforts for each district in each map. **Moving forward, you will also choose the map on which you would like to compete. Your opponent will do the same. After you have made your choices of (1) preferred map and (2) efforts, either the map you selected or the map your opponent selected will be chosen as the map which will determine your payoff for the round. It is equally likely that the map you choose or the map your opponent chooses will be used to determine your payoff.** Since you do not know what map your opponent might choose, you should choose your effort carefully for each district for each map because any map could be the one selected.

Continue

Starting in the next round, you will be randomly assigned to a Player each round. However, you will not know what player you are when you are asked to select a map.

After you make your map selection the computer will randomly pick either the map you selected or the map your opponent selected, but the selected map will not be revealed to either you or your opponent.

You will then learn which player you are, and be asked to choose your effort for each district for each map. Since you do not know what map your opponent might choose, you should choose your effort carefully for each district for each map because any map could be the one selected.

Continue

7 Appendix B: Additional Analysis

This appendix provides the additional analysis mentioned in the main body of the paper. The first subsection evaluates the impact of being labeled as Player A or Player B in strategically equivalent situations. The second subsection compares expenditures in Stage 2 with those in Stage 1.

7.1 Impact of Role Assignment

The following tables report coefficients on being randomly assigned the B role using district level regression analysis with standard errors clustered at the session level. Subject level random effects are used because player roles are fixed during Stage 1. Over all there is little statistical difference between roles although in gerrymandered maps there are some differences. Most notably, Player Bs tend to spend less in the white district where there is one partisan regardless of whether or not the B player is advantaged or disadvantaged. However, the difference is small relative to the magnitude of expenditures in the white district on competitive maps.

Table 4: Effect of Player B on Bidding in Advantaged

	Three Partisan Against	Two Partisan For	One Partisan For
Advantaged	1.45^{**}	3.70^{**}	-4.33^{*}
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 5: Effect of Player B on Bidding in Disadvantaged

	Three Partisan For	Two Partisan Against	One Partisan Against
Disadvantaged	3.15	2.02	-4.65^{**}
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 6: Effect of Player B on Bidding in Symmetric Maps

	D Player A to L Player B	L Player A to D Player B	W for Both Players
$Sym_{1,1}$	0.39	3.48	-3.17
$Sym_{1,3}$	0.58	3.45	-2.89
$Sym_{3,1}$	1.67	-0.36	-0.89
Note:	*p<0.1; **p<0.05; ***p<0.01		

7.2 Expenditures in Stage 2

The regression results reported in Table 7 replicates the analysis presented in Table 3, but includes expenditures in Stage 2 as well as Stage 1. A dummy variable for Stage 2 is included and this term is interacted with each of the treatment variables. The negative coefficient for β_{Stage2} suggests that expenditures are lower in Stage 2 than in Stage 1, continuing the trend noted in the paper that expenditures fell over the course of Stage 1. The only significant interaction term between the Stage 2 dummy variable and a map variable is for players in the advantaged position of a gerrymandered map. This indicates the reduction in expenditure when advancing to Stage 2 is smaller for the Advantaged map than the others (estimated change for Advantaged map is $\beta_{Stage2} + \beta_{Adv \times Stage2} = -3.190$). However, the general conclusions about relative expenditures across maps are similar to those reported in Table 3.

Table 7: Comparison of Total Expenditure Across Maps for Stages 1 and 2

	Dependent Variable: Total Expenditure	
	Periods 1 - 13	Periods 6 - 13
	(1)	(2)
$\beta_{Advantaged}$	-1.470^{*} (1.223)	-1.547 (1.581)
$\beta_{Disadvantaged}$	-3.656^{**} (1.727)	-4.425^{***} (1.506)
$\beta_{Sym_{1,3}}$	1.417^{**} (0.655)	1.172 (0.782)
$\beta_{Sym_{3,1}}$	7.189^{**} (2.268)	6.666^{***} (2.246)
β_{Stage2}	-5.405^{**} (1.741)	-4.271^{***} (0.992)
$\beta_{Adv \times Stage2}$	2.215^{**} (0.959)	2.292^{**} (1.058)
$\beta_{Disadv \times Stage2}$	0.224 (1.341)	0.993 (1.725)
$\beta_{Sym_{1,3} \times Stage2}$	0.822 (0.905)	1.068 (0.797)
$\beta_{Sym_{3,1} \times Stage2}$	-2.408 (2.154)	-1.884 (1.942)
β_0	38.543^{***} (0.985)	30.168^{***} (0.795)
Observations	4,160	2,560
R^2	0.558	0.642
Adjusted R^2	0.551	0.632
Residual Std. Error	14.864 (df = 4087)	13.264 (df = 2487)
F Statistic	71.773^{***} (df = 72; 4087)	62.021^{***} (df = 72; 2487)
Note:		*p<0.1; **p<0.05; ***p<0.01