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How to Visualise Decision-Making using Preferential Voting

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Abstract

People make decisions every day, some by themselves, others within a group. Making a decision with a group can be hard and harsh. The eventual decision can feel unfair to part of the group. We look at situations where groups make organised joint decisions – group decision-making events – in which all participants can indicate multiple preferences – preferential voting. We give an overview of relevant and representative voting methodologies to indicate which can be used for preferential group decision-making events. To make suggestions to improve the comprehensibility of ballots, we describe different models of the relations between options in decision-making and give examples supporting these models. We use research on elections and ballot design in multiple countries and research from other disciplines to improve a variety of decision-making examples. Finally, we combine our findings in a new type of ballot designed to help voters by showing intermediate results and additional information, the Interactive Preference Ballot. Our conclusion shows that graphic interactive preference ballots – in combination with a methodology that supports the form of the desired result – can improve the accessibility, effectiveness and fairness of group decision-making.

Contents

Chapter 1

Introduction

Everyone has an opinion nowadays; in contrast to a decade ago, the possibility of sharing this opinion with a large public has grown on social media, during manifestations and protests or by correspondence with those in charge of the specific subject. Moreover, in society, the call for more influence on big decisions made by the government increases; referenda and preferenda are potential serious options to do this. Between 2015 and 2018, three national preferenda were held in the Netherlands. Unfortunately, some say, fortunately, in 2018, the legal possibility of having a referendum was abolished [8].

David Van Reybrouck [29, 30] argues that the United Kingdom might not have left the European Union if the UK government had not asked their citizens 'Remain' or 'Leave' in a referendum but instead held a preferendum and given multiple different options between the two extremes. Van Reybrouck also suggests using preferenda to increase citizen participation regarding decisions on climate policy. He is not the first to suggest using referenda and preferenda in the Netherlands for important *life-changing* decisions. In 2007 the 'Wetenschappelijke Raad voor het Regeringsbeleid' (WRR) wrote about the Netherlands in Europe [31] and called the preferendum an opportunity to increase direct democracy and citizen participation. They also argue that citizens must be included in such events preparations to ask the correct questions and have sufficiently and correctly formulated options from which to choose.

Asking for an opinion while narrowing the answer to two predefined possibilities gives little room for one's opinion. Yet, this is the way a referendum works. Giving only two options, **A** or **B**, **Yes** or **No**, **Remain** or **Leave** or **Park** or **Playground** gives an answer to which is preferred by the group participating in your referendum, but not by how much it is preferred over the other.

Suppose we do know the strength of preference in a vote. Say that out of 35 people, 19 very slightly prefer option **A** to option **B**, while the remaining 16 very strongly prefer **B** to **A**. It might seem fair to say that **A** is the way to go because this is what the majority wants, yet option **B** will be the fairer choice here. Of the people involved, not only the 16 with the strong preference will be satisfied, but also those with a slight preference for the latter.

A more striking example is picking a restaurant for tonight. Say Bob goes to dinner with Alice and Charlie, and the options considered for the evening are sushi and pizza. Since the sushi restaurant is new and Alice heard great stories about it, both Alice and Charlie would like to go there. But Bob *strongly* prefers pizza because he doesn't like to eat fish and, therefore, most sushi. If the three friends would "take a vote" and follow the majority, Bob's evening wouldn't be very comfortable or satisfying, going to the sushi restaurant and dismissing a great part of the available food. But using the strength of preference – which can already be seen and heard in the phrasing of the choices – all friends would have a pleasant evening eating in the pizza restaurant.

What happens on the National level is also relevant on a smaller scale. Lower governments and provincial- and municipal governments increasingly ask their citizens for input. Because if they don't, action committees ensure that a lot of work has to be done again or was in vain. Examples of these situations are the choices for temporary shelter for refugees[1], wind farm locations[2] or the data centre in Zeewolde in 2022[3].

Outside the government, there is also an increasing need and demand for high levels of participation. For example, associations – in the Nederlands very often run by volunteers – get more serious responsibilities due to the new law[4] introduced in 2020. And last but not least, in families, the input of all family members is asked, but also given more often due to the influence of social media, the changes in the raising of children and the increased vitality and participation of elderly citizens.

[1] `https://nos.nl/artikel/2434346`
[2] `https://nos.nl/artikel/2378005`
[3] `https://nos.nl/artikel/2421747`
[4] Wet Bestuur en Toezicht

Related Work

Despite various studies about situations where decision-making went wrong, there are no actual suggestions for improving both the design and visualisation of the options in decision-making events. Many scholars, political experts and journalists wrote about the 2016 Brexit referendum in the United Kingdom. Bush [3] reasons about what would happen if a new referendum would be held among citizens that are tired of discussions. Menon [19] argues that the two available options – 'Leave' and 'Remain' – leave too much room for implementation after the decision is made. While Oliver [21] states that voters misuse referenda in general, to 'punish' governments for other decisions they don't agree on, which are not part of the referendum. But also about the misuse by political leaders to push through decisions for which their opponents have little arguments with sentimental worth, making it very hard to inform voters from their side.

Pachón and Pichiliani studied the complexity of ballot design and user interface of electronic ballots in Colombia in 2017 [22] and Brazil in 2014 [24] respectively. They conclude that the design of the ballot is often too complex for a substantial part of the population which increases the number of invalid votes or eligible voters that do not show up on election day. The same holds for electronic voting in terms of errors made, accessibility and overall confusion due to the user interface.

Suggestions for the improvement of ballots are often not very explicit. Banducci [1] shows that text is often not the best way to visualise options on a ballot; pictures do a far better job; we reason the same goes for icons and even maps. Ballots will rarely include charts, but the effect graphical information has over textual information can be partially generalised towards group decision-making [7, 23]. By taking the step to an electronic platform – and ignoring potential security issues often raised by concerned opponents – the number of invalid votes (ballots) can be minimised, as discussed by Pachón [22]. The role of the positioning of options – or the place on a ballot list – is enormous, as Marcinkiewicz and Stegmaier [18] show in their research in Eastern Europe, which is also confirmed by research in Denmark by Blom-Hansen [2] using eye-tracking software. Conati [4] also used visual analytics to evaluate how the layout impacts users. But not for political ballots, but for personal decision-making like "selecting a hotel" and "buying a smartphone". The evaluation of multiple electronic systems by Michel [20] has shown that besides a mix of text and graphics the incorporation of instructions in the interface is important, especially for illiterate and elderly voters.

Research

This research takes the possibilities of a preferendum and generalises it into preferential group decision-making events. We examine different kinds of voting methodologies and show how they influence the results of examples and their robustness with different requirements, for example, the number of preferences in relation to the number of candidates and the possibility of ties. By defining various models, describing use cases and using the research handled before, we create a way to better visualise group decision-making events using preferential voting methodologies. The various aspects needed for these visualisations are covered in four separate chapters.

Chapter Outline

In Chapter 2 the relevant stages of group decision-making are highlighted. To choose the correct methodology for decision-making events we handle the most relevant voting methodologies in Chapter 3. In Chapter 4 we present various decision models to show if and how options relate to each other before creating preference ballots. In Chapter 5 we present our suggestions for the visualisation of group decision-making using preferential voting, Interactive Preference Ballots. Finally, we present our conclusions in Chapter 6.

Chapter 2

Group Decision-Making

Everyone makes decisions about the things they do. We make most decisions without giving them any thought. Many decisions only influence you and are of little impact on society. But we are all part of society as we are also part of one or more smaller groups within society.

You often make decisions together with the other people in your group. Decisions may vary from "electing the representatives in your country" to "the next destinations of your family holiday". And from "the restaurant, you and your friends will go visit tonight" to "the points awarded to candidates during the Eurovision Song Contest".

Deciding with a group of people is an event which consists of three parts. We will briefly describe and elaborate on the three parts in the coming sections and chapters.

The first part is *eligibility*, who will be allowed to participate as a voter and the options from which the voters can choose. The second part is *casting of votes*, how will the voters show their preference. Will they raise their hands – or use a ballot? Is only their first preference relevant – or do voters need to assign multiple preferences? The last part is *tallying of votes* or counting of votes which includes the methodology used to establish the results, the specific conditions and exceptions for the event.

2.1 Eligibility

Eligibility consists of two main things. First, who is allowed to vote, and second, what options can be voted on. The independence of counting, the security of votes and the integrity of decision-making are not in the scope of this research.

2.1.1 Voters

We simplify who is allowed to vote, take out exceptions and make it very black and white. We will illustrate with some examples.

If you are a Dutch national and are 18 years of age, you are allowed to vote in a national election.

If you live in a municipality and are asked to give your opinion, you are allowed to cast a vote.

If you are a member of a (sports) club, you are allowed to cast a vote during a member meeting.

If you are part of a group of friends deciding on a holiday destination, you are allowed to weigh in.

2.1.2 Voting Options

The outcome of every group's decision-making depends heavily on the options available. Therefore, every aspect of defining options is essential, from the global essence to the last detail.

For (sub)national elections, the question asked is, in essence "which candidate do you prefer as a representative in parliament (or your city council)". The options for these elections are *people* – by name and their place of residence. The placing of a candidate on the list depends on choices made by the party. The placing, however, has an enormous impact on whether a candidate is elected. We will elaborate on this subject in Chapter 4.

For other decision-making events, the wording of the question and options play a significant role in the result. The 2016 national referendum in the United Kingdom is an example of such an event. The United Kingdom European Union membership referendum is also referred to as the EU referendum or the Brexit referendum. As shown in Figure 2.1, the topic of the referendum is very clear, as is the question posed and the options to choose from.

Despite the clearness of all aspects on the ballot, scholars, politicians and citizens in the United Kingdom, the European Union and the rest of the world ask whether the methodology used and the phrasing of the question and options were fair. Many expect that differently phrased questions, options and information provided by the government would have given a different outcome [3, 19, 21]. In Chapter 3 we will elaborate on fairness in decision-making when we use several examples to show the outcome of decision-making using different methodologies and in Chapter 4 on decision types for decision-making.

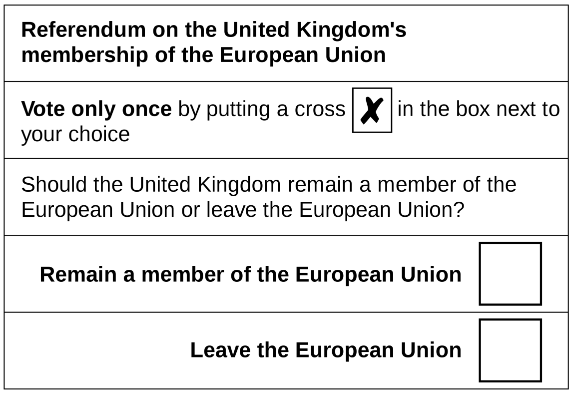


Figure 2.1: 2016 EU Referendum Ballot Paper.
Source: `www.wikipedia.org`

2.2 Voting

Voting or casting your vote is nothing more than stating your preference in a decision-making event. Decision-making can be done by raising hands. Or by allowing each voter to express their preference out loud one after the other. Both are not part of this thesis. Instead, our focus will be on events using ballots. Ballots can be both printed ballots and digital.

2.2.1 Preferences

Preferences are personal. Ones preference might be stronger if a subject is essential to that person. However, a voter could also lack interest in a subject or find it very difficult and have trouble stating a preference toward one option. Sometimes a voter might only know what their least preferred option is.

2.2.2 Ballots

In Chapter 5 we present a way for visualising options on a ballot to help voters cast their preferences. These visualisations are linked to the decision types presented in Chapter 4 and methodologies from Chapter 3.

2.3 Tallying

Tallying is nothing more than summing the votes for the various options in a decision-making event, following the rules of the methodology used.

An anecdote about Abraham Lincoln goes that he once asked his cabinet for a show of hands on a proposal he had made, and then announced, "Ayes 1, Noes 6: the Ayes have it" [6].

We can only hope that the proposal was not very important – or that Lincoln was only kidding. The anecdote shows that it is imperative to have a fair way of processing the ballots cast, tally the votes in correspondence with the methodology used and present the results. These results should not surprise a significant part of the group – which was the case in the anecdote.

2.3.1 Methodologies

The voting methodology chosen to evaluate the decision-making event can significantly influence the result. In Chapter 3 we will show the impact of various well-known methodologies, using several examples.

Chapter 3

Voting Methodologies

In this chapter, we will show various voting systems [16, 27] – methodologies for decision-making. We can make two significant distinctions between the methodologies. The first distinction is between two options and three-or-more options. And the second distinction is between non-preferential and preferential methodologies. Table 3.1 shows an overview of the methodologies covered in this chapter. We will use several examples to illustrate these methodologies' effects on the outcome.

	Non-preferential	**Preferential**
Binary	Majority Voting	
Non-binary	Plurality Voting Two-round System	Condorcet Instant Run-Off Voting Copeland Borda Count Modified Borda Count

Table 3.1: Overview of Voting Methodologies handled in this research

This chapter will not assign grades and present the best methodology because all have flaws; some are better suited for situation A while others are better suited for situation B. Instead, we focus on preferential voting, and research shows that preferential voting increases the fairness of decision-making events. However, the same study shows that there is no perfect methodology [9]. Still, some are fairer than others, according to Emerson. We say fairness means attributing the same value to all votes and being inclusive. The Modified Borda Count, Condorcet and Copeland methodologies, handled in sections 3.3.4, 3.3.1 and 3.3.3 respectively, are the only methodologies that take all preferences cast by all voters into account. These three can therefore be claimed to be the most inclusive.

In the coming sections, voters will “cast their votes”, “fill the ballot”, “indicate their preferences”, or “choose an option”. All these terms have the same essence and are interchangeable unless specifically stated.

In informal situations, there is no need to administer a decision. Raising hands, or having everyone say their choice, are good enough to decide most cases. However, in more formal decision-making situations, the administration is often essential. Then ballots are used to administrate votes – for the registration of votes. Ballots can have several forms depending on the voting system, the number of candidates, etc.

Both binary and non-preferential methodologies will require only one voter input. A preferential methodology requires voters to put one or more preferences on the ballot. These ballots are called *Preference Ballots.* We will give more details on the preference ballot in section 3.3. The physical form of ballots is not relevant for this chapter. But, we will elaborate on ballots in Chapter 5.

3.1 Binary (Two-option) Methodologies

A binary – or two-option – methodology is decision-making between two options. The options could be of various forms, for example, between the options, Yes and No, the candidates Alice and Bob or between the options Remain or Leave.

3.1.1 Majority Voting

In the majority voting methodology, the winner is the option with more votes than the other. For two options, this may be as simple as $50\% + 1$ of the votes. But it could also be required to have a majority of $2/3$ or some other fraction greater than $1/2$. A straightforward example of a majority vote is the one used in the introduction. Alice, Bob and Charlie choosing a restaurant for dinner. The choiche going between an Italian restaurant and a Sushi restaurant.

If two friends vote for sushi and one votes for Italian, the majority vote winner is *sushi.* Putting the votes in a table creates table 3.2. It also shows that sushi gained the most votes, more specific, over 50% of the votes and thus the majority.

	Sushi	Italian
Alice	X	
Bob		X
Charlie	X	
Total	2	1

Table 3.2: Picking a Restaurant via Majority Vote. Sushi is chosen

An organisation might use more than one voting system depending on the nature of the decision. The Council of the European Union is an example of such an organisation[1]. It uses three systems (1) simple majority, (2) qualified majority and (3) unanimous vote. A simple majority is like the dinner example above, which results in a majority if 14 out of the 27 member states favour an option. We will shortly discuss the latter two systems separately.

3.1.2 Qualified Majority Vote

The Council of the European Union uses qualified majority voting for almost 80% of their decisions. There are two conditions – which both have to be satisfied – to reach a qualified majority:

- 55% of the member states vote in favour, this means 15 out of 27 member states.
- The member states that vote in favour must represent at least 65% of the citizens of the European Union.

Some additional rules handle cases of abstention and other exemptions. For other groups or organisations that use qualified majority voting, the rules could be different and more fitting to their situation.

3.1.3 Unanimous Vote

The unanimous vote is very straightforward. All votes should be in favour of one option. In the case of the European Union, no member can vote "not in favour" for a decision to be made. The European Union uses this system when deciding on foreign policy.

[1] `https://www.consilium.europa.eu/en/council-eu/voting-system/`

3.2 Non-Preferential Multi-option Methodologies

A non-preferential multi-option methodology is a decision-making between three or more options. Non-preferential does not mean that voters cannot indicate their preference or more than one preference – it means that the voting methodology only considers their first preference.

3.2.1 Plurality Voting

Plurality voting requires voters to cast only their first preference. And the option with the highest number of preferences wins. Plurality voting does not require a minimum percentage of preferences to have a winner – in contrast to majority voting. The only requirement is to have more first preferences than any other option. In the case of a tie, the overseeing authority will decide what happens. To show how plurality voting works, we will use an example.

Ten friends need to pick the location of their next winter holiday. The options are Austria, Switzerland and France. The holiday preferences of the friends are shown in Table 3.3 together with the resulting number of preferences.

	Austria	Switzerland	France
Alice	X		
Bob	X		
Carol			X
Dave		X	
Eve	X		
Frank			X
Grace		X	
Heidi			X
Judy		X	
Mike	X		
Result	4	3	3

Table 3.3: Winter Holiday via Plurality Vote. Austria is chosen

We see that Austria has four (4) preferences, more than Switzerland and France with three (3) each. This outcome means that Austria would not have been the majority winner since it has only 40% (4 out of 10) of the votes.

Insincere Voting

An effect that might occur when using plurality voting is *insincere voting.* Insincere voting – sometimes also called strategic or tactical voting. Insincere voting is when one or more voters cast their ballots counter from their actual preferences for strategic purposes. Using the winter holiday example, we will make some assumptions and then show what happens with the result.

Both Carol and Frank would like to go to either Switzerland or France – but since they were allowed only one option – they chose France. Austria is definitely not an option for them. While everyone writes down their preference, they both decide to alter their first preference to Switzerland and hope for the best. Table 3.4 shows the new results.

	Austria	Switzerland	France
Alice	X		
Bob	X		
Carol		X	
Dave		X	
Eve	X		
Frank		X	
Grace		X	
Heidi			X
Judy		X	
Mike	X		
Result	4	5	1

Table 3.4: Winter Holiday via Plurality Vote with Insincere Voters. Switzerland is chosen

The insincere voting was successful. The preferred destination for the group is no longer Austria. Switzerland now has five (5) preferences compared to four (4) and one (1) for Austria and France, respectively.

We will illustrate the effect of insincere voting again with a new example. This example regards the election for a special position at Radboud University. There are three candidates: Alice and Bob, both working in the Computing Science department. And Charlie from the Physics department. All 750 employees are eligible to vote for the candidates. Their votes are combined and shown in Table 3.5 together with the percentages of votes they received.

Alice	$251/750 \approx$	33.5%
Bob	$188/750 \approx$	25.1%
Charlie	$311/750 \approx$	41.5%

Table 3.5: University Election via Plurality. Charlie is chosen

Charlie is the plurality winner because he has the most preferences. As a result, none of the Computing Science department candidates will be appointed for the position even though more than half of the voters (58.5%) do not want Charlie in that position.

The Computing Science department recognises that their two candidates will battle for the same votes. So they choose to intervene by asking their employees to cast a strategic – insincere – vote for Bob despite their preference for Alice. If half of the employees – with Alice as their first preference – do this, then Bob will get $188 + 125 = 313$ preferences. This result makes Bob the plurality winner.

3.2.2 Two-round System

A Two round system, also called Runoff Voting, Second Ballot or Ballotage, is used to elect a single candidate as the winner. We will illustrate how a two-round system works using the French Presidential Election of 2022.

> *The President of the Republic shall be elected by an absolute majority of votes cast. If such a majority is not obtained on the first ballot, a second ballot shall take place on the fourteenth day thereafter. Only the two candidates polling the greatest number of votes in the first ballot, after any withdrawal of better placed candidates, may stand in the second ballot.* [14]

In the first round of the election, there were 12 candidates eligible for the function of President. Table 3.6 shows the results of the first round.

Candidate	Votes	Percentage	Second Round
Anne Hidalgo	616478	1,75%	
Emmanuel Macron	9783058	27,85%	X
Éric Zemmour	2485226	7,07%	
Fabien Roussel	802422	2,28%	
Jean Lassalle	1101387	3,13%	
Jean-Luc Mélenchon	7712520	21,95%	
Marine Le Pen	8133828	23,15%	X
Nathalie Arthaud	197094	0,56%	
Nicolas Dupont-Aignan	725176	2,06%	
Philippe Poutou	268904	0,77%	
Valérie Pécresse	1679001	4,78%	
Yannick Jadot	1627853	4,63%	
Total	35132947	100%	

Table 3.6: French Presidential Elections Round One

The quote from the French Constitution tells us that the first round is a mixture of a majority and plurality voting where the winner needs an absolute majority (more than 50% of the preferences). If there is no such candidate, the two candidates with the most preferences continue to the second round. This second round is a majority vote. In Table 3.7 we see that no candidate has an absolute majority. Therefore, Emmanuel Macron and Marine Le Pen are the candidates proceeding to the second round.

Candidate	Votes	Percentage	Winner
Emmanuel Macron	18768639	58,55%	X
Marine Le Pen	13288686	41,45%	
Total	32057325	100%	

Table 3.7: French Presidential Elections Round Two

The results of this second round, depicted in Table 3.7 show that Emmanuel Macron is the majority winner of the second round.

3.3 Preferential Multi-option Methodologies

A multi-option preferential methodology is decision-making between three or more options where all voters indicate their order of preference for at least one and at most all options. The winner is decided using a non-majoritarian process, this does not mean that the winner using majority voting cannot be equal to the winner of a methodology from this section.

We will use preference ballots for the preferential multi-option methodologies handled in this section. We will explain and illustrate the concept of a preference ballot before explaining several methodologies.

Preference Ballots

A preference ballot is a ballot on which voters indicate their order of preference towards the options in the voting.

To illustrate the use of a preference ballot, we will use the Winter Holiday example from Section 3.2.1, Table 3.8 shows the votes of the friends again. Now all ten friends rank the three holiday destinations to their preferences. Table 3.9 shows the ballots. The destinations are Austria (A), France (F) and Switzerland (S).

	Alice	Bob	Carol	Dave	Eve	Frank	Grace	Heidi	Judy	Mike
A	X	X			X					X
S				X			X		X	
F			X			X		X		

Table 3.8: Winter Holiday via Plurality Vote. Austria is chosen

	Alice	Bob	Carol	Dave	Eve	Frank	Grace	Heidi	Judy	Mike
1^{st}	A	A	F	S	A	F	S	F	S	A
2^{nd}	F	S	S	A	S	S	A	S	A	S
3^{rd}	S	F	A	F	F	A	F	A	F	F

Table 3.9: Holiday Preference Ballots

Evaluating the ballots no longer comes down to a tally of the first preferences for the methodologies in this section. It is essential to keep an overview. This example uses a mere ten preference ballots – since the group eligible to vote consists of only ten people. However, the French Presidential elections consisted of two rounds with over 35 million ballots each – around 35 million French citizens voted during the 2022 election. To maintain an overview and make the evaluation of larger decision-making events possible, we create a *preference schedule*. The preference schedule contains all processed ballots.

The preference schedule for our holiday example consists of all possible combinations of the options {AFS, ASF, FAS, FSA, SAF and SFA}. The counter of that specific combination increases every time a ballot is processed. For visualisation purposes, we create a table with all possible combinations. That way, we can show what happens in the various methodologies. Publication of such a table rarely occurs in actual elections. Table 3.10 shows the preference schedule with the processed ballots for our example.

	1	3	0	3	3	0
1^{st}	A	A	F	F	S	S
2^{nd}	F	S	A	S	A	F
3^{rd}	S	F	S	A	F	A

Table 3.10: Holiday Preference Schedule

Table 3.10 shows all six (6) combinations of the three destinations. Two combinations are greyed-out; these are on none of the ballots cast. Options that do not occur on ballots are omitted later.

We used this example in Section 3.2.1 while explaining plurality voting. Austria was the plurality winner with four (4) votes against three (3) for France and Switzerland. By adding the corresponding columns for the same first preferences, we can also read this from the preference schedule:

Austria	(AFS + ASF)	$1 + 3 = 4$
France	(FAS + FSA)	$0 + 3 = 3$
Switzerland	(SAF + SFA)	$3 + 0 = 3$

3.3.1 Condorcet

The Condorcet methodology is named after Nicolas de Condorcet. In the 18th century, de Condorcet tried to devise a fairer way to elect a winner in an election compared to the traditional majority voting systems. The *Condorcet winner* wins in every one-to-one comparison with the other options. Of course, there might not always be such a winner, and ties are also possible. The method itself does not describe solutions for such a situation.

The methodology is also used as the Condorcet criterion [15, 16]. The Condorcet criterion is a widely accepted way of testing the fairness of other voting methodologies. The Condorcet criterion is one of many fairness criteria that exist. We will introduce other criteria later on.

We will use the holiday example to illustrate how the Condorcet methodology is applied and how it can be used as a criterion. Table 3.11 shows the preference schedule – with the empty combinations omitted.

	1	3	3	3
1^{st}	A	A	F	S
2^{nd}	F	S	S	A
3^{rd}	S	F	A	F

Table 3.11: Holiday Preference Schedule

We can find the most preferred option for every one-to-one comparison using the preference schedule. We have three options, which means we have to look at three cases: (1) Austria vs France, (2) Austria vs Switzerland and (3) France vs Switzerland.

In Tables 3.12, 3.13 and 3.14 we visualise the one-to-one comparison between Austria and France, Austria and Switzerland and France and Switzerland respectively. We create two identical tables per comparison. In these tables, we highlight the column if the first of the two wins in the left table, and if the second of the two wins in the right column. Winning means having a higher preference in that specific table.

Austria vs France

	1	3	3	3
1^{st}	A	A	F	S
2^{nd}	F	S	S	A
3^{rd}	S	F	A	F

	1	3	3	3
1^{st}	A	A	F	S
2^{nd}	F	S	S	A
3^{rd}	S	F	A	F

Table 3.12: Holiday Preference Schedule: Austria vs France

The left table of Table 3.12 shows that Austria is preferred $1 + 3 + 3 = 7$ times. And the right table of Table 3.12 shows that France is preferred 3 times. Austria is preferred over France 7 out of 10 times.

Austria vs Switzerland

	1	3	3	3
1^{st}	A	A	F	S
2^{nd}	F	S	S	A
3^{rd}	S	F	A	F

	1	3	3	3
1^{st}	A	A	F	S
2^{nd}	F	S	S	A
3^{rd}	S	F	A	F

Table 3.13: Holiday Preference Schedule: Austria vs Switzerland

The left table of Table 3.13 shows that Austria is preferred $1 + 3 = 4$ times. And the right table of Table 3.13 shows that Switzerland is preferred $3 + 3 = 6$ times. Switzerland is preferred over Austria 6 out of 10 times.

France vs Switzerland

	1	3	3	3
1^{st}	A	A	F	S
2^{nd}	F	S	S	A
3^{rd}	S	F	A	F

	1	3	3	3
1^{st}	A	A	F	S
2^{nd}	F	S	S	A
3^{rd}	S	F	A	F

Table 3.14: Holiday Preference Schedule: France vs Switzerland

The left table of Table 3.14 shows that France is preferred $1 + 3 = 4$ times. And the right table of Table 3.14 shows that Switzerland is preferred $3 + 3 = 6$ times. Switzerland is preferred over France 6 out of 10 times.

Combining the three results, we see that Austria is preferred over France, and Switzerland is preferred over both Austria and France, which means that the Condorcet winner is Switzerland. While, the plurality winner for this exa,mple was Austria.

On page 15 we also mentioned insincere voting. The insincere voting example resulted in Switzerland being the preferred holiday destination. In other words, the winner of the insincere plurality vote is the same as the Condorcet winner. And if we look back at the insincere example, the reason for Carol and Frank to change their vote was that France and Switzerland were of equal preference to them, but they were not allowed to put both on the ballot. So another expression for insincere voting is tactical voting, which is a better expression – and sounds friendlier – for the action of Carol and Frank.

3.3.2 Instant Run-Off Voting (IRV)

Instant run-off voting (IRV) is also known as "single transferable voting" and "alternative voting". In Section 3.2.2 we discussed the Two Round System (TRS) and used the French Presidential Elections as an example. An alternative name for TRS is Run-off Voting, which seems similar to IRV. However, TRS does not use preferential voting and that makes a substantial difference between the two methodologies. Because of the preferential voting IRV requires only one round.

IRV allows voters to cast preferences for one, some, or all options available. The first round exists of a plurality voting where there is a winner if any option has a majority. If there is no winner, the option with the least preferences is eliminated. This is done by removing the option from the preference schedule. All preferences lower than the eliminated option move up a place. This process continues until there is a majority winner. We will illustrate this with a new example. In Table 3.15 we see the preference schedule resulting from 20 voters indicating their preferences for 5 options $\{A \ldots E\}$. All options need to be on the ballot – partially filled ballots are not allowed in this example.

	3	4	2	4	6	1
1^{st}	B	B	B	C	D	E
2^{nd}	C	D	E	A	C	A
3^{rd}	A	C	A	D	A	D
4^{th}	D	A	C	B	E	B
5^{th}	E	E	D	E	B	C

Table 3.15: Preference Schedule 5 options, 20 voters

We now tally the first preferences for the different options.

Option A	0
Option B	9 $(= 3 + 4 + 2)$
Option C	4
Option D	6
Option E	1

Option B is the most preferred option and has 9 out of 20 votes, but is not the majority winner. Therefore, we continue to the next round by eliminating the least preferred option, option A with no first preferences. Table 3.16 shows the result of the elimination. Table 3.16 consists of two tables, on the left with option A crossed out, and on the right with option A removed. If an option is removed from a column, any options below option A moves up a preference in order to keep the table compact.

	3	4	2	4	6	1
1^{st}	B	B	B	C	D	E
2^{nd}	C	D	E	$\cancel{A}$	C	$\cancel{A}$
3^{rd}	$\cancel{A}$	C	$\cancel{A}$	D	$\cancel{A}$	D
4^{th}	D	$\cancel{A}$	C	B	E	B
5^{th}	E	E	D	E	B	C

	3	4	2	4	6	1
1^{st}	B	B	B	C	D	E
2^{nd}	C	D	E	D	C	D
3^{rd}	D	C	C	B	E	B
4^{th}	E	E	D	E	B	C

Table 3.16: Preference Schedule after 1 elimination

If we compare Table 3.16 with Table 3.15, we see that nothing has changed in the first preferences. We will tally the results again; since we have eliminated option A, it will no longer be a part of this.

Option B	9 $(= 3 + 4 + 2)$
Option C	4
Option D	6
Option E	1

Option B is still the most preferred, but has no majority. Table 3.17 shows the elimination option E, the new least preferred option. The resulting table has less columns as before since there are less variations left.

	3	4	2	4	6	1
1^{st}	B	B	B	C	D	~~E~~
2^{nd}	C	D	~~E~~	D	C	D
3^{rd}	D	C	C	B	~~E~~	B
4^{th}	~~E~~	~~E~~	D	~~E~~	B	C

	5	4	4	6	1
1^{st}	B	B	C	D	D
2^{nd}	C	D	D	C	B
3^{rd}	D	C	B	B	C

Table 3.17: Preference Schedule after 2 eliminations

We tally the results after the second elimination round.

Option B 9 $(= 5 + 4)$

Option C 4

Option D 7 $(= 6 + 1)$

There is still no majority winner. Therefore, we eliminate option C as the least preferred option.

	5	4	4	6	1
1^{st}	B	B	~~C~~	D	D
2^{nd}	~~C~~	D	D	~~C~~	B
3^{rd}	D	~~C~~	B	B	~~C~~

	9	11
1^{st}	B	D
2^{nd}	D	B

Table 3.18: Preference Schedule after 3 eliminations

There are only two options left with the elimination of the third option. Looking at Table 3.18, we see that option D is preferred 11 out of 20 times over option B. Therefore, option D is the IRV winner, while option B had the most preference until the final elimination.

Using the Condorcet criterion, we will see if the IRV winner matches the Condorcet winner. Then, using Table 3.15 we make a one-to-one comparison of option D with all other options. Because there are 20 comparisons to be made, we will only show the results in the form of a matrix (table 3.19).

	Option A	Option B	Option C	Option D	Option E
Option A		11	3	10	17
Option B	9		9	9	13
Option C	17	11		9	17
Option D	10	11	11		17
Option E	3	7	3	3	

Table 3.19: Condorcet Matrix

The rows correspond with the number of preferences that options have over the option in the column. In the matrix, we see that option D is preferred over options B, C and E in a one-to-one comparison. The comparison with option A resulted in a tie. This tie indicates that there is no Condorcet winner. Although some literature also implies the *weak Condorcet winner*, which is the winner of almost all one-to-one comparisons. Taking this additional rule into account option D is the *weak* Condorcet winner.

Option D is both the IRV winner and the weak Condorcet winner. Since there is no Condorcet winner, IRV can not meet the Condorcet criterion – for this example. Still we can see that IRV can meet the Condorcet criterion with a little bit of imagination.

The Instant Run-Off Voting methodology can also fail the Condorcet criterion while there is a Condorcet winner. We will use the University Election example from page 16 without the insincere votes to show this. The winner of the plurality vote was Charlie. We will include the other candidates to use this example for methodologies that use preference ballots. We make two assumptions and show the preference schedule in Table 3.20.

1. If Alice or Bob are the first preference,
   Charlie always is the third preference
2. If Charlie is the first preference,
   Bob is always the second preference

	251	188	311
1^{st}	Alice	Bob	Charlie
2^{nd}	Bob	Alice	Bob
3^{rd}	Charlie	Charlie	Alice

Table 3.20: University Election Preference Schedule

The IRV winner is not clear from the initial preference schedule. Therefore, we eliminate the candidate with the least amount of first preferences – Bob.

	251	188	311
1^{st}	Alice	~~Bob~~	Charlie
2^{nd}	~~Bob~~	Alice	~~Bob~~
3^{rd}	Charlie	Charlie	Alice

	251	188	311
1^{st}	Alice	Alice	Charlie
2^{nd}	Charlie	Charlie	Alice

Table 3.21: University Election IRV Elimination of Bob

In the left part of Table 3.21 we see that Alice now has a majority preference of $251 + 188 = 439$ out of 750 votes. Therefore, Alice is the IRV winner.

To establish the Condorcet winner, we need to look at the one-to-one comparisons (section 3.3.1). Table 3.22 shows these one-to-one comparisons.

	Alice	Bob	Charlie
Alice		251	439
Bob	499		439
Charlie	311	311	

Table 3.22: University Election Condorcet Matrix

Bob wins both one-to-one comparisons with Alice and Charlie. Bob is the Condorcet winner.

All three methods establish another winner – Alice for IRV, Charlie for plurality voting and Bob for Condorcet. The Condorcet methodology is also defined to be a fairness criterion. For this example, both plurality voting and Instant Run-Off Voting do not meet the Condorcet criterion.

For Instant Run-off voting, we can now state that the methodology does not meet the Condorcet Criterion – where it did satisfy the criterion in the previous example, with some leniency towards the weak Condorcet winner.

3.3.3 Copeland

The Copeland methodology is in many ways similar to the Condorcet methodology. The basis of this methodology was to satisfy the Condorcet criterion, but we will see this is not always the case. Not every event has a Condorcet winner because if an option wins every one-to-one comparison except for one, it is not the winner in Condorcet's methodology. Some adoptions call it a weak Condorcet winner, but then it is debatable how many ties a winner is allowed to have.

Copeland also uses a one-to-one comparison between all options. The winner in a one-to-one comparison gets 1 point, the loser gets 0 points and if there is a tie, both get $\frac{1}{2}$ points. After all comparisons, the scores are tallied and the winner becomes clear. We will reuse the example from the previous section in which we explained the IRV methodology. And for which we also established that there was no Condorcet winner because of 1 tie, but only the weak Condorcet winner.

In Table 3.23 we see the Condorcet Matrix of the example from the previous section, we shall now call this the ‘Copeland matrix’.

	Option A	Option B	Option C	Option D	Option E
Option A		11	3	10	17
Option B	9		9	9	13
Option C	17	11		9	17
Option D	10	11	11		17
Option E	3	7	3	3	

Table 3.23: Copeland Matrix with one-to-one comparison ‘win-counts’

Since there are 20 one-to-one comparisons per pair a winner has 11 or more wins, a loser has 9 or fewer wins and if there are 10 wins, it is a tie. In Table 3.24 the numbers from Table 3.23 are altered in a 1, 0 or $\frac{1}{2}$ depending on the outcome. For clarity, the one-to-one comparisons are not removed yet but crossed out.

	Option A	Option B	Option C	Option D	Option E
Option A		$\cancel{11}$ 1	$\cancel{3}$ 0	$\cancel{10}$ 1/2	$\cancel{17}$ 1
Option B	$\cancel{9}$ 0		$\cancel{9}$ 0	$\cancel{9}$ 0	$\cancel{13}$ 1
Option C	$\cancel{17}$ 1	$\cancel{11}$ 1		$\cancel{9}$ 0	$\cancel{17}$ 1
Option D	$\cancel{10}$ 1/2	$\cancel{11}$ 1	$\cancel{11}$ 1		$\cancel{17}$ 1
Option E	$\cancel{3}$ 0	$\cancel{7}$ 0	$\cancel{3}$ 0	$\cancel{3}$ 0	

Table 3.24: Copeland Matrix with one-to-one comparison ‘win-counts’ crossed out and Copeland-points

To identify the Copeland winner we tally the points for every candidate. For clarity, we add an extra column to the Copeland Matrix and remove the one-to-one comparison ‘win counts’. Table 3.25 shows the result.

		Option A	Option B	Option C	Option D	Option E
Option A	$2\frac{1}{2}$		1	0	1/2	1
Option B	1	0		0	0	1
Option C	3	1	1		0	1
Option D	$3\frac{1}{2}$	1/2	1	1		1
Option E	0	0	0	0	0	

Table 3.25: Copeland Matrix with Copeland-points and tally per option

The Copeland winner is Option D, which was also the (weak) Condorcet winner and IRV winner.

Although Condorcet is more well known and seen as an important criterion an issue might be that there is no Condorcet winner. Because of the way ties are handled with the Copeland methodology this doesn't happen very often.

3.3.4 Borda Count

Jean-Charles de Borda devised his Borda Count in the 18th Century [5]. His methodology consists of several voting systems and has been used to conduct elections in France. The Borda Count was initially used from 1770 until 1794 when Napoleon Bonaparte decided to use the Condorcet methodology instead [9].

Currently, the Borda Count is used in some form or as a part of national elections in Slovenia, Iceland, Kiribati, Nauru and Finland [9, 10, 13, 25]. But also, on numerous occasions in private companies, organisations and competitions, Borda Count is used. The most well-known example is the Eurovision Song Contest, which we will elaborate on later.

Although named after Jean-Charles de Borda, he was not the first nor the only one to develop the system. It was devised at least once independently, over three centuries earlier, in 1435 by Nicholas of Cusa in an attempt to reform the Holy Roman Empire and the election of its Emperors [15, 28].

The Borda Count methodology takes all preferences on the ballot into account. It is based on having a certain number of options N. An event with six to ten options ($6 \leq N \leq 10$) is most efficient for decision making – depending on the complexity of the matter [9]. All voters get to rank the options on their preference ballot (1^{st}, 2^{nd}, etc.). The options on the ballot(s) are awarded points according to the rule (n, $n-1 \ldots 1$). Hence, it is a weighted count.

While the name Borda Count is often used for one specific system, it is the general name and consists of three different voting systems aiming for *consensus voting*. The three systems are: (1) The Modified Borda Count (MBC), which is used for collective decision-making; (2) The Quota Borda System (QBS), which is used to elect a pluralist parliament in a plural society; and (3) The Matrix Vote, which is used to elect a power-sharing executive [11]. Our research will only use the Modified Borda Count methodology; the other two are not relevant for our group decision-making events.

3.3.5 Modified Borda Count

The Modified Borda Count (MBC) is an alteration of the first of three voting methodologies devised by Jean-Charles de Borda, the Borda Count. BC requires voters to assign preferences to all options on the ballot; MBC allows voters to fill the ballot with fewer options.

With Borda Count, an event with N options means filling the ballot with n preferences. Points are assigned to all options, which means n points for the first preference, $n-1$ for the second preference, etc., and the least preferred options get 1 point. The same event with Modified Borda Count requires voters to fill the ballot with m options, where $1 \leq m \leq n$. The first preference gets m points, the second preference – if there is more than one preference – gets $m-1$ points, etc., and the least preferred option gets 1 point in MBC. Table 3.26 shows what points are awarded in a situation with seven options ($N = 7$).

	BC	MBC ($m = 7$)	MBC ($m = 6$)	MBC ($m = 5$)	MBC ($m = 2$)	MBC ($m = 1$)
1^{st} preference	7	7	6	5	2	1
2^{nd} preference	6	6	5	4	1	0
3^{rt} preference	5	5	4	3	0	0
4^{rt} preference	4	4	3	2	0	0
5^{th} preference	3	3	2	1	0	0
6^{th} preference	2	2	1	0	0	0
7^{th} preference	1	1	0	0	0	0

Table 3.26: Overview of points assigned to preferences using Borda Count (BC) and Modified Borda Count (MBC) with different number of preferences (m) for an event with seven options ($N = 7$)

In the Borda Count voters are required to order all options because that is how de Borda initially thought preference voting was the most fair [5]. The advantage of the Modified Borda Count is that voters and organisers can alter the number of preferences they list on the ballot. This enables voters to rank their least preferred options last without any action. And it allows organisers to enforce fewer preferences on the ballot than the number of options available. Hence one can force voters to make decisions. Research shows that six to ten options are the most efficient for decision-making, but some events have more than ten options.

By rule of thumb, you can say that you need to either limit the number of options a voter has or limit the number of options a voter must choose. Hypothetically we might ask voters to rank all numbers from 1 to 31. The ranking should be done in such a way that on top is their favourite and at the bottom of their ballot is the least favourite. Choosing the first few might be easy; the day of birth, the month of birth, the jersey number you used to have as a kid playing soccer, the birthday of your partner, your children, your parents, or your house number. But somewhere along the line, you don't care anymore, and all are tied for the same place. Forcing voters to rank *all* numbers will result in a distorted result because many voters will probably fill up the list starting with the lowest and skipping those in their favourites.

An example of an event with more than ten options is the Eurovision Song Contest. We will use the edition of 2021 to look at the use of the MBC methodology in that event. But first, we will use the Winter Holiday example to illustrate the division of points in the Modified Borda Count methodology. Table 3.27 shows the preference schedule from earlier in this chapter again.

	1	3	3	3
1^{st}	Austria	Austria	France	Switzerland
2^{nd}	France	Switzerland	Switzerland	Austria
3^{rd}	Switzerland	France	Austria	France

Table 3.27: Holiday Preference Schedule

This event has three options ($N = 3$), and all voters must fill a complete ballot ($m = 3$). Since $N = m$, this example follows the Borda Count points as well. Therefore, the first preference will get 3 points, the second preference 2 points, and the least preferred option will earn 1 point. Table 3.28 shows the table where the Borda Count Points are also in.

	1	3	3	3
1^{st} (3 points)	Austria ($1 \times 3 = 3$)	Austria ($3 \times 3 = 9$)	France ($3 \times 3 = 9$)	Switzerland ($3 \times 3 = 9$)
2^{nd} (2 points)	France ($1 \times 2 = 2$)	Switzerland ($3 \times 2 = 6$)	Switzerland ($3 \times 2 = 6$)	Austria ($3 \times 2 = 6$)
3^{rd} (1 point)	Switzerland ($1 \times 1 = 1$)	France ($3 \times 1 = 3$)	Austria ($3 \times 1 = 3$)	France ($3 \times 1 = 3$)

Table 3.28: Holiday Preference Schedule with Borda Count points

We can find the result of the holiday example using MBC by adding the points awarded to the options. There are three options with 3, 2 and 1 points, respectively, making each ballot award 6 points. The group consists of ten friends, meaning 60 points are awarded.

Austria	21	$= 3 + 9 + 3 + 6$
France	17	$= 2 + 3 + 9 + 3$
Switzerland	22	$= 1 + 6 + 6 + 9$

The MBC and BC winner is Switzerland. The results of this example using plurality voting was Austria and using Condorcet, it was Switzerland. For this example, both BC and MBC satisfy the Condorcet criterion. On page 15, we discussed tactical (insincere) voting for this example using Plurality voting. We will show what would happen if we follow said insincere voting example and have Carol and Frank leave the least preferred option, 'Austria', from their ballots. Table 3.29 shows this preference schedule with Borda Count Points.

Partially Filled Ballots

	1	3	1	2	3
1^{st}	Austria $(1 \times 3 = 3)$	Austria $(3 \times 3 = 9)$	France $(1 \times 3 = 3)$	France $(2 \times 2 = 4)$	Switzerland $(3 \times 3 = 9)$
2^{nd}	France $(1 \times 2 = 2)$	Switzerland $(3 \times 2 = 6)$	Switzerland $(1 \times 2 = 2)$	Switzerland $(2 \times 1 = 2)$	Austria $(3 \times 2 = 6)$
3^{rd}	Switzerland $(1 \times 1 = 1)$	France $(3 \times 1 = 3)$	Austria $(1 \times 1 = 1)$		France $(3 \times 1 = 3)$

Table 3.29: Holiday Preference Schedule with Modified Borda Count points $(1 \leq m \leq 3)$

The amount of points distributed over the three options is less than 60 because two partially filled ballots are not dividing 6 points. The result of the tally is:

Austria	19	$= 3 + 9 + 1 + 6$
France	15	$= 2 + 3 + 3 + 4 + 3$
Switzerland	20	$= 1 + 6 + 2 + 2 + 9$

Switzerland is also the winner in this example. If we look at both examples and compare the awarded points, we see that all options get 2 points less when the ballots are not completely filled, but the result stays the same.

Using the above example and generalising this using the literature, we can say that because of the methodology casting a partially filled ballot has no significant effect because that ballot distributes fewer points to all on the ballot – also the most preferred option. There are other ways to handle partially filled ballots, of which some are fairer than others. Another fair way is to assign the average of the points to all options, not on the ballot. An unfair way is to give the options, not on the ballot 0 points, but assign the options on the ballot the points as if the ballot was filled. Table 3.30 shows these examples, the two columns at the bottom indicate the total points per ballot and whether the division of points is considered fair or unfair. The last alternative we will handle is discarding all partially filled ballots, which is extreme but also very clear.

	(M)BC ($m = 5$)	MBC ($m = 3$)	MBC ($m = 2$)	average ($m = 2$)	average ($m = 1$)	zero ($m = 2$)	zero ($m = 1$)	discard
1^{st}	5	3	2	5	5	5	5	0
2^{nd}	4	2	1	4	$2\frac{1}{2}$	4	0	0
3^{rt}	3	1	0	2	$2\frac{1}{2}$	0	0	0
4^{rt}	2	0	0	2	$2\frac{1}{2}$	0	0	0
5^{th}	1	0	0	2	$2\frac{1}{2}$	0	0	0
total	15	9	3	15	15	9	5	0
	fair	fair	fair	fair	fair	unfair	unfair	fair

Table 3.30: Point division for partially filled ballots using various rules using Modified Borda Count methodology with five options ($N = 5$)

Ties on a Ballot

Similar to handling partially filled ballots is allowing and handling ballots on which voters tied two or more options. Without elaborating too much and suggesting alternatives that are not fair, we will give the two fair options. We called the first extreme when using it for partially filled ballots, which is discarding the ballot. This is, of course, only an option if ties are not allowed. The other way is awarding the average points to all tied options.

In Table 3.30 two columns showed examples of point division using the average method. In a partially filled ballot, the options that are not listed are tied for last place – or the one after the lowest preference on the ballot. Table 3.31 shows a few examples of ties on ballots and the point division using the average method.

	MBC ($m = 5$)		MBC ($m = 5$)		MBC ($m = 5$)		MBC ($m = 4$)
1^{st}	5	1^{st}	$4\frac{1}{2}$	1^{st}	5	1^{st}	4
2^{nd}	$3\frac{1}{2}$	1^{st}	$4\frac{1}{2}$	2^{nd}	3	2^{nd}	3
2^{nd}	$3\frac{1}{2}$	3^{rd}	3	2^{nd}	3	3^{rd}	$1\frac{1}{2}$
4^{rt}	$1\frac{1}{2}$	4^{rd}	$1\frac{1}{2}$	2^{nd}	3	3^{rd}	$1\frac{1}{2}$
4^{rd}	$1\frac{1}{2}$	4^{rd}	$1\frac{1}{2}$	5^{th}	1		
	15		15		15		10

Table 3.31: Point division for ballots with ties applying the average method using Modified Borda Count methodology with five options ($N = 5$)

Alternative Point Distributions

As mentioned earlier, variations on Borda Count are used for various elections and events. We will use the Eurovision Song Contest because this is an excellent example of an event with many candidates that are not all ranked by every voter and uses an alternative point distribution.

The 2021 edition of the Eurovision Song Contest (ESC) [12] had a final with 25 contestants. After their performances, a total of 40 nations – some did not make it through the semi-finals – were allowed to cast two ballots. The first was based upon a professional jury, the other on the preference of their respective citizens. All ballots are filled with ten candidates, and ties are not allowed on the ballot. Using Borda Count voting, first preferences would get 10 points, since $N = 10$, but the organisers of ESC have decided that first preferences get 12 points, second preference gets 10 points, and from third up until tenth get 8, 7, etc. points. That means that a ballot distributes $12 + 10 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 = 58$ points, instead of 55 for a MBC with $m = 10$.

For ESC 2021, we have looked at three methodologies: the one used by ESC, a normal MBC points distribution, and finally, looking at only the first preferences. The results are shown in Figures 3.1, 3.2 and 3.3. The top 5 for all three methodologies contain the same participants (countries); the first difference is found in the sixth place. The order for ESC distribution and regular MBC are the same, but another winner is using only all first preferences, which is the runner-up of the other two, namely France.

We haven't looked at other editions of the ESC because there have been many changes in how points are awarded. What is clear is that ESC made the way of awarding points and determining the winner of an event more accessible to the larger public. And assigning "Douze points!" or "Twelve points!" to the first preference makes it unique.

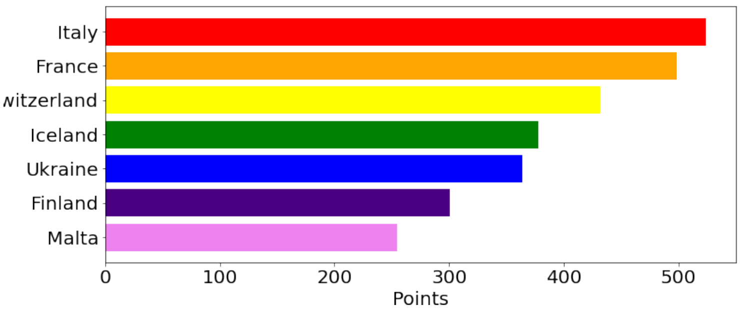


Figure 3.1: Eurovision Song Contest (ESC) 2021
Top 7: results using ESC points distribution $\{12, 10, 8, 7..1\}$.
Winner: Italy

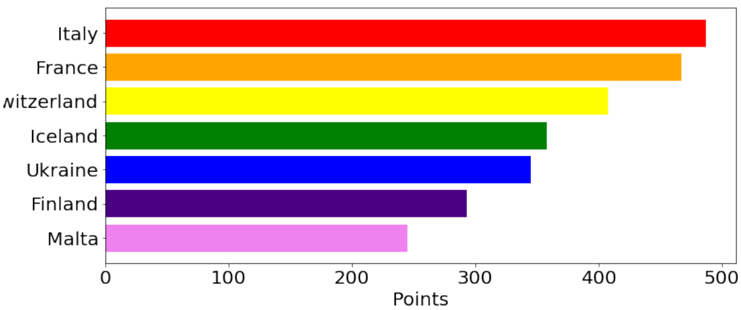


Figure 3.2: Eurovision Song Contest (ESC) 2021
Top 7: results using MBC points distribution $\{10, 9..1\}$.
Winner: Italy

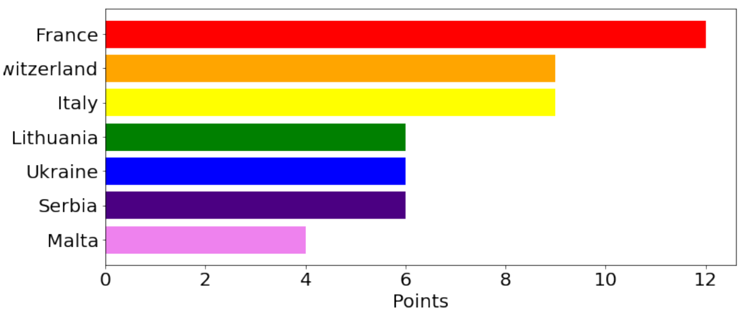


Figure 3.3: Eurovision Song Contest (ESC) 2021
Top 7: results using only first preferences.
Winner: France

Chapter 4

Decision Design

In this chapter, we will discuss the design of group decision-making. First, we will look at the various types (or forms). The type is not only determined by the question posed to the voters but also by the options available. Secondly, we will also give modelled examples matching the types.

We distinguish four main decision types, which we will discuss further in the following sections. Type A is where the options do not overlap; in type B, two or more options do overlap; in type C, the options become more – or less – specific, and type D is a mix of types A, B and C.

We will use figures with red circles to represent the various types, where each circle represents an option. Although our models might have similarities to Venn diagrams or Euler diagrams, we do not use their theory because our circles represent a single option and not a set of options. Shapes surrounding one or more circles indicate that they have one or more properties in common, but they do not make them a set. Figure 4.1 illustrates the model for a binary decision-making event. Figure 4.1a presents the general model with only the two red circles representing the two options. Figure 4.1b represents such an event with the options *Yes* and *No*. The size of the circles will vary throughout the chapter; this, however, does not mean anything about the importance or weight of the options.

(a) Binary Decision-making model

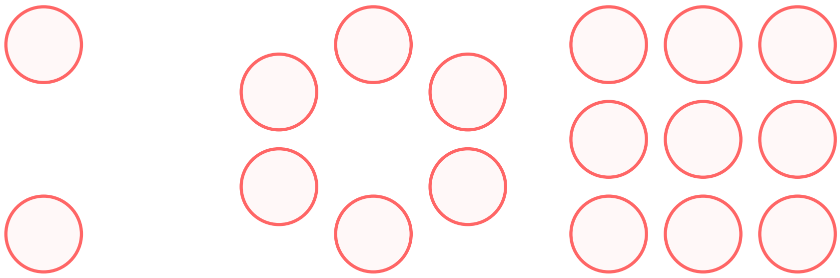
(b) Model for Yes-No event

Figure 4.1: Models for Binary Decision-making event

The focus of the decision types will be on multi-option preferential decision-making; almost all models in this chapter will have more than two circles to represent the various options.

4.1 Type A: No Overlap

In the first decision type, there is no overlap between the options available. Section 4.1 shows three of these models. As each circle represents an option, the main difference between the a, b and c is the number of options. For the decision design, the order or form in which options are presented to the voters is unimportant. Options can be in a circle as in Figure 4.2b or a grid as in Figure 4.2c; they are part of type A as long as the options do not overlap.



(a) Two options (b) Multiple options (c) Multiple options

Figure 4.2: Type A: No Overlap Between Options

The options in most decision-making events are presented as if they have no overlap because there is no overlap, the overlap is not acknowledged, or it is irrelevant. We will illustrate this using two examples: the elections for the Dutch Parliament and the Eurovision Song Contest of 2021.

Elections for the Dutch Parliament

Citizens of the Netherlands over 18 years – with some more exemptions – are allowed to vote every four years to elect their representatives in parliament. The candidates – the options – are presented on a ballot considered reasonably large as shown in Figure 4.3 and Figure 5.2. On each ballot are 27 parties with a total of 900 candidates, for 150 seats in parliament.

While the ballot and voting system seem to indicate that there is no overlap between the options there are multiple overlaps divisible. Gender and place of residence – which are both stated on the ballot for each candidate – are two of those. The important overlap is *Political Party* in this case. In the elections for parliament there is no one winner because there are 150 seats to be filled, but there are candidates that gain far more votes then others. For example, in 2021 the 6 candidates with the most votes gained more than halve of the votes available [1] [2].

[1] www.kiesraad.nl
[2] www.parlement.com

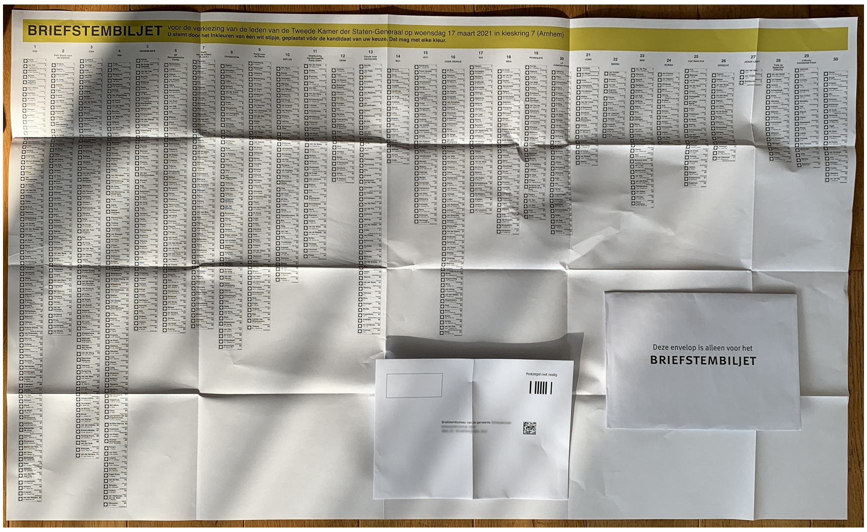


Figure 4.3: Ballot for mail-voting in 2021 Dutch Parliament Elections with envelops (source: `www.wikipedia.nl`)

The total amount of votes all candidates in a party receive determines the amount of seat the party gets. Which means that although some candidates receive too little votes to get elected by themselves, they are elected in parliament because their party needs to fill the seats. Figure 4.4 shows – a portion of – the model of such an election.

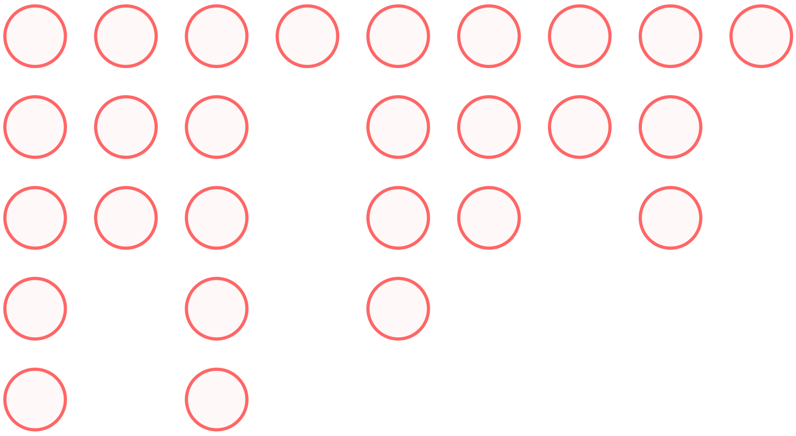


Figure 4.4: Model of candidates in hypothetical election with **no overlap** and “consequential overlap” not visible

All candidates try to gain as many votes as possible themselves and as a result, for their party. The overlap is not a direct effect of a person being eligible as a candidate but is a *consequential overlap* that arises from a party system. All candidates can therefor still be considered as non overlapping options. In such an election – or other decision-making event with similar properties – a model like that in Figure 4.5 should be considered. The boxes clearly indicate that the options have a relationship with eachother. Having the circles – options – overlap eachother would make the relationship greater than it actually is, and it would also make the model complicated.

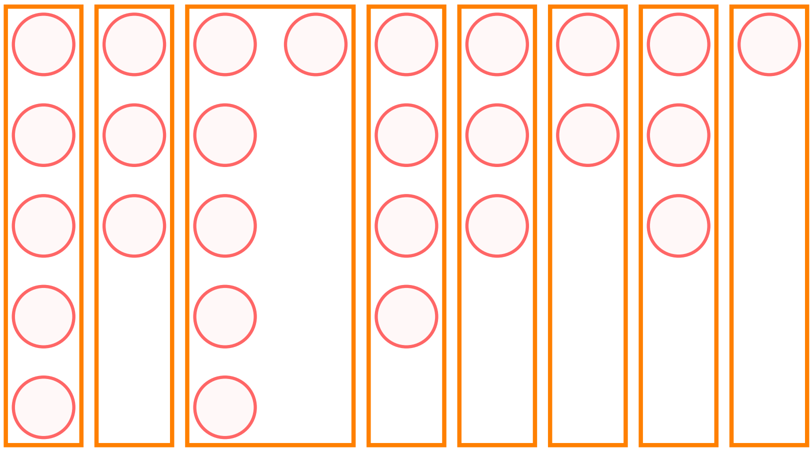


Figure 4.5: Model of candidates in hypothetical election with **no overlap** and "consequential overlap" visible

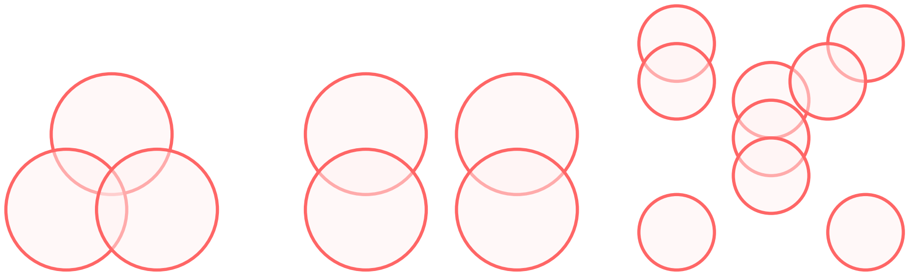
Eurovision Song Contest

The Eurovision Song Contest is an annual Pan-European music contest. All participating countries distribute a defined set of points after all acts have been performed in the finale. All candidates come from different countries – there are no parties and no natural way to collude – which makes this an excellent example of non-overlapping options and votes. Another important aspect is that there is only one winner.

A model to represent the contestants – options – in this case would be the number of circles representing the contestants without any overlap between the circles, as shown in Figure 4.2b and Figure 4.2c.

4.2 Type B: Overlap

In the second decision type, there is an overlap between the available options. However, it is not necessarily so that all options overlap. Some might have no overlap at all, while others overlap with one or more options. We will show various options in the figures below.



(a) All overlapping (b) Multiple overlapping (c) Some overlapping

Figure 4.6: Type A: Overlap Between Options

The example in Section 4.1 of the Dutch Parliament elections showed that not all overlap should result in overlapping circles in the model. However, there are situations where this does give a decision-making event a better look and feel.

Wedding Anniversary Holiday

Many married couples like to celebrate their 25th, 40th or even 50th anniversaries with either a party or a holiday. Such a holiday often becomes a family affair with their children, grandchildren and even great-grandchildren. But where two people have two opinions, sixteen people have even more, which makes it a decision-making event.

Since the married couple pays for the trip, they get to decide the destinations. They think of all possibilities, the age differences and the time people need to take off work and come up with four destinations and combine them into five options:

1 Majorca (M)
2 Italy (I)
3 Majorca and Efteling (M+E)
4 Spain and Efteling (S+E)
5 Spain and Disneyland Paris (S+D)

The model for this option could very well be five circles with no overlap as Figure 4.7 shows. But to show the overlap between the options, the second model shown in Figure 4.8 works better.

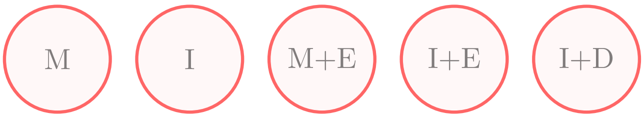


Figure 4.7: Wedding Anniversary Holiday Model with No Overlap

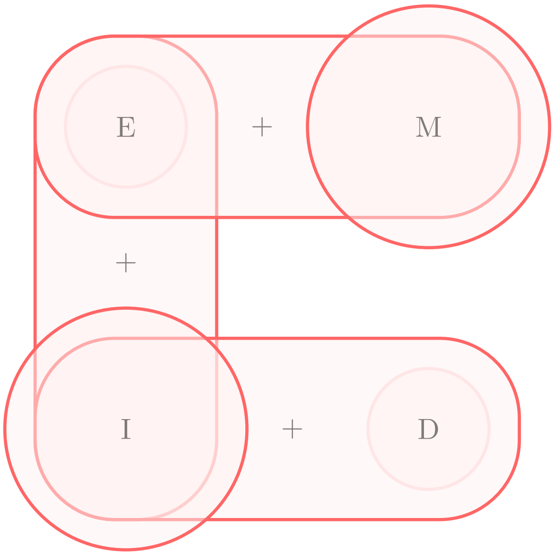
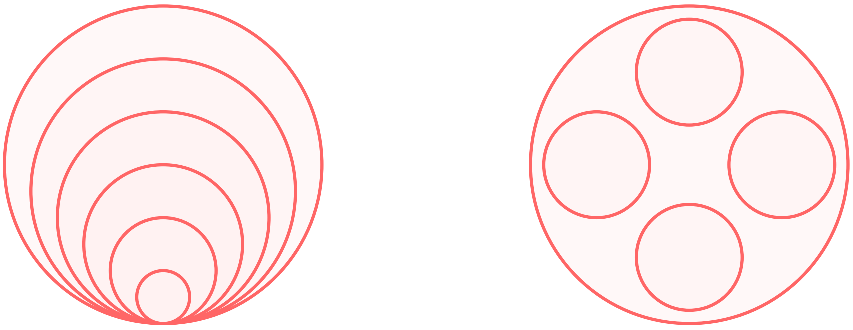


Figure 4.8: Wedding Anniversary Holiday Model with Overlap

4.3 Type C: Specificity

The options become more general or specific in the third decision type. There could be more than one specific option to one general option or options becoming increasingly specific. Figure 4.9 shows some of these variations.



(a) Options become more specific (or more general)

(b) General option with four more specific options

Figure 4.9: Type C: General option with four more specific options

We see examples of the left type very often when using software packages or applications on your laptop or smartphone. The smallest circle is the free-to-use trial version. The second circle is the light version where you have all the basic options and pay only a small fee. The third circle is named the premium version and contains all features of the light version but gives you additional storage space for a little bit more money. And the biggest circle is the gold version which gives you unlimited support and access to all future features. Figure 4.10 shows this small example.

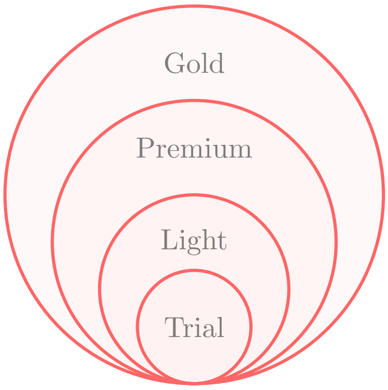
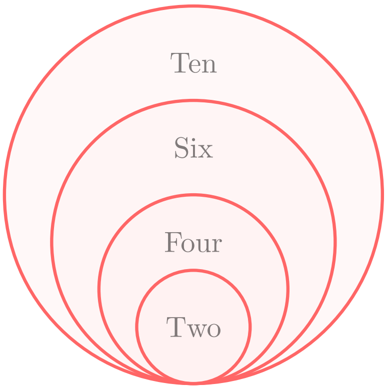


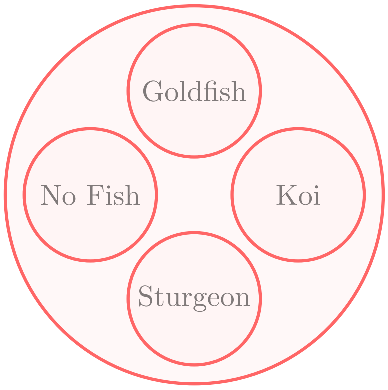
Figure 4.10: Software package membership model with increasing features and charge

Private Garden of Apartment Buildings

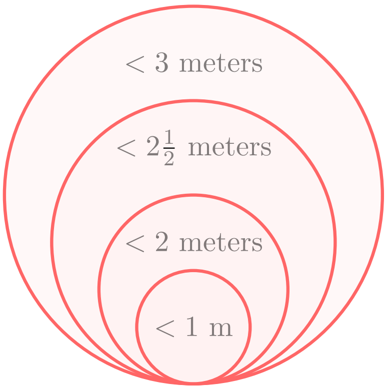
In this example a number of new apartment buildings are built, these buildings surround a fairly large area which is destined for the recreation of the residents. This example shows how multiple types can be combined into one decision-making event with multiple subquestions. There are over 300 new apartments and the new resident commission has already made an inventory of the wishes of all residents. They have decided to create a group decision-making event with multiple questions. From all subquestions, the residents need to choose at least one option. Figure 4.11 shows four of these questions.



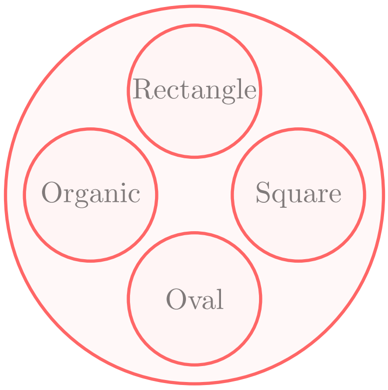
(a) Minimum number of persons to fit the communal sauna



(b) Options for in the communal pond



(c) Height of water element



(d) Form of the pool (approx $30m^2$)

Figure 4.11: Apartment Building Garden model containing four submodels, each representing a subquestion in a larger decision-making event

4.4 Type D: Mix

The final decision type is a mix of the types mentioned earlier. We chose to explicitly state this type and show a possible model in Figure 4.12. However, we find it very hard to offer an example of such options and suggest never creating a decision-making event based on this type. Instead, we advise altering the central question in such cases and creating an event based on one of the other three types.

Creating a decision-making event with a mix of types like the apartment building example is possible. But we must stipulate that such a complicated question – or set of questions – cannot be combined into one single model.

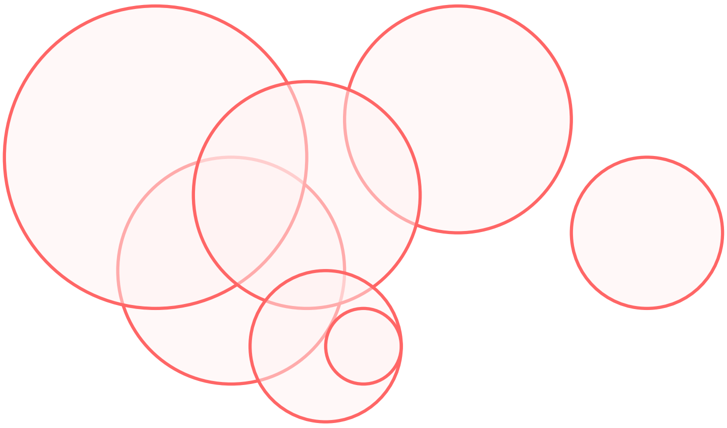


Figure 4.12: Type D: Mixed options

Chapter 5

Ballot Design

In elections and other decision-making events, ballots are used to administer votes. We will use some (hypothetical) real-world examples to illustrate the importance of visualising voting options. In our examples, we show the current way of ballot design and offer an alternative which uses icons, photographs and logos. The form of the ballots we present in this chapter could be both printed or digital. Both ballot forms have advantages and disadvantages, which we will not elaborate on in detail. However, research by Pachon in Colombia and Pichiliani in Brazil shows that the design of electronic ballots is as crucial as the design of hard-copy ballots to decrease invalid votes [22, 24]. For every decision-making event, the organisers must determine the best option for the situation. The same goes for the number of options, the presentation and the used methodology.

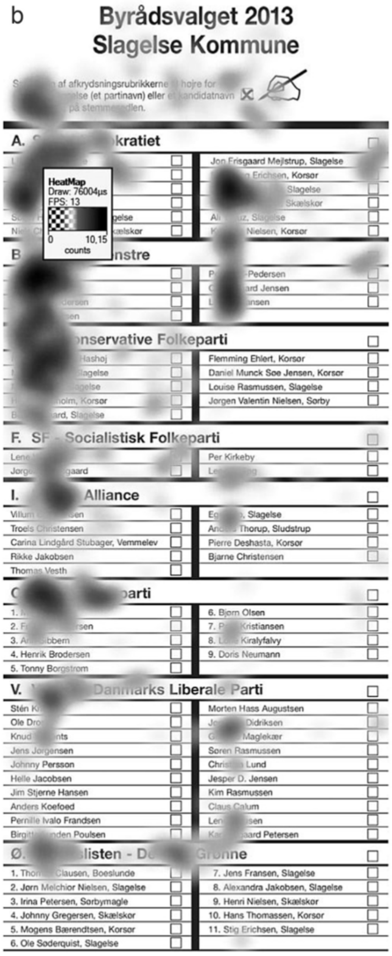
There are many reasons to use only text on ballots, yet research by Banducci shows that, especially when voting in elections, the use of photographs adds value. While in theory, voters should be prepared and informed, most often, they are not *well* informed and prepared [1]. Adding photographs of the candidates to the ballot in low-information elections helps voters to vote for their candidate. Low-information elections are local municipal elections; for example, those candidates don't get time in national media, and their names might be hard to remember. An earlier encounter with the candidate or a poster in the neighbourhood is enough to recognise a photograph on the ballot. Alongside municipal elections, this also works for Dutch provincial elections. If we move away from political examples, we can consider electing people to a new board at the sports club or for the participation committee at your children's school.

Another reason for adding images to existing text or replacing the text where possible is the variation in voter education level and illiteracy amongst voters. Illiteracy is a problem in many parts of the world. Unfortunately, the Netherlands is no exception. Over 1.3 million citizens over 16 years have trouble reading[1], which will also influence their participation in decision-making events. This means that roughly 10% of the voters in Dutch elections are illiterate, which might cause them not to cast their vote, or, if they do vote, cause them to feel intimidated by it on a certain level.

One final important aspect of ballot design we will cover is the order in which options are presented. Research by Blom-Hansen and Marcinkiewicz and Stegmaier looks at various elections in Denmark [2] and Poland and Czech Republic [18]. Both find that candidates listed on top of a ballot – whether well-known or not – gather a significantly larger amount of votes than lower-placed candidates. While Marcinkiewicz assigns this effect to the uninformed voters, Blom-Hansen worked with a well-informed group of voters and observed a similar effect, even with the order of the ballot randomly generated. Eye-tracking software confirmed that voters lingered around the candidates on the top of the ballot the longest, an image from the article is shown in Figure 5.1. The darker the "smudges", the longer eyes lingered on that spot. Blom-Hansen states that voters unconsciously associate "top" with "good".

In the first example in the next section, we will elaborate on ballot positioning. Marcinkiewicz and Stegmaier examined the effects of ballot positioning in Poland and the Czech Republic; both countries have different rules regarding the cumulative number of votes a party gets determining the number of seats assigned. Yet the effect of the ballot position is transferable to Dutch elections. Blom-Hansen looked at Danish elections, which can be more easily compared to Dutch elections because of the likeness of voters.

[1] `https://www.lezenenschrijven.nl/`



Note: The figure shows the result of an eye-tracking experiment where 18 subjects were asked to vote for a candidate or party/list on the ballot paper from the 2013 election in the municipality of Slagelse. Dark shades indicate the places where the subjects' eyes lingered.

Figure 5.1: Result of eye-tracking of voters on ballot [2].

5.1 Ballot Examples

In this section, we will illustrate alternatives to the current ballot design. The first example, although not a preferential decision-making event, are the Dutch Parliamentary Elections of 2021. The second and third examples a related to the same municipality. It asks for the participation of its citizens on two separate issues. The first is about the priorities for several projects, and the second is about the preference for the location of the new swimming pool. Finally, the last example regards the holiday choice of a reasonably large family.

5.1.1 Dutch Parliamentary Elections

In (sub)national elections in the Netherlands, voters cast their vote on a ballot by marking their first preference with a red pencil. The size of the ballots is significant because they hold all candidates printed in columns underneath their respective parties, as the examples in Figure 5.2 show.

(a) Ballot with red pencil

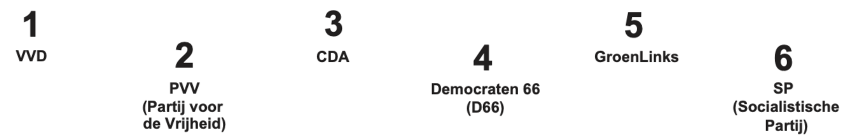
(b) Former Interior Minister Ollongren Presenting Ballot to the press

Figure 5.2: Example of Ballots for National Election
Source: `www.nos.nl`

The current representation of parties and candidates is in text, where all candidates have a white dot in front which needs to be coloured with a red pencil. The order of the parties is mainly based on the number of votes they received in the previous election; if a party is new or not represented in parliament yet, there are additional factors that we will omit here, but they are added on the righthand side of the ballot. Having a place on the left side of the ballot, numbers 1 to 6 are more likely to gather more votes because of their position and how people start to read a piece of paper. The order in which candidates are placed underneath their respective parties is an internal party decision. However, both orders are essential. The order of the parties because research shows that even in random order, parties on the left of the ballot get more votes than they would get on other positions. For the candidates, this is important because the cumulative number of votes for all party candidates determines the number of seats in Dutch elections. In other words, a higher place on the list represents a higher chance of getting elected, and the other way around, as long as all fellow party candidates gather enough votes. The most prominent and well-known candidates will often be on top of the list. Standing both on top but also on the very last place at the bottom (in Dutch: "Lijstduwer") gives a significant advantage in receiving votes according to Marcinkiewicz and Stegmaier [18]. Part of this is because the names of the non-prominent candidates are not well known to the voter, similar to the candidates in low-information elections [17, 26]. For example, in 2021, a total of 900 candidates from 27 parties were on the ballot. As a result, learning everything about a party and all its candidates is almost impossible.

Visualisation of Parties

The visualisation of parties is done with text, while all parties have very distinct logos and colours. Figures 5.3a, 5.3b and 5.3c show the current representation of the first six parties on the ballot and two alternatives with the logos in the original colours and black and white, respectively.



(a) Cutout of first six parties on 2021 election ballot

(b) Alternative visualisation for first six parties on 2021 election ballot using party logos

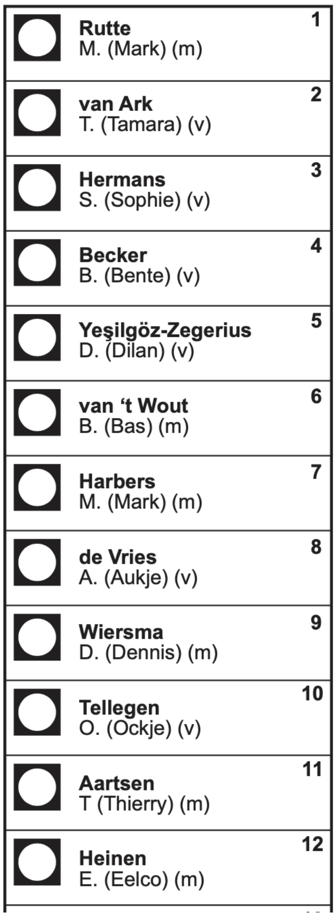
(c) Alternative visualisation for first six parties on 2021 election ballot using party logos in Black and White

Figure 5.3: Cutout of the current and two alternative representations of parties for the Dutch Parliamentary election of 2021.
Sources: `www.prodemos.nl` and `www.wikipedia.org`

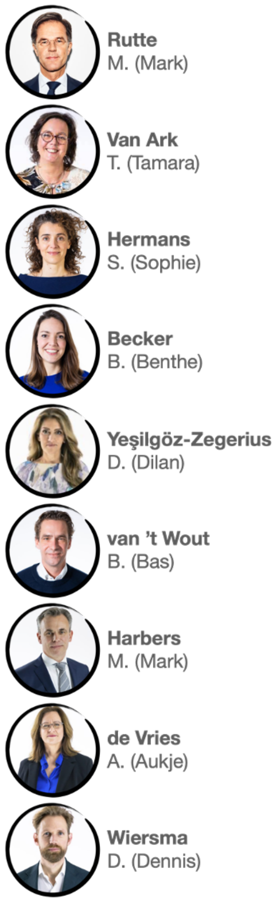
Parties and their candidates are better recognisable when using logos. It is how they campaign, what is on the leaflets they hand out and on the billboards throughout the country.

Visualisation of Candidates

The visualisation of candidates can also be done using photographs in combination with only their names for example. Of course, any other information can also be added if the organiser wishes to.



(a) Cutout from (partial) candidate list VVD 2021 elections



(b) Alternative (partial) candidate list VVD 2021 with pictures

Figure 5.4: Current and alternative visualisation of (partial) VVD candidate list for 2021 parliament elections
Sources: `www.prodemos.nl` and `www.vvd.nl`

5.1.2 Municipality Project Priorities

Municipalities have many projects running in their area simultaneously and many more upcoming projects. Some are annual, like maintenance work on landscaping. Some are done every so many years and don't need extensive planning. Then some tasks are urgent, like the shelter of citizens after a fire or the reception of refugees. With all of its staff, the municipality decides on these tasks and projects with little consultation with its citizens. But there are also possibilities to gather input from the municipalities' citizens. For example, if the city has a list of projects that are "nice" to execute but not enough money to do all of them, they could ask their citizens to set the priorities.

Municipalities have a lot of citizens – a relatively small city like Nijmegen has 180.000. Organising an evening where people can tell what they want would only give a small portion the possibility to interact. Electronic polls are often used to gather the answers in these cases. Google Forms and SurveyMonkey are two options that allow you to make this. But there are limitations to the freedom you have; this holds for the way you ask questions but, more importantly, for the way the result is generated – the methodology used. Majority Voting is the methodology used by Google Forms apart from a display of all the answers given. SurveyMonkey has a variety of possibilities, depending on the licence you purchase, but no obvious choice in methodology.

In the example above, we would strongly recommend a Preferential Multi-option Methodology. The municipality can indicate which projects should be executed first by looking at the preferences of its citizens. Working from the most preferred toward the least preferred – until the budget runs out – will satisfy as many citizens as possible. For the example, we will use a hypothetical municipality with 30.000 citizens. Five projects are on the list, all cost the same amount of money, and there is room in the budget for three projects.

The voting methodology used is the Modified Borda Count. If there are any ties, the project with the most first preferences gets the advantage, followed by the second preference, etc. Voters must assign their preferences to all options, and ties are not allowed. Figure 5.5 shows a text-based ballot with the following five projects used in this example:

Project A:	New skatepark on location Z
Project B:	Planting of new trees in Parc X
Project C:	Placing of public restrooms in Parc X
Project D:	Renewal of the playground in Parc X
Project E:	Placing of padel courts on location Z

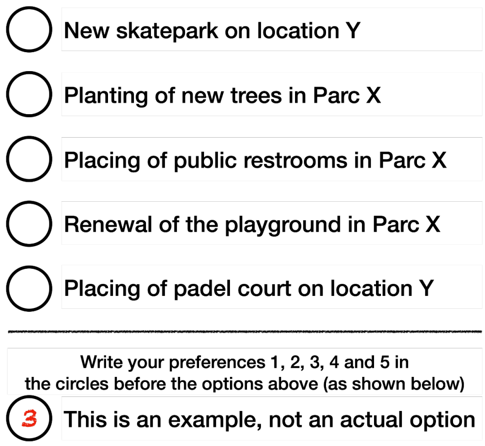


Figure 5.5: Text-based preference ballot with five project options

Voters would indicate their preferences for the five options in the circles by writing the numbers 1, 2, 3, 4 and 5. Although writing down five numbers might seem pretty straightforward, given the research by Pachón in Columbia, voters can make many mistakes in such events [22]. For Dutch elections, where only one circle has to be coloured, there are 16 examples of valid and invalid votes in the manual for the people counting the ballots[2] published by 'de Kiesraad'. Examples given are ballots with names written on them, arrows pointing to a candidate, multiple circles coloured and two circles coloured but one crossed out. In the 2021 Dutch elections, 0.22% of the ballots – around 22.000 – were deemed invalid and thus, the votes of these citizens were lost.

[2] https://www.kiesraad.nl/adviezen-en-publicaties/publicaties/2016/03/staatscourant-e.d/voorbeelden-blanco-geldige-en-ongeldige-stemmen

To prevent invalid votes, we suggest using an alternative as shown in Figure 5.6. By using images with text, the options become more apparent. The images used in the example are dummy images. Photos of trees and sketches of buildings or facilities would significantly improve recognisability for the voters as photographs of candidates also do, according to Banducci [1]. Furthermore, voters can see the order themselves by putting the options in order of preference. There is no need to interpret the numbers standing before, which could be helpful to illiterate citizens.

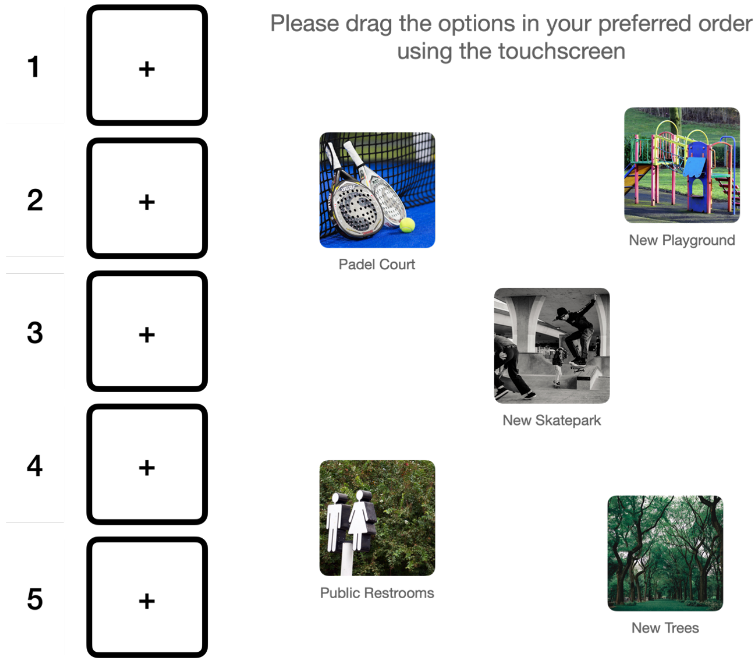


Figure 5.6: Image-based preference ballot with five project options using touch-screen technology.
Sources: `www.pexels.com` and `www.freeimages.com`

The form of this ballot favours a digital decision-making event, but this is not necessarily so. We can also make such a ballot in a hard-copy variant. With a few changes to the design, for instance, omitting the '+'-signs and other "digital-overhead" as in Figure 5.7, the ballot can be printed and sent to every household by mail. The five options can be included as stickers, so voters can stick the options on the ballot in their preferred order and send them back via mail or hand-deliver them to city hall.

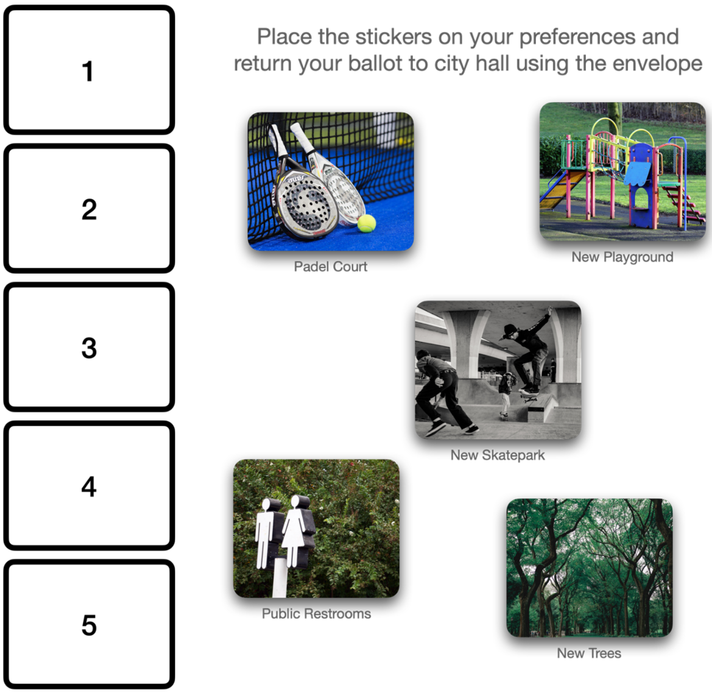


Figure 5.7: Image-based preference ballot with five project options using stickers for hard-copy use.
Sources: `www.pexels.com` and `www.freeimages.com`

Our hypothetical municipality has only 30.000 residents, which means that they are all familiar with location Y and Parc X. We also assume that there is more information available on the various options, but we have omitted that from this example. Of the 30.0000 residents, exactly 20.000 have returned valid ballots, some citizens did not vote, and others were not allowed to vote yet because of their age. The results of the decision-making event are displayed in Table 5.1 in the form of a preference table.

	3000	4000	2000	4000	6000	1000
1^{st} preference	Option B	Option B	Option B	Option C	Option D	Option E
2^{nd} preference	Option C	Option D	Option E	Option A	Option C	Option A
3^{rd} preference	Option A	Option C	Option A	Option D	Option A	Option D
4^{th} preference	Option D	Option A	Option C	Option B	Option E	Option B
5^{th} preference	Option E	Option E	Option D	Option E	Option B	Option C

Table 5.1: Preference schedule Municipality Project example.

As mentioned before, we use the Modified Borda Count (Section 3.3.5). The first preferences get 5 points, the second preferences 4 points, etc. These numbers are added to the table and shown in Table 5.2.

	3	4	2	4	6	1
1^{st} preference	Option B $3 \cdot 5 = 15$	Option B $4 \cdot 5 = 20$	Option B $2 \cdot 5 = 10$	Option C $4 \cdot 5 = 20$	Option D $6 \cdot 5 = 30$	Option E $1 \cdot 5 = 5$
2^{nd} preference	Option C $3 \cdot 4 = 12$	Option D $4 \cdot 4 = 16$	Option E $2 \cdot 4 = 8$	Option A $4 \cdot 4 = 16$	Option C $6 \cdot 4 = 24$	Option A $1 \cdot 4 = 4$
3^{rd} preference	Option A $3 \cdot 3 = 19$	Option C $4 \cdot 3 = 12$	Option A $2 \cdot 3 = 6$	Option D $4 \cdot 3 = 12$	Option A $6 \cdot 3 = 18$	Option D $1 \cdot 3 = 3$
4^{th} preference	Option D $3 \cdot 2 = 6$	Option A $4 \cdot 2 = 8$	Option C $2 \cdot 2 = 4$	Option B $4 \cdot 2 = 8$	Option E $6 \cdot 2 = 12$	Option B $1 \cdot 2 = 2$
5^{th} preference	Option E $3 \cdot 1 = 3$	Option E $4 \cdot 1 = 4$	Option D $2 \cdot 1 = 2$	Option E $4 \cdot 1 = 4$	Option B $6 \cdot 1 = 6$	Option C $1 \cdot 1 = 1$

Table 5.2: Preference schedule Municipality Project example.
Number of votes and points $\times 1000$.

Now we tally the number of points from the table per option (project) and come to the following result:

Option C: 73.000 points
Option D: 69.000 points
Option B: 61.000 points
Option A: 61.000 points
Option E: 36.000 points

Option C wins the decision-making event, followed by option D. Option B and A gather the same points, but option B has the most first preferences (9000 versus 0). Therefore, project B will be third after projects C and D.

The reason for choosing the Modified Borda Count as the methodology for this decision-making event is that besides getting a winner, the preferences of the other options are also immediately clear. In addition, there was a budget for three projects which means that the organising municipality needed more than only one winner.

The preference table for this example was also used in Section 3.3.2 where option D was both the Instant-Runoff winner and Condorcet-winner. Unfortunately, both methodologies do not give second and third place; This could have been C and D, which would have meant the same three projects were to be executed in this situation, but we can't know for sure.

5.1.3 Municipality Swimming Pool Location

For the design of the ballot in the previous example, the locations of all options were expected to be well known to the voters (residents). For this example, we will take a larger municipality resembling Nijmegen and ask the citizens to give their opinion about the location of a new swimming pool. Currently, there are three public swimming pools, as indicated on the map with stars in Figure 5.8. Before continuing, we want to stretch that this example is purely hypothetical. We have used a mirrored map of the city of Nijmegen with the locations of the current swimming pools and altered their names. If there are any plans for new swimming pools, we have no prior knowledge of that, and this is purely coincidental.

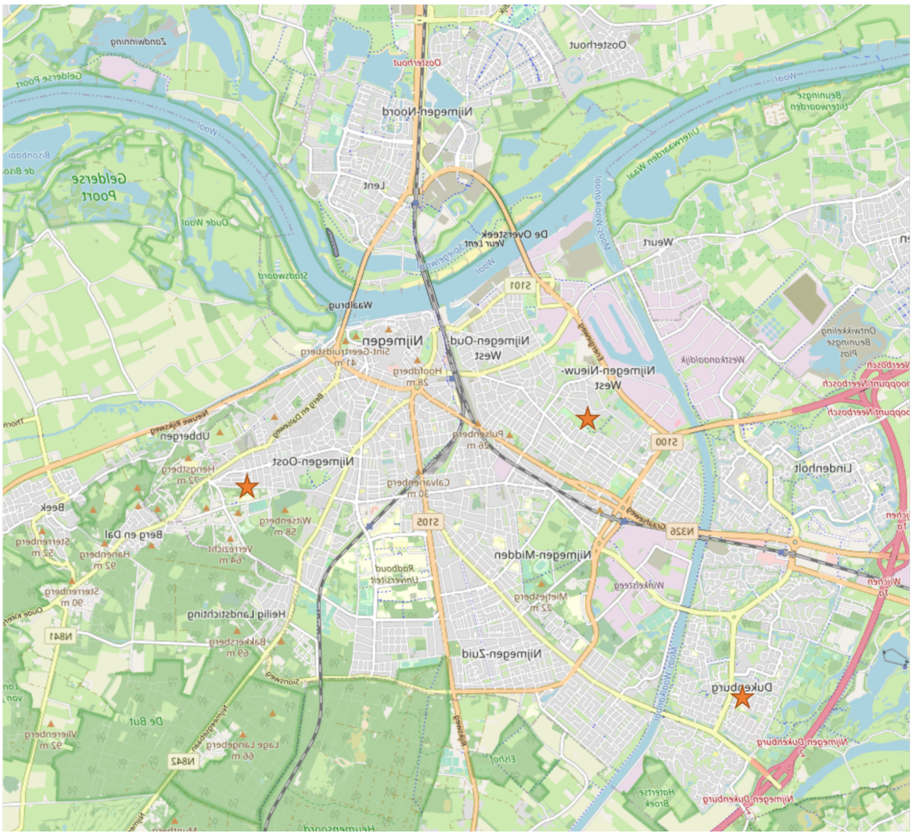


Figure 5.8: Map of the city with locations of current swimming pools.
Source: `www.openstreetmap.org`

The workgroup working on the various locations finds it a good idea for the city's residents to decide which of their options is realised. Therefore, four possibilities have been developed and are listed below, including a short description and presented on the map in Figure 5.9. The options have the letters N, W, B and G, corresponding with the locations.

- Option N is located in the northern part of the city, a growing area with many new houses and youth.
- Option E is located at the current location of swimming pool East; this option means an extension and renovation of the current swimming pool.
- Option P is located in the Central Parc and means a takeover and renewal of the privately owned outdoor pool and expanding it with indoor capacity.
- Option B is located close to an adjacent city. This location will only be possible if the other municipality also agrees.

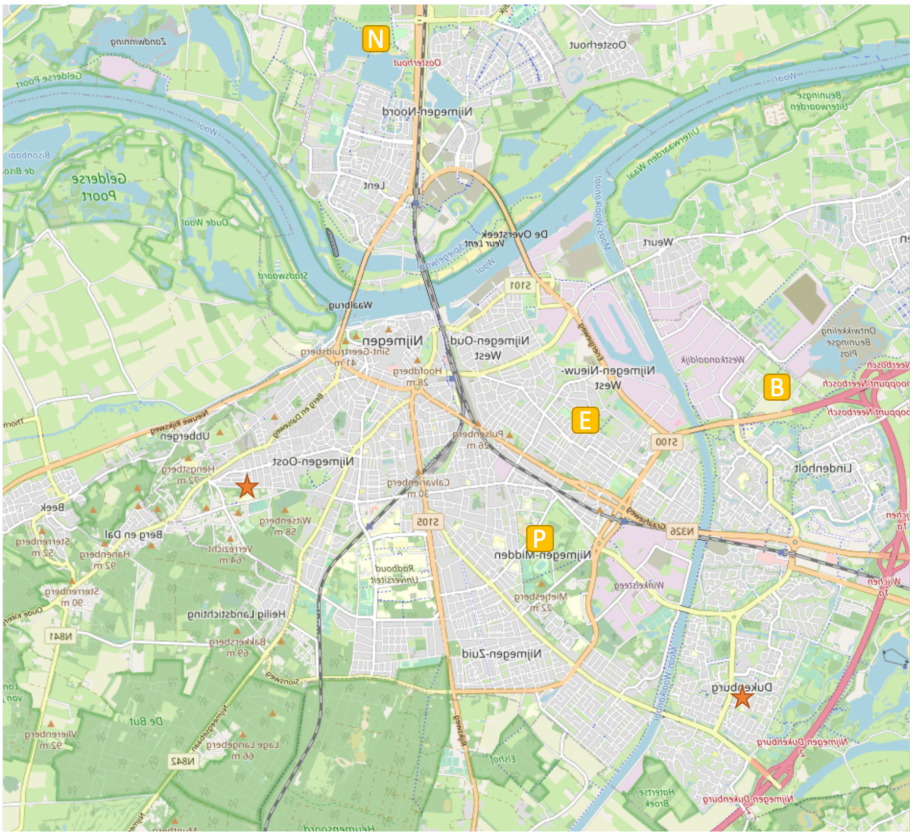


Figure 5.9: Map of the city with locations of current swimming pools and possible new locations.
Source: `www.openstreetmap.org`

The way of voting would strongly represent the previous example in Section 5.1.2. All voters would give their preferences either digitally or in hard copy. The ballot itself – from which the options can be moved towards the preference list – could include the map and pictures of the locations and, where possible visualisations of the future situate, an example is presented in Figure 5.10.

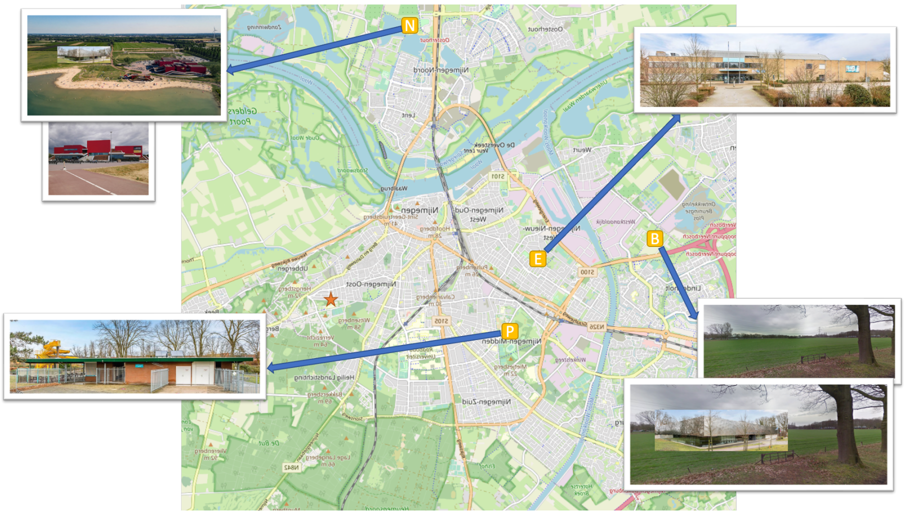
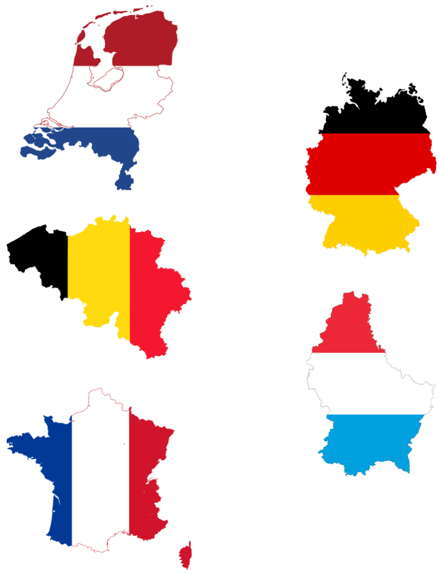


Figure 5.10: Visualisation for decision-making event for new swimming pool with photos, visualisations and map indicating the various locations. Sources: `www.openstreetmap.org`, `www.wikipedia.org`, `www.gelderlander.nl`, `www.goffertbad.nl` and `www.google.com/maps`

5.1.4 Holiday Destinations

For our final example, we look at friends and family matter, namely choosing a holiday location. Especially with a large group, this is a serious group decision to be made. To have all voters have an equal part in the destination, the group should make this a decision-making event with ballots and a fair methodology. Before choosing an accommodation, the group has to pick a country to travel to; the options are (in alphabetical order): Belgium, France, Germany, Luxembourg and the Netherlands. While the names in writing might suffice for these locations and most groups, using images or flags increases both recognisability and experience. Figure 5.11 present two variations using flags, one with the country abbreviation and the other with the country contours.

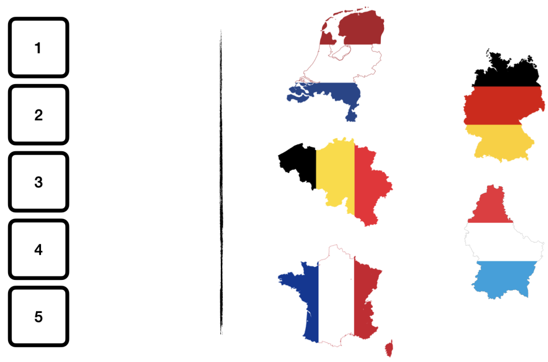
(a) Visualisation of holiday countries using circles filled with country flags



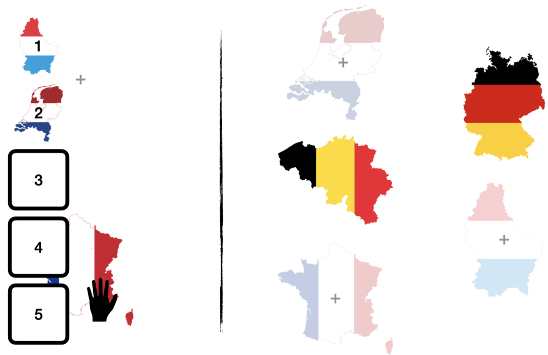
(b) Visualisation of holiday countries using contours of the countries filled with respective flags

Figure 5.11: Two examples of visualising holiday destinations. Sources: `www.wikipedia.org` and `www.jetpunk.com`

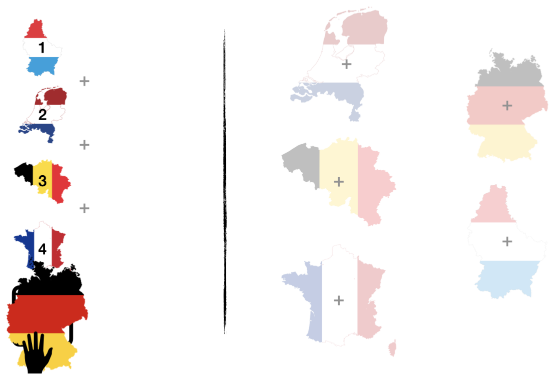
To make filling the preference ballot more interactive, we suggest using *Interactive Preference Ballots*, which we will discuss in Section 5.2. We have created a mock-up of such a ballot; Figure 5.12 shows some parts. The complete mock-up can be found in Appendix A.



(a) Empty Ballot



(b) Adding third option to the ballot (France)



(c) Filled Ballot

Figure 5.12: Selection of snapshots from Holiday Mock-up. The full mock-up can be found in Appendix A.

5.2 Interactive Preferential Ballots

The examples from the Section 5.1 all show that using photos, logos, maps, and images increases the recognisably of options. We conducted an extensive search in both literature and for tools online. Online tools like `rankedvote.co`, `electionbuddy.com` and `debordavote.org` use preferential voting, but none use an interactive approach. And neither does the research we found in our search.

The last example about the holiday destinations was more elaborate than the others; the mock-up in Figure 5.12 and Appendix A shows how a ballot can be filled in a digital environment using a touch screen or, of course, a mouse or track-pad. What is still missing in the mock-up are the instructions and the buttons for submitting the ballot and starting over, for example, and very important for using the ballot [20].

The ballot layout is designed to counter the liking research shows that voters have for candidates on the top left corner of the ballot, a natural bias. Therefore, we decided to move all options to the right side to eliminate this effect. Although we did not see any research supporting this theory, we may assume that similar research on Arabic ballots will favour the right side because of the opposite reading direction.

The order of the options on the ballot significantly influences the result, as we have shown earlier in this chapter. The order of the example in Section 5.1.4 is alphabetical in the initial listing of the options. When visualising, the order represents the geographical locations of the countries as shown in Figure 5.11. When creating an interactive preference ballot, we recommend using such a geographical or other intuitive order for the options on the ballot. If such an order does not exist, we recommend using a random order for every voter to minimise advantages regarding ballot positioning.

In this section, we will present a new mock-up also selecting a holiday destination, but this time the decision-making regards four regions in Italy. The group will choose the order of preferences regarding; Sardegna, Sicily, Tuscany and Veneto. Figure 5.13 shows the four regions.

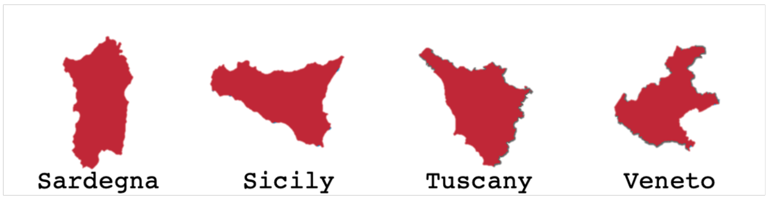


Figure 5.13: Contours of four candidate destinations and their names.
Source: `www.wikipedia.org`

Decision Model

The four candidate destinations we will use in this example result from a prior decision-making event. In this event, the organisers narrowed the options down from all regions in France, Italy and Spain to four candidate destinations in Italy. Figure 5.14 shows the decision model with all these regions.

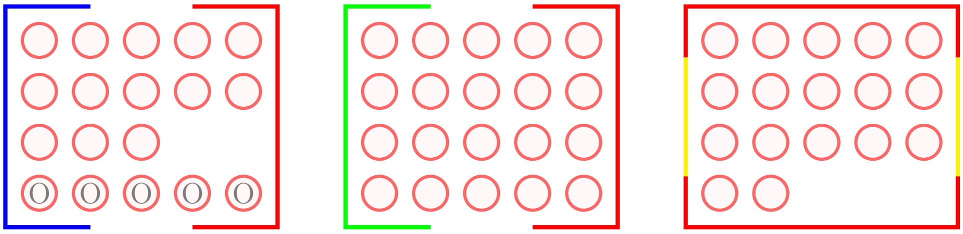
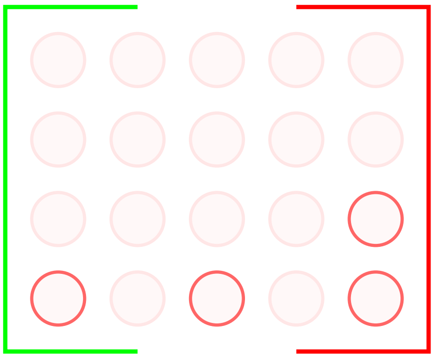
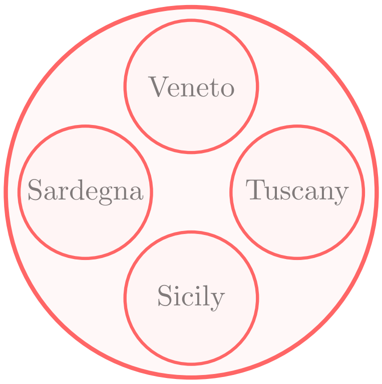


Figure 5.14: Model of regions of France ($13 + 5$), Italy (20) and Spain (17) as a model of options containing three specificity models

Before continuing to the ballot, we show the decision design model which belongs to this example. First, Figure 5.15 shows the model of Italy with all 20 regions as circles as used in Figure 5.14 but with the 16 destinations that have fallen shown faded in Figure 5.15a. Finally, Figure 5.15b shows the model with only the four remaining options.



(a) Model of Italy with 20 Regions as specificity options. The 16 regions that are not part of the decision-making event are faded.

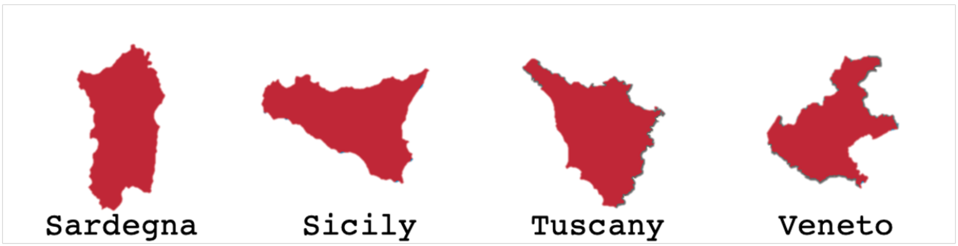


(b) Model of Italy with the four candidate options. The 16 regions that are not part of the decision-making event are removed.

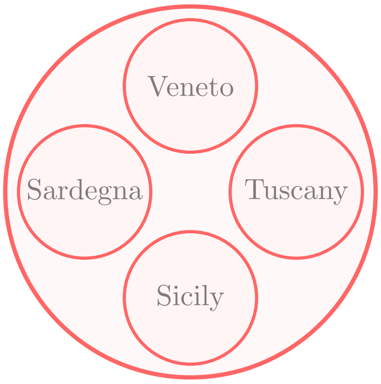
Figure 5.15: Two possible representations for the model of Italy belonging to the decision-making event.

Option Visualisation

The next step is creating a ballot using the models in Figure 5.15. If we combine the earlier representation of the options from Figure 5.13 with the model in Figure 5.15b in one image, this gives Figure 5.16.



(a) Contours of four candidate destinations and their names. Source: `www.wikipedia.org`. Copy of Figure 5.13



(b) Model of Italy with the four candidate options. The 16 regions that are not part of the decision-making event are removed. Copy of Figure 5.15b

Figure 5.16: Options and model side-by-side

Figure 5.16 shows that the circles in the decision model are perfectly represented by the contours and names of the four regions – and the other way around. But the four contours with the names provide little information to the voters in this decision-making event. Without significant knowledge of Italy or a map, the regions could be anywhere in Italy. In a decision-making event like this, including the remaining regions, in other words, the rest of Italy, is crucial.

Figure 5.17 shows the map of Italy with all 20 regions separated by their borders and the four candidate destinations highlighted and displayed on the right side of the map. By displaying the options like this, voters will immediately get a lot of visual relevant information about regions.

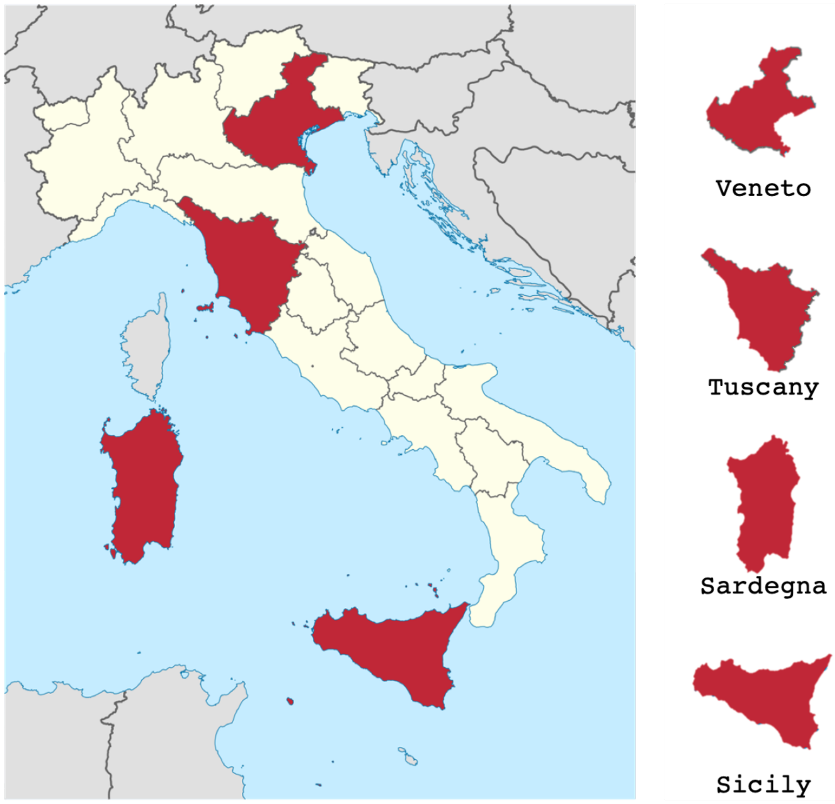


Figure 5.17: Map of Italy with all regions separated by their borders and the four candidate destinations highlighted and their contours and names on the right side next to the map.
Source: `www.wikipedia.org`

Italy is a very popular holiday destination, but there are many different areas in Italy. Cities like Rome and Venice will speak to the mind of many people, but for the remaining part of Italy, extra information is essential. All these destinations have different weather, landscape and places to visit, which also varies throughout the year, including the well-known sites like Rome and Venice.

An interactive preference ballot can help a group make an informed decision. By implementing the relevant information about the options on the ballot, we can make it available to the voters. This way, voters do not need to look up the destinations beforehand, discarding a potential low-information vote [1]. At the same time, we can provide all voters with relevant information when needed, just in time and just enough.

We can minimise the amount of text by using icons to display this information in combination with a few words. That way, we prevent an overload of information and a cluttered ballot, a set of icons as shown in Figure 5.18.

Figure 5.18: Set of icons to provide additional information to voters.

This set shows:

A car	For the distance to travel from the Netherlands
A building	For the name of the capital
A sun	For the average temperature in said month
An umbrella	For the average rainfall in a said month (1-5)
A city	For the level of tourist cities and attractions (1-5)

Depending on the overall design of the ballot, the best place for additional information has to be decided upon. For example, using icons and little text makes the information not take up to much space. Alternatively, multiple locations can be used to display information to keep other relevant information available as well. For example, Figure 5.19 shows the information of one of the regions in this example.

Figure 5.19: Example of additional regional information of Tuscany.

Figure 5.20 shows the first screen of the Interactive Preference Ballot belonging to this example. We have used the various elements shown above and added four areas to place the choices in the preferred order, a submit button to press when the preferences are in order, and some instructions in the text on top of the screen to guide voters through the process.

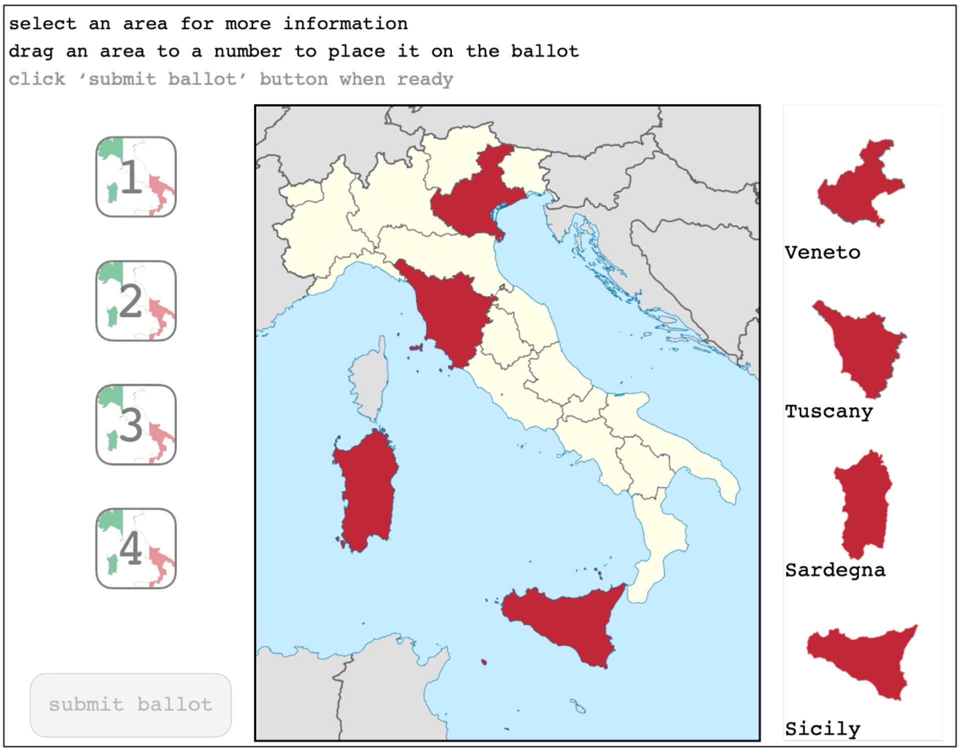


Figure 5.20: First screen of Interactive Preference Ballot of Italy example

The first screen of the Interactive Preference Ballot in Figure 5.20 is ready to be used. Additionally, an animation demonstrating the actions can be shown.

Users can drag the regions to the squares on the left side of the ballot. To accommodate users they are able to select the areas from the map and the list on the right side of the ballot. Additional information will be shown when hovering over an option, either on the map, or the list on the right side, but also if options are already placed on a preference spot, on the left side.

The "submit ballot" button is faded because no preferences are given yet. This event does not require a full ballot, so if one preference is given, the submit button will be available. Figures 5.21 - 5.26 will show some snapshots of the various aspects of this Interactive Preference Ballot. In appendix B all actions in relation to selecting the preferences and submitting the ballot are shown. The respective captions will elaborate on the specifics of the snapshot.

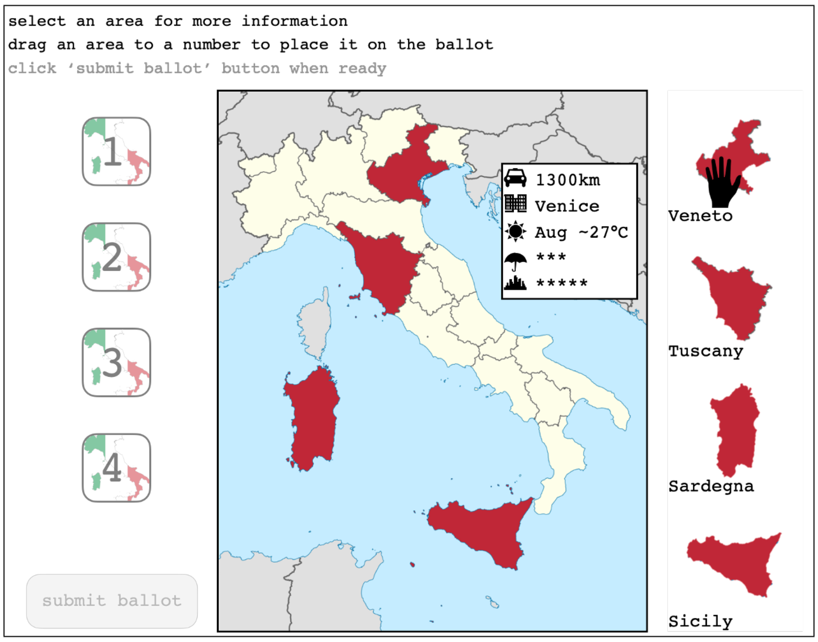


Figure 5.21: Hoover over an option (Veneto) in the list on the right to show additional information

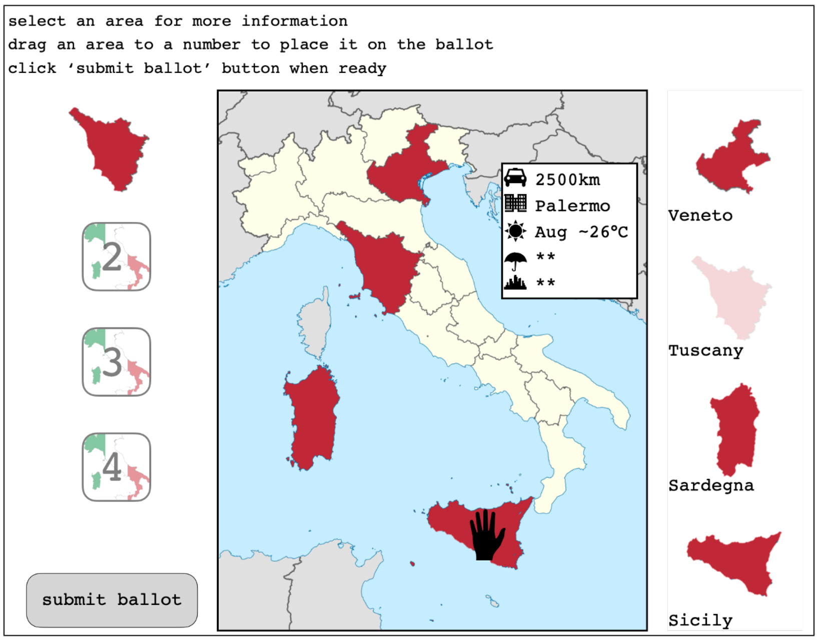


Figure 5.22: Hoover over an option on the map (Sicily) to show additional information

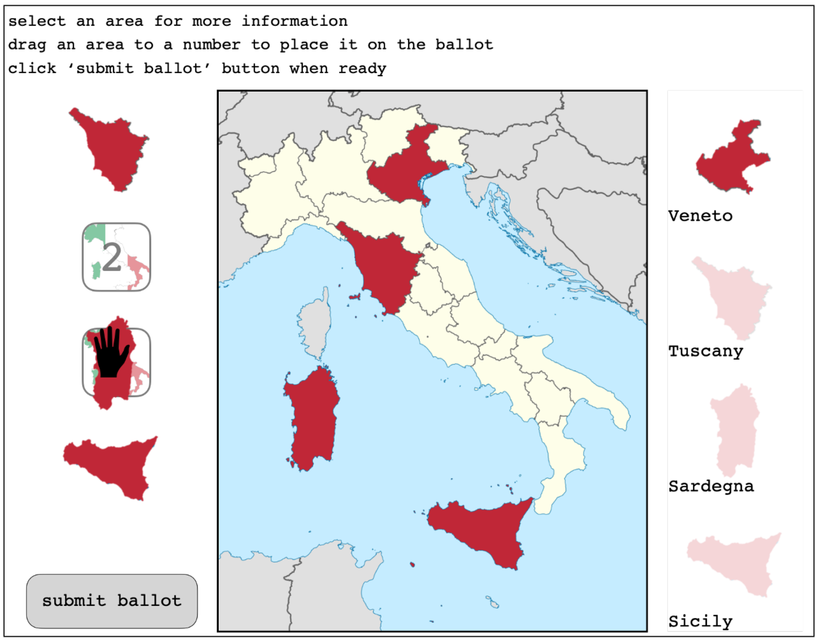


Figure 5.23: Place selected option (Sardegna) over third preference area

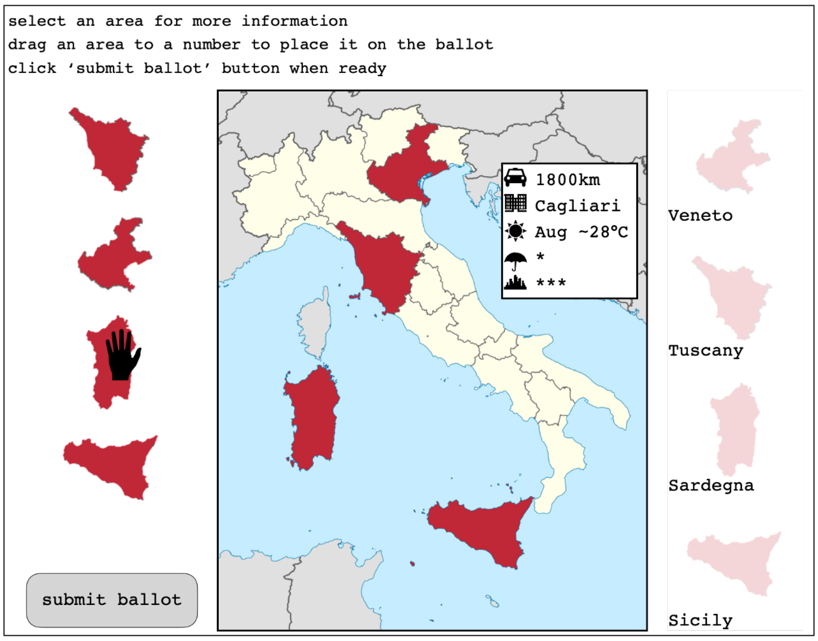


Figure 5.24: Hoover over an option in the preference list (Sardegna) on the left to show additional information

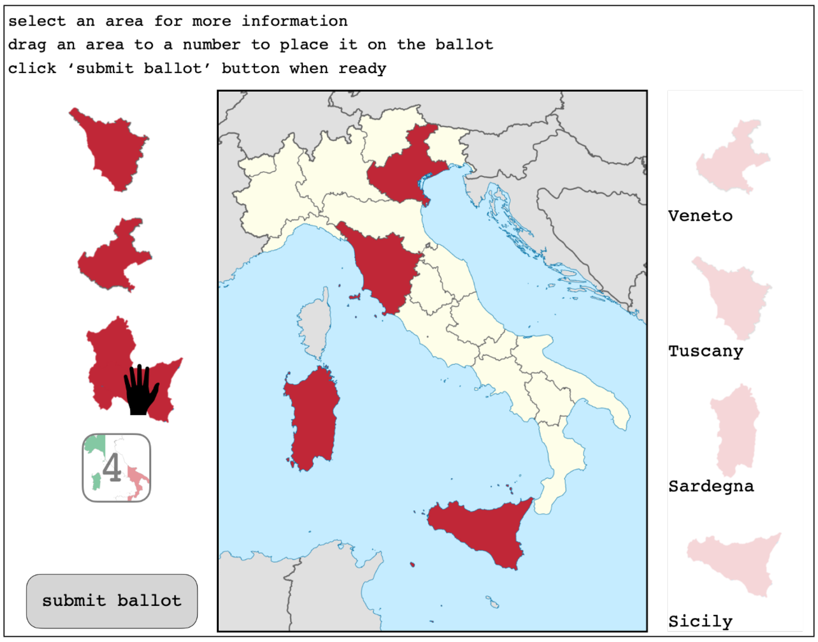


Figure 5.25: Swap two preferences on the preference list by dragging and dropping one (Sicily) over the other (Sardegna)

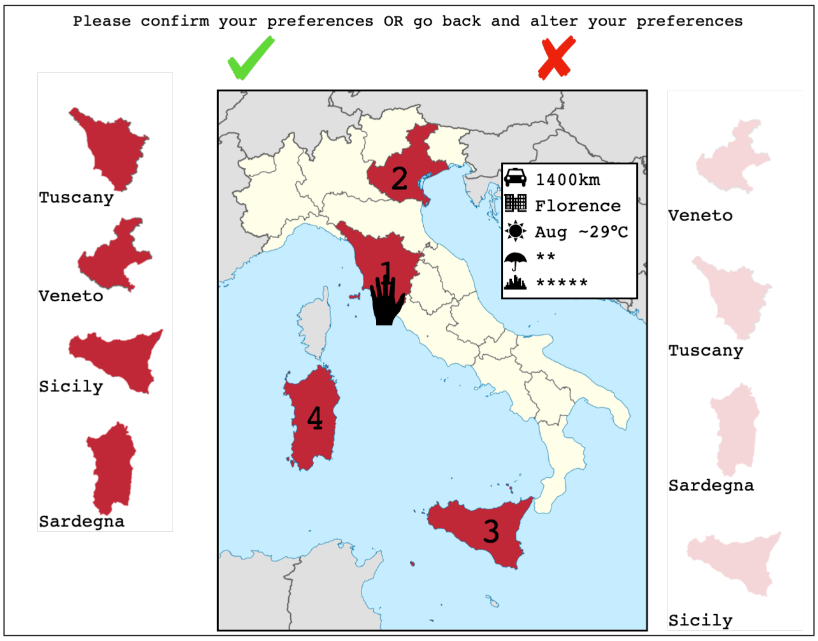


Figure 5.26: Hoover over first preference (Tuscany) on the map to show additional information

Chapter 6

Conclusions

This research looked at *visualising group decision-making events* that use preferential voting. With the suggestions for *Interactive Preference Ballots*, we made an attempt to make decision-making more accessible, effective and fair.

We have taken apart the decision-making process to focus on the relevant parts to our goal; Voting Methodology, Decision Type and Ballot Design.

We have shown that the results of non-preferential methodologies can be very different and often less fair than those using preferential voting in the same situations. Of all methodologies in this research, the Modified Borda Count, Condorcet and Copeland are the most inclusive. However, suppose a decision-making event also requires the possibility of partially filled ballots or at least ballots that do not contain all options or should allow individual voters to tie two or more options. In that case, the Modified Borda Count is the most suitable and robust methodology. Although the Modified Borda Count is not perfect and does not satisfy all criteria the literature describes, we consider it to be the fairest and most suitable for group decision-making events.

By describing various decision types, in which the common grounds the options share varies, we have shown that it is essential to put effort into preparing a decision-making event. The preparation includes phrasing the question of the decision-making event, the number and phrasing of the options presented to voters and showing relevant relations between options. The poor phrasing of a question can lead to the answer to a question one did not intend to ask. An incomplete set of options can lead to a dissatisfied population of voters during and after the event, maybe resulting in a new attempt. On the other hand, having an overcomplete set of options, in the sense that options are too much alike, can result in the division of a majority of voters between those options and therefore losing the vote to another option.

The phrasing of questions and options is also essential to allow all voters to participate. Literature suggests using photos and images to support the visualisation of options for accessibility to the illiterate, for example. While these visual aids make the options more recognisable, filling a ballot with several preferences in one's order of preference is more complicated than selecting the one preferred most. We suggest making the ballot interactive to see your progress the whole time in contrast to statically giving the options a preference and maybe seeing them in order before submitting the ballot.

We have created multiple examples for the visualisation of options using maps, icons, photographs and logos. If possible, we suggest using a random order for the positioning of options to prevent a bias towards options in the top-left area of the ballot. However, if options must have a specific order because of rules or law, or if options have a geographical location and can be placed on a map, this is more important than randomness.

While most of the examples we give seem the most viable for electronic voting situations, we also suggest a possibility for hard-copy interactive preference ballots by using stickers. Voters can move the options around and examine whether they are happy with the preference ballot before sticking the options on the ballot and submitting it.

Our research was limited to literature research. Preferential methodologies increase the fairness of group decision-making, this has been shown before. Our suggestion for Interactive Preference Ballots is only based on literature research and is not supported by usability and accessibility testing. In theory, the design should increase the fairness of decision-making because it removes room for natural biases and minimises these subconscious actions. We see an opportunity for future research for user testing the concept of Interactive Preference Ballots with actual decision-making events.

The conclusion of this research is that using Interactive Preferential Ballots can increase accessibility, effectiveness and fairness of group decision-making.

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Appendix A

Mockup Holiday with Country Contours and Flags

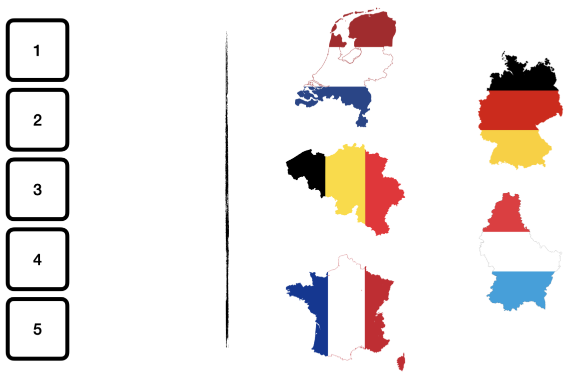

Figure A.1: Empty ballot with five options

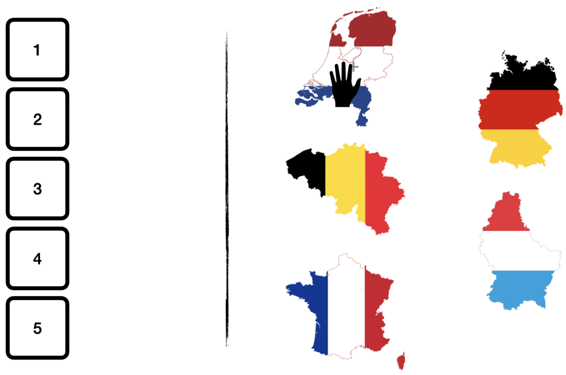

Figure A.2: Selection of the first option (The Netherlands)

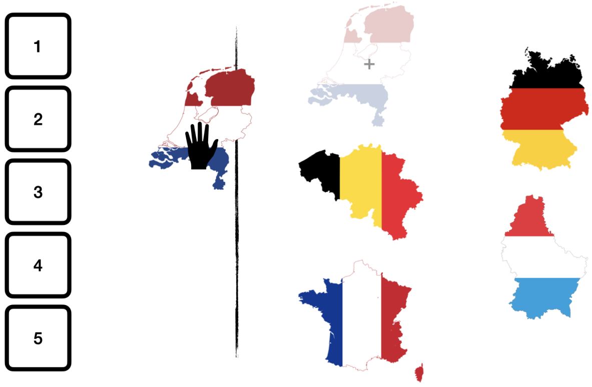

Figure A.3: Move of the first option

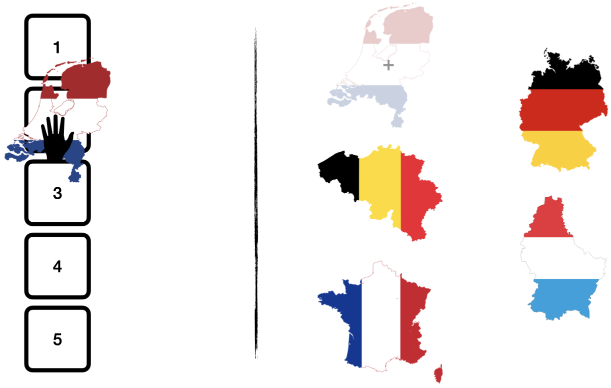

Figure A.4: Release of the first option on the second preference

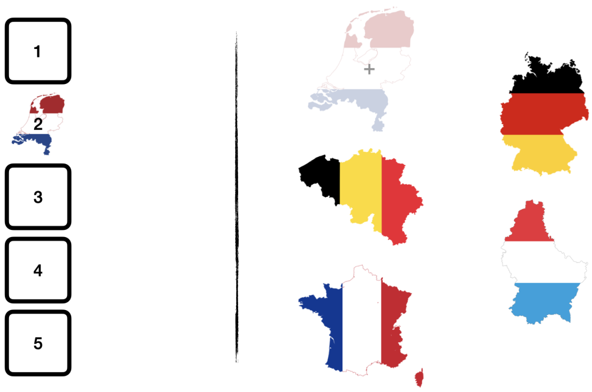

Figure A.5: One preference on the ballot

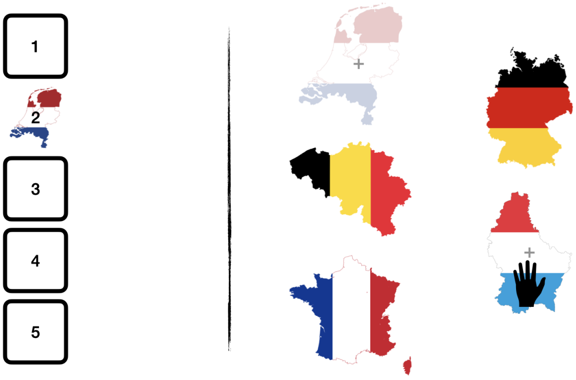

Figure A.6: Selection of the second option (Luxembourg)

Figure A.7: Move of the second option

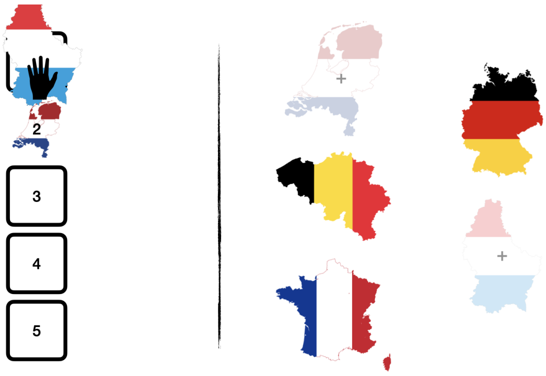

Figure A.8: Release of the second option on the first preference

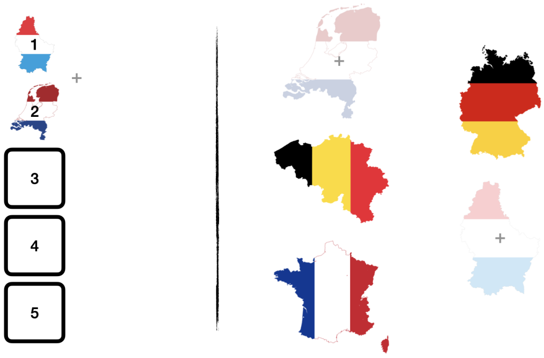

Figure A.9: Two preferences on the ballot

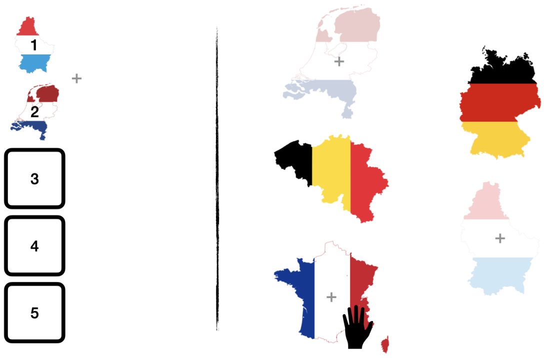

Figure A.10: Selection of the third option (France)

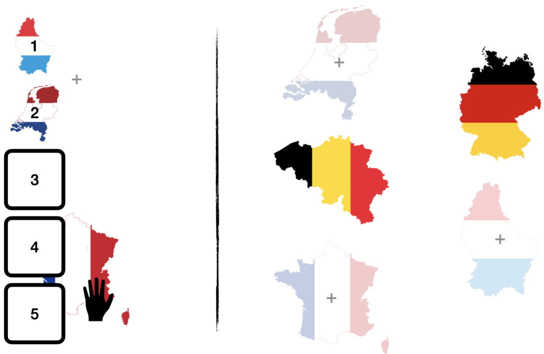

Figure A.11: Move of the third option

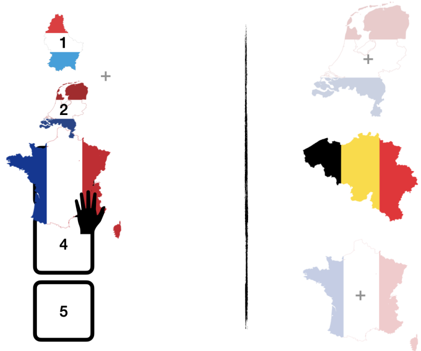

Figure A.12: Release of the third option on the third preference

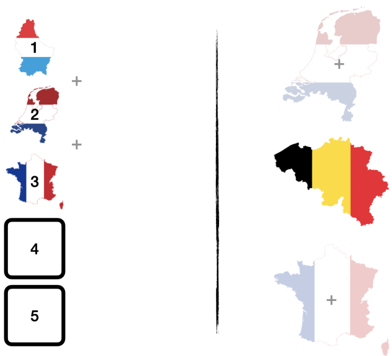

Figure A.13: Three preferences on the ballot

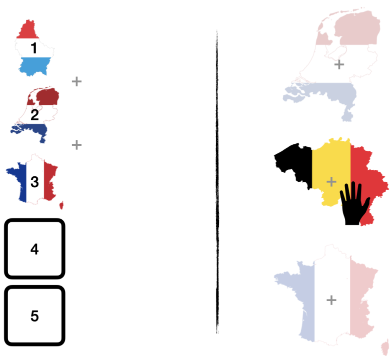

Figure A.14: Selection of the fourth option (Belgium)

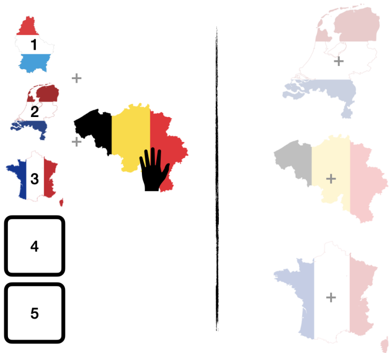

Figure A.15: Move of the fourth option

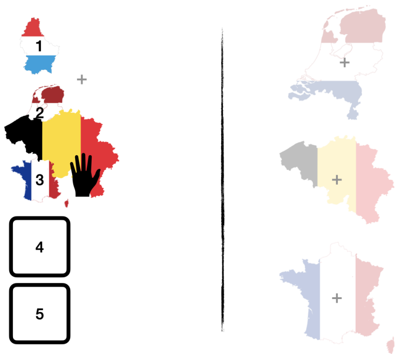

Figure A.16: Release of the fourth option on the third preference.
France moves from third to fourth preference

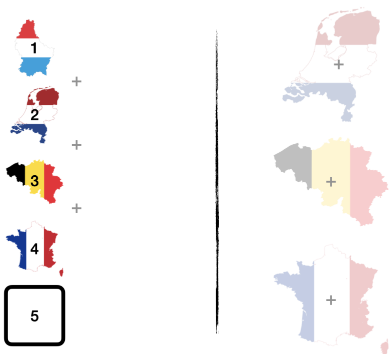

Figure A.17: Four preferences on the ballot

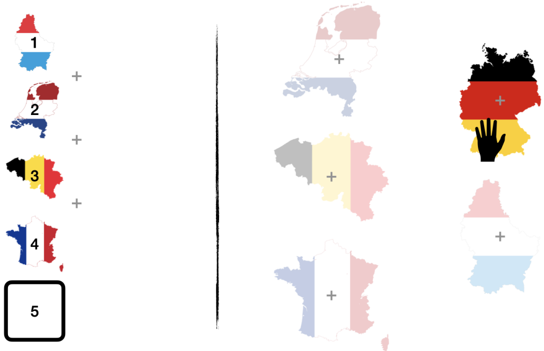

Figure A.18: Selection of the fifth option (Germany)

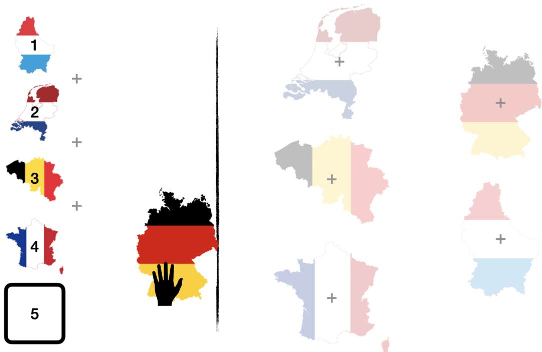

Figure A.19: Move of the fifth option

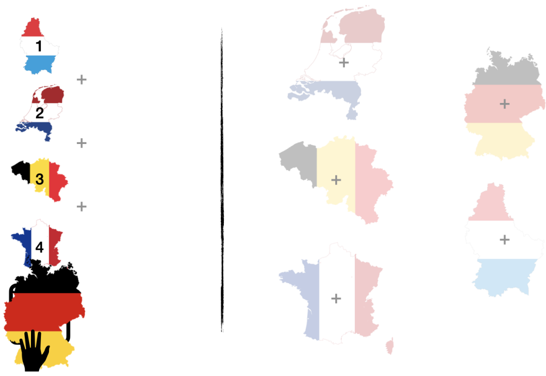

Figure A.20: Release of the fifth option on the fifth preference

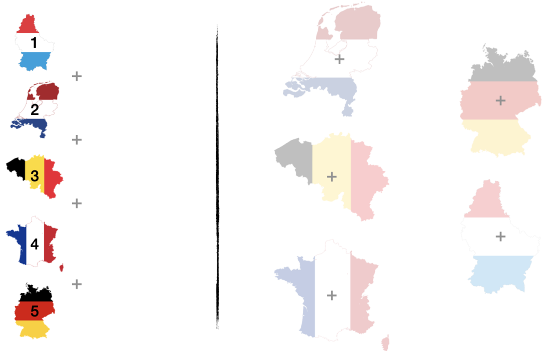

Figure A.21: Four preferences on the ballot

Figure A.22: Filled ballot on big screen for confirmation

Appendix B

Interactive Preference Ballot: Italy

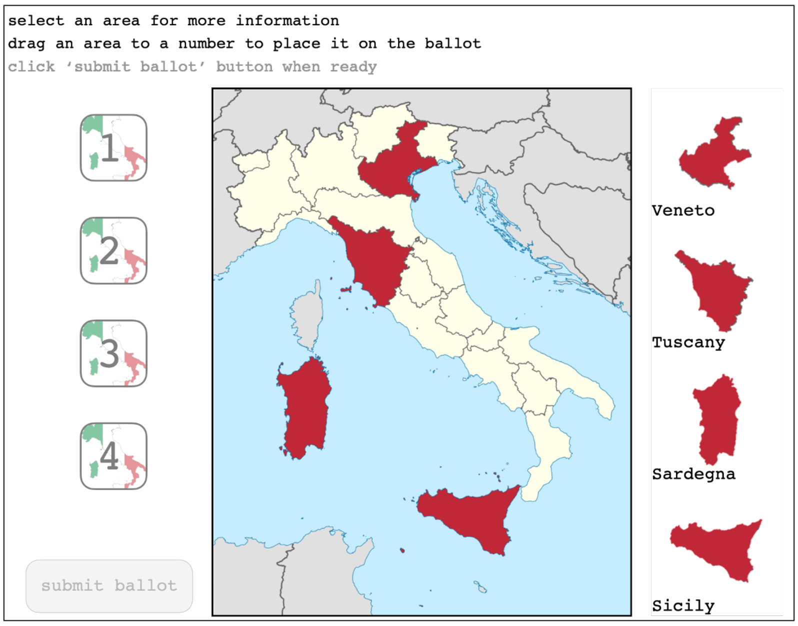

Figure B.1: Startscreen Interactive Preference Ballot

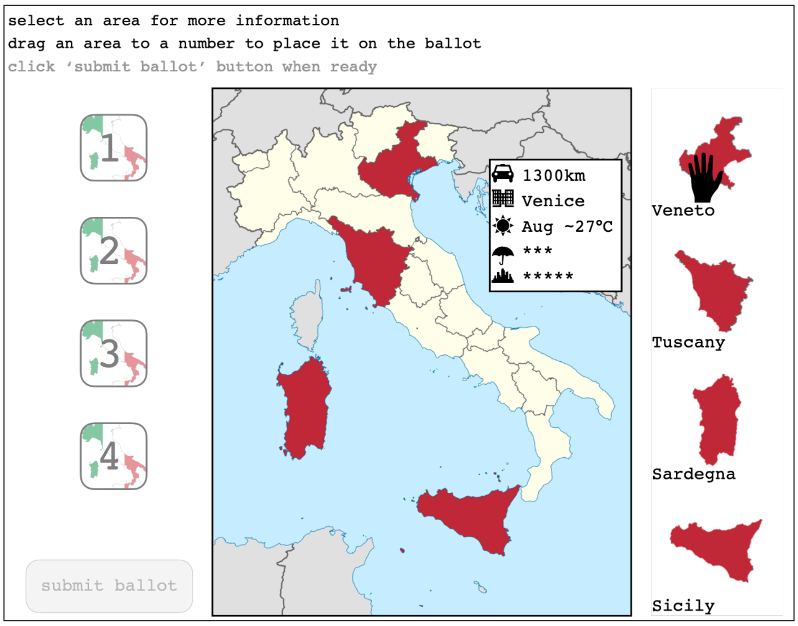

Figure B.2: Hoover over an option (Veneto) in the list on the right to show additional information

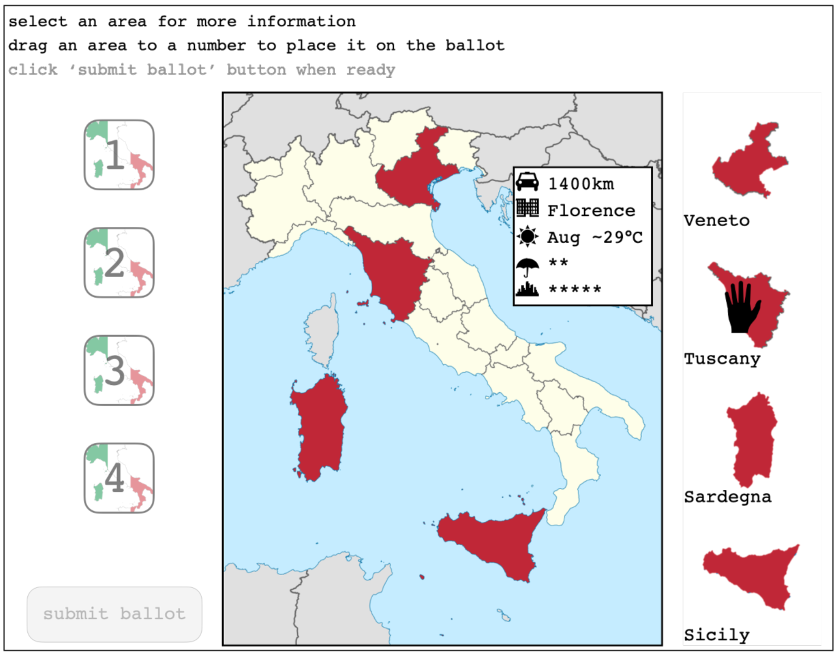

Figure B.3: Hoover over an option (Tuscany) in the list on the right to show additional information

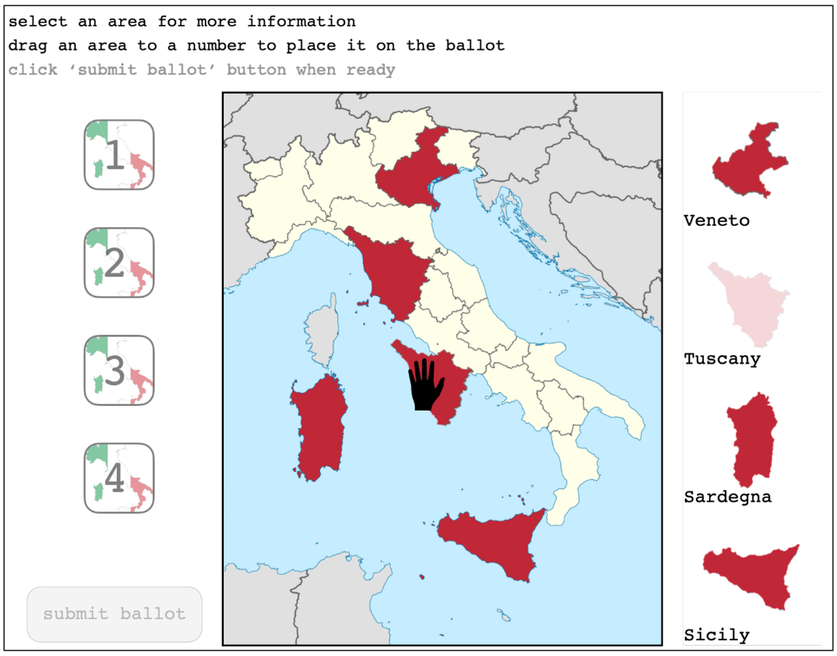

Figure B.4: Select and drag option (Tuscany) from the list on the right towards the preference area

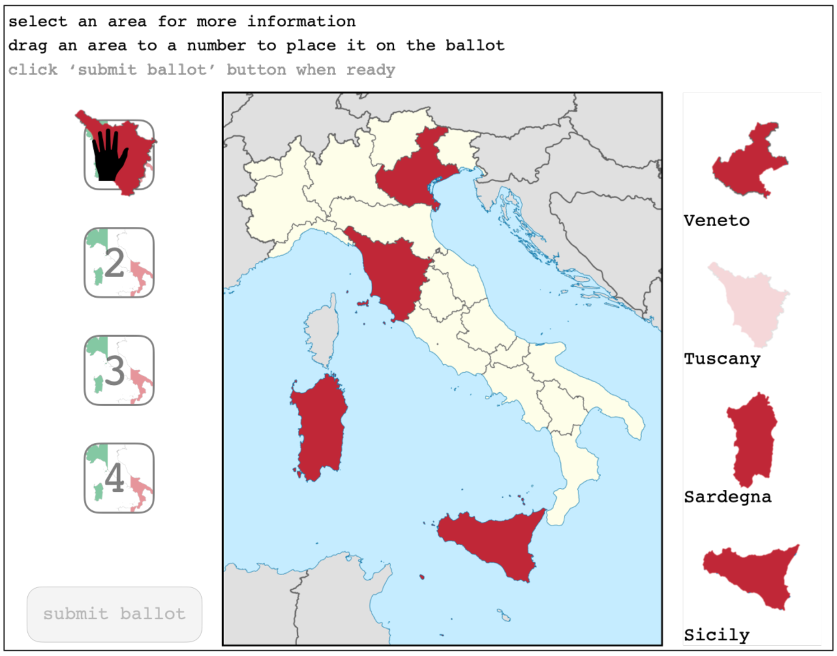

Figure B.5: Place selected option (Tuscany) over first preference area

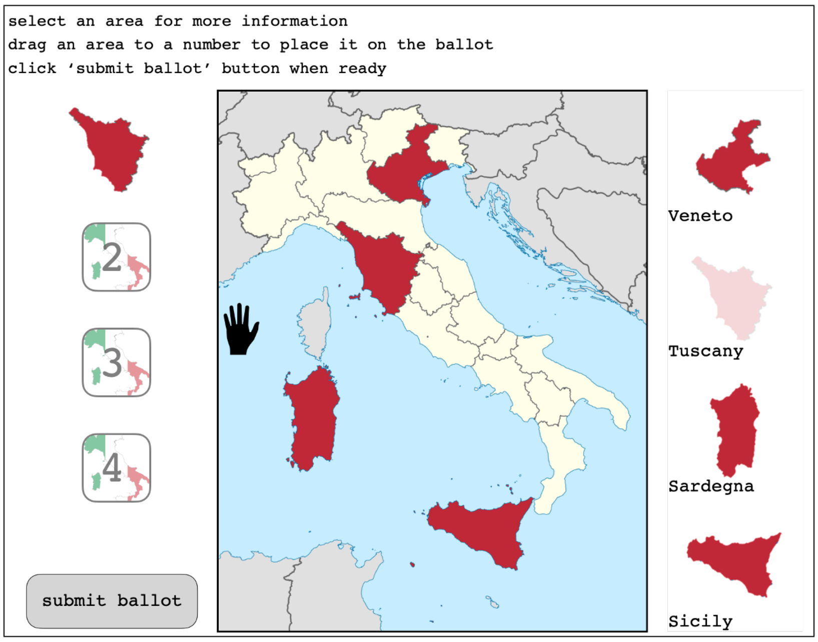

Figure B.6: Option (Tuscany) released on first preference area; move to the second option

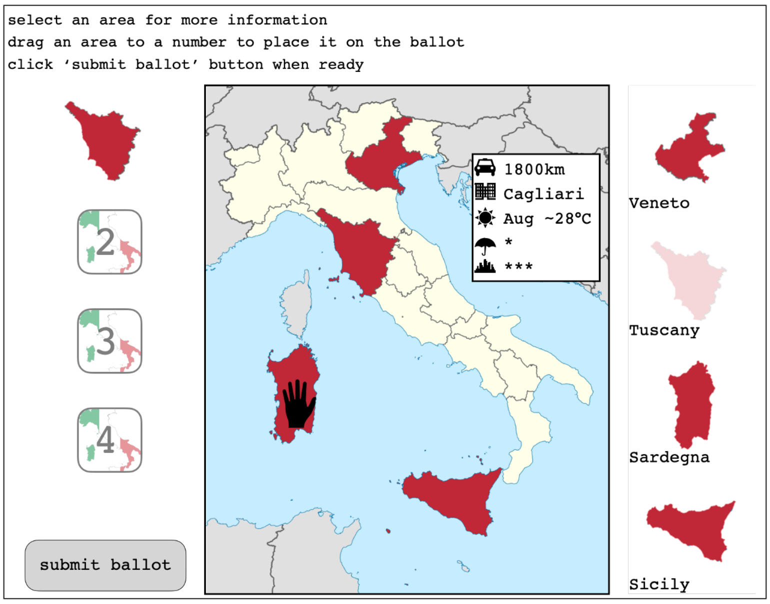

Figure B.7: Hoover over option (Sardegna) on the map to show additional information

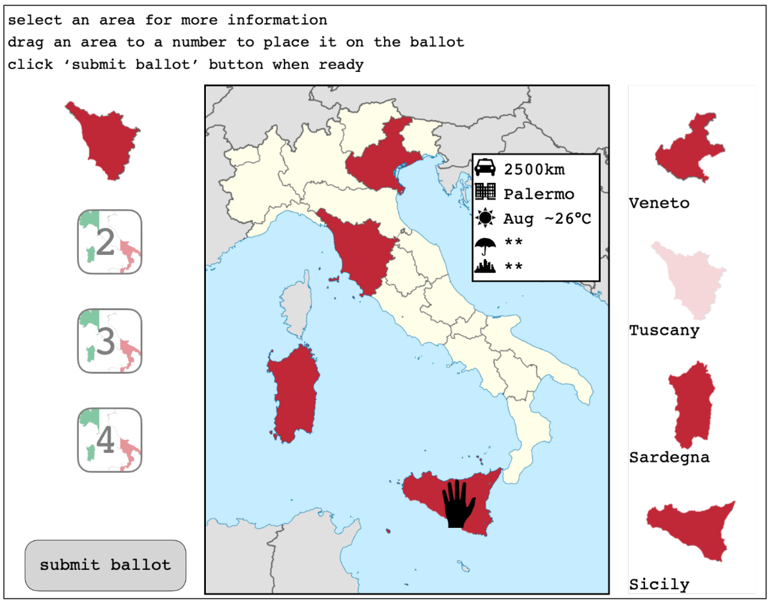

Figure B.8: Hoover over option (Sicily) on the map to show additional information

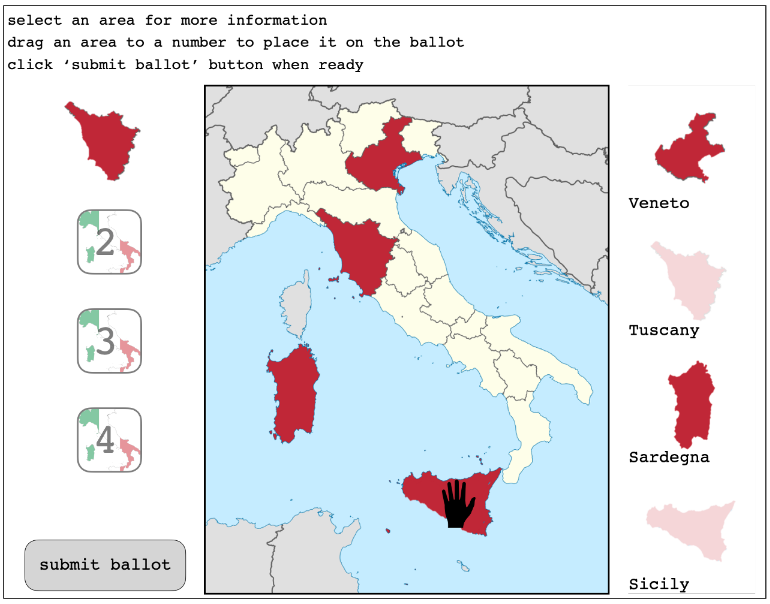

Figure B.9: Select option (Sicily) from the map

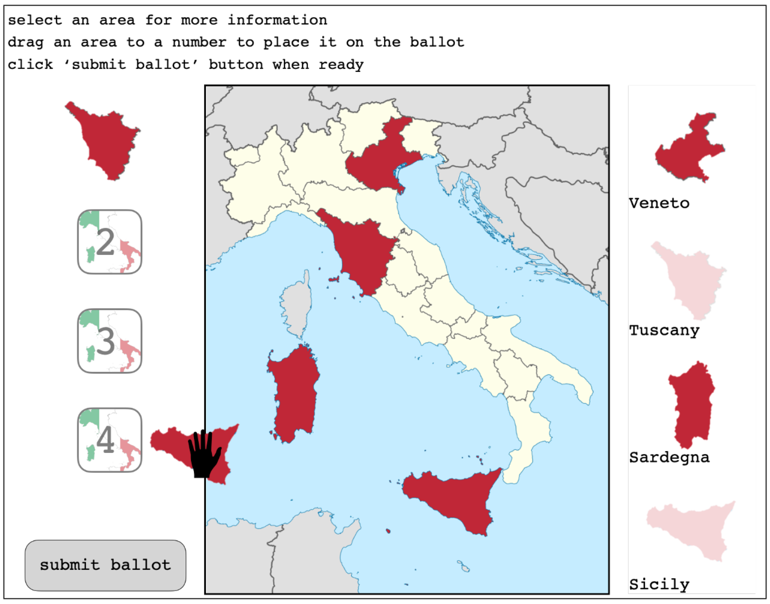

Figure B.10: Drag option (Sicily) from the map towards preference area

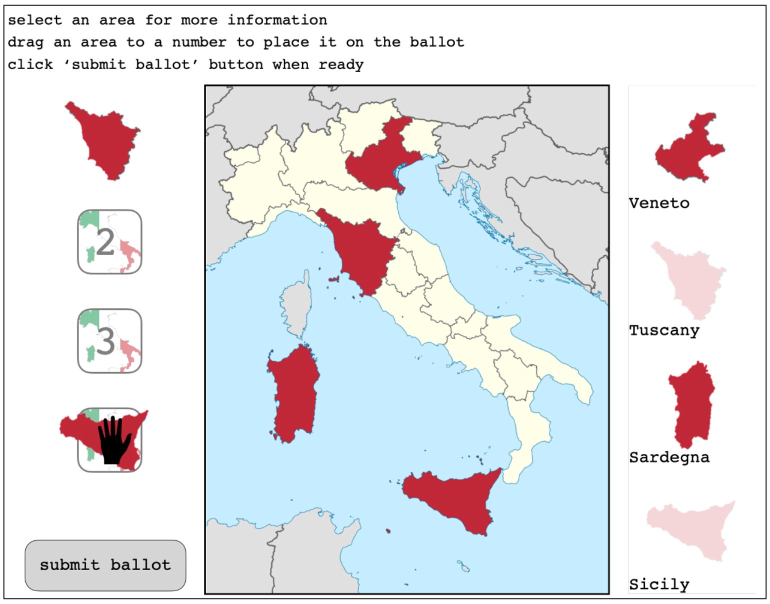

Figure B.11: Place selected option (Sicily) over fourth preference area

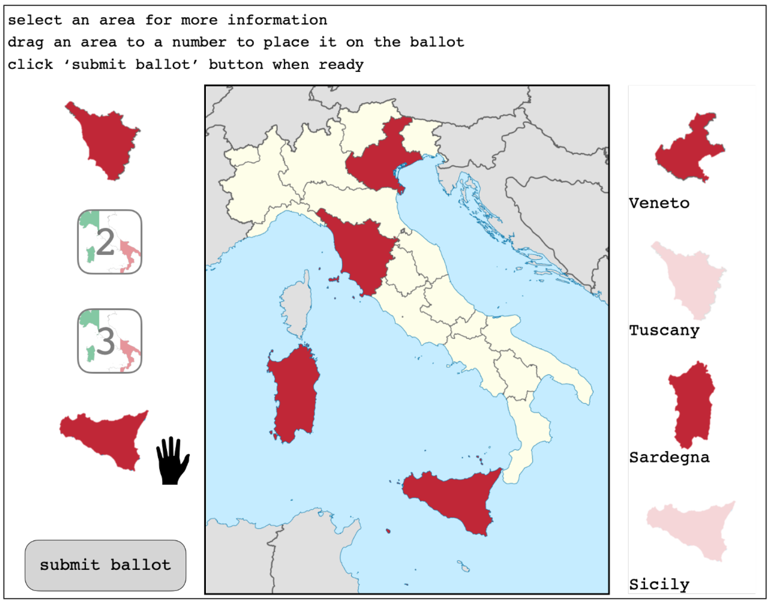

Figure B.12: Option (Sicily) released on fourth preference area; move to the third option

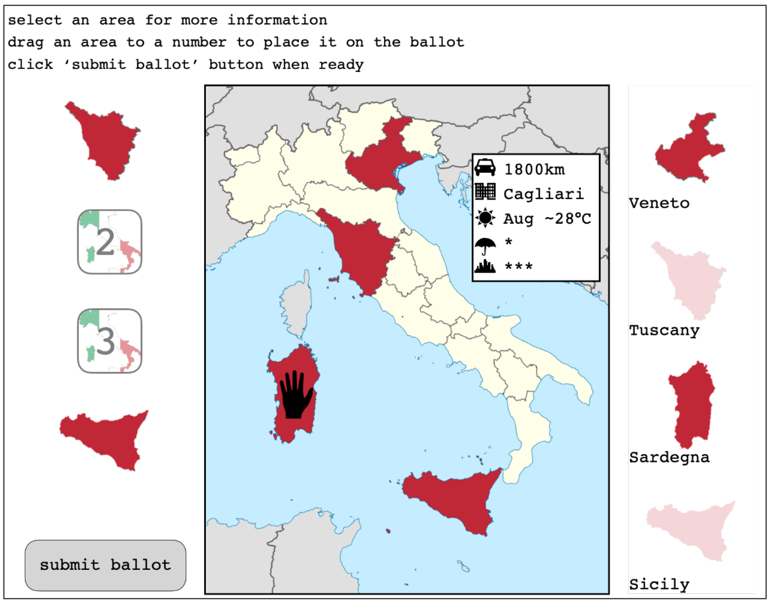

Figure B.13: Hoover over option (Sardegna) on the map to show additional information

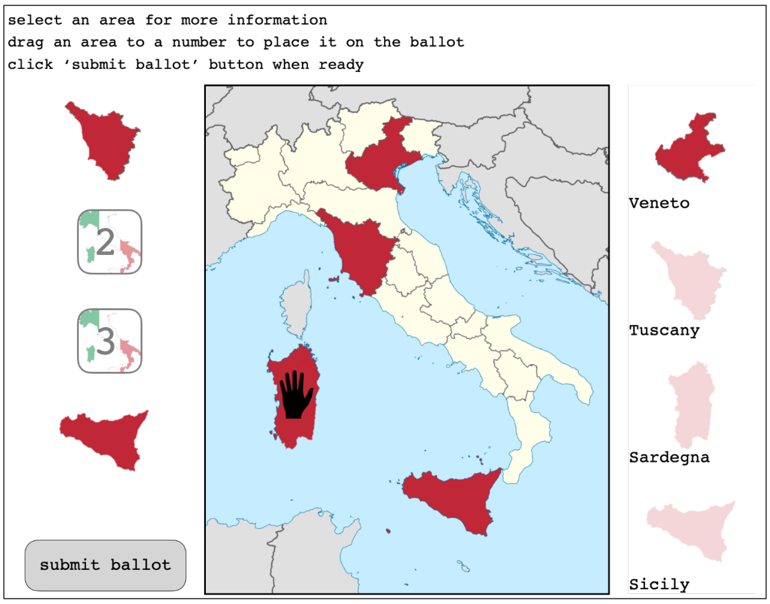

Figure B.14: Select option (Sardegna) from the map

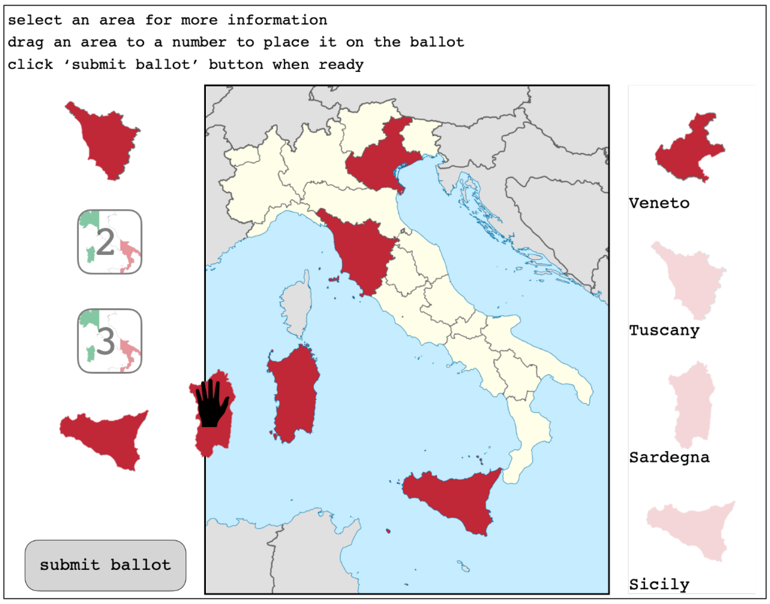

Figure B.15: Drag option (Sardegna) from the map towards preference area

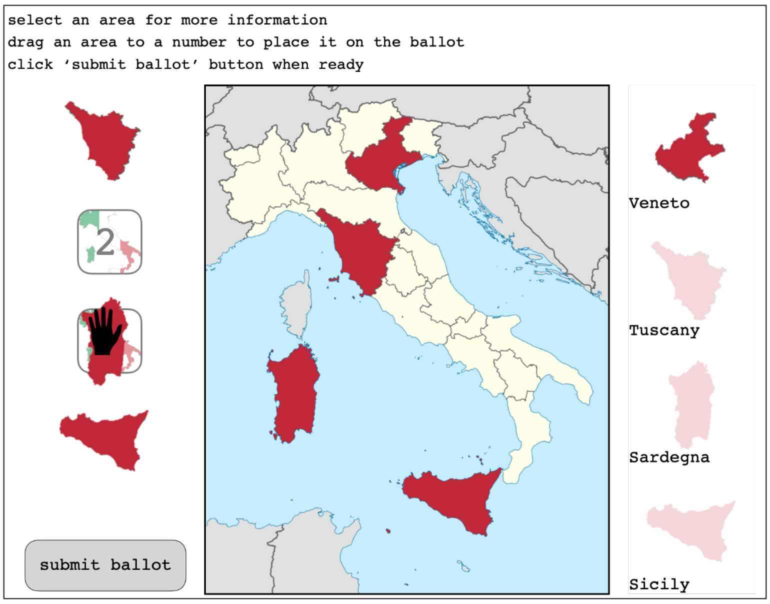

Figure B.16: Place selected option (Sardegna) over third preference area

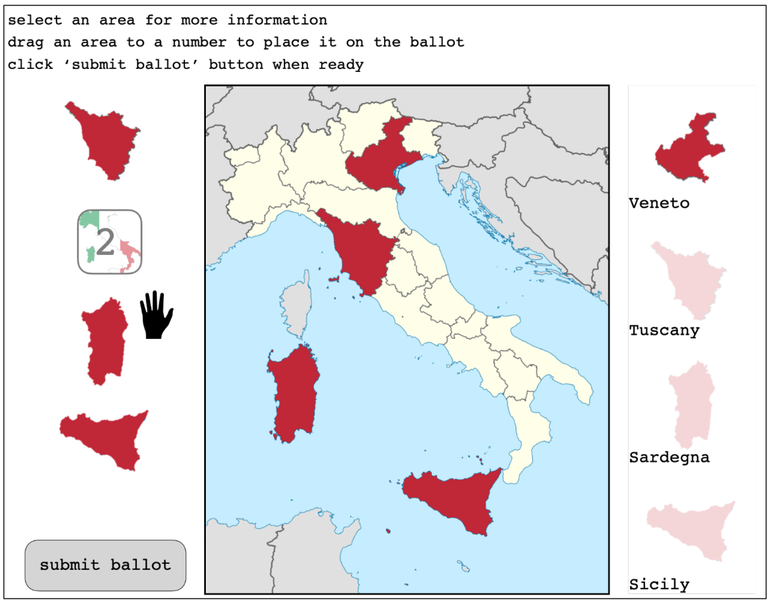

Figure B.17: Option (Sardegna) released on third preference area; move to the fourth option

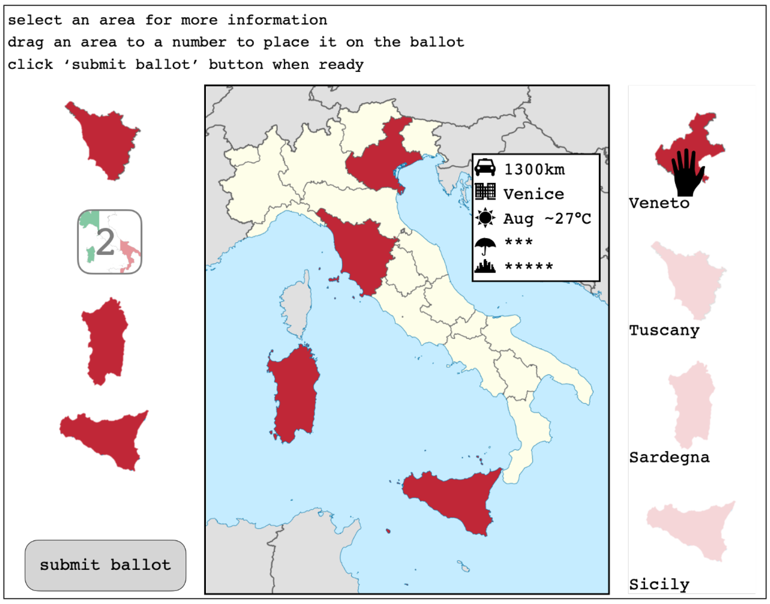

Figure B.18: Hoover over option (Veneto) in the list on the right to show additional information

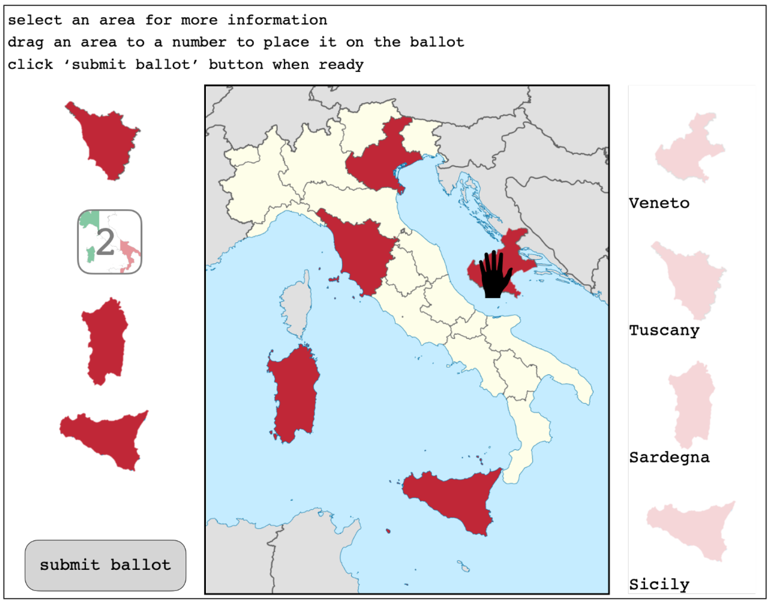

Figure B.19: Select and drag option (Veneto) from the list on the right towards the preference area

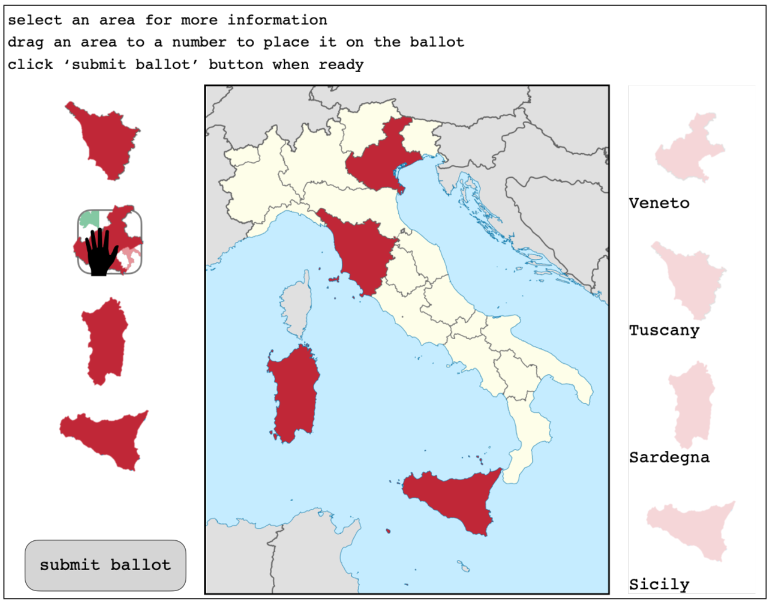

Figure B.20: Place selected option (Veneto) over second preference area

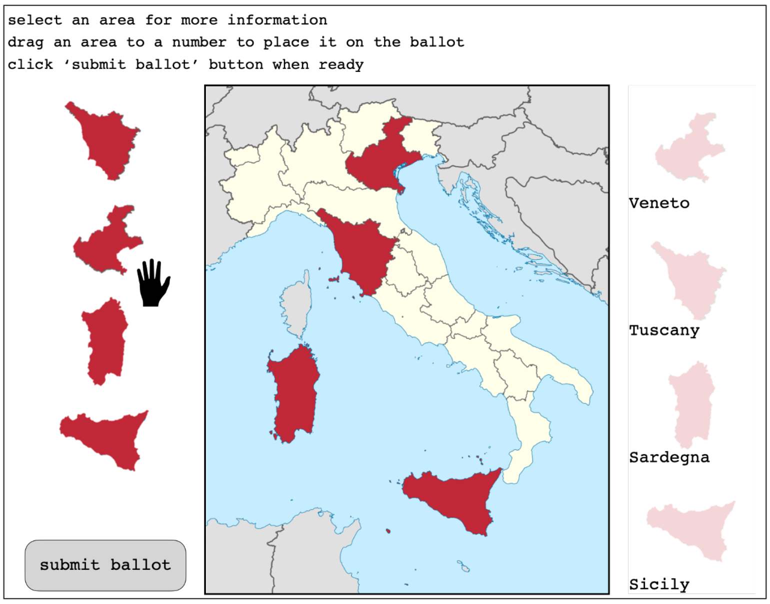

Figure B.21: Option (Veneto) released on second preference area

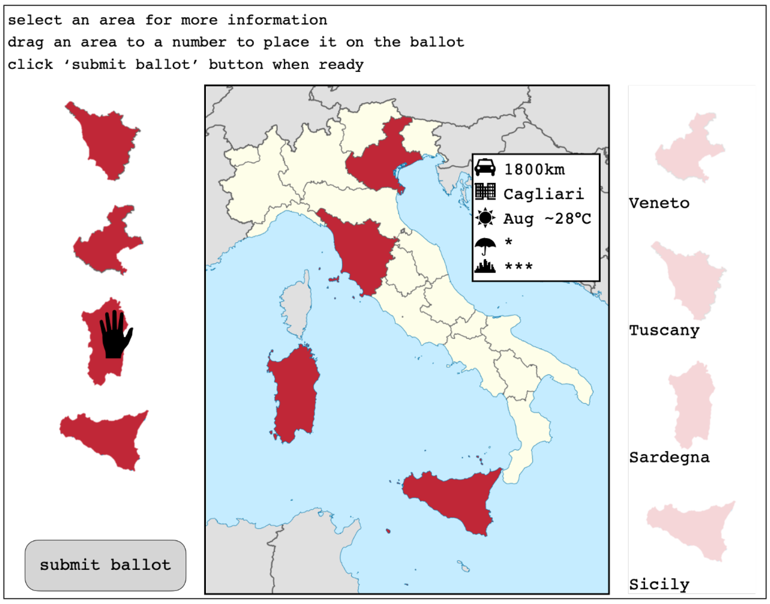

Figure B.22: Hoover over option (Sardegna) in the preference list on the left to show additional information

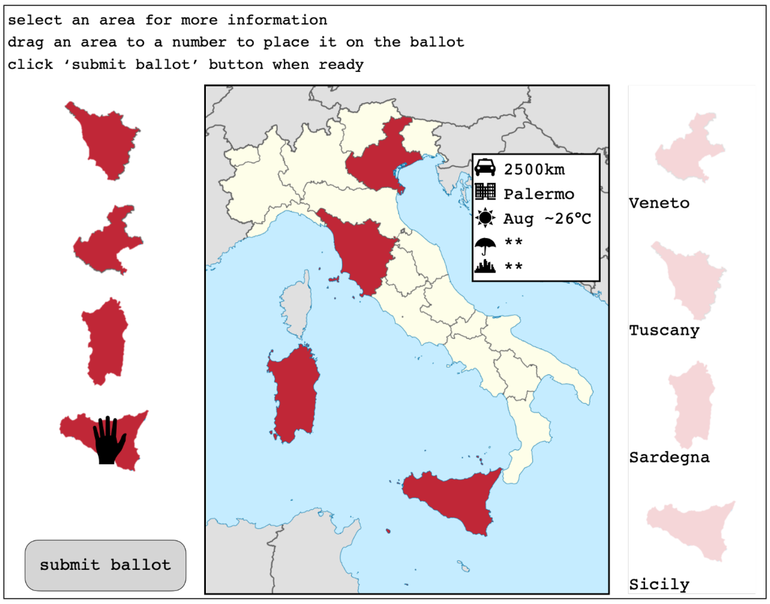

Figure B.23: Hoover over option (Sicily) in the preference list on the left to show additional information

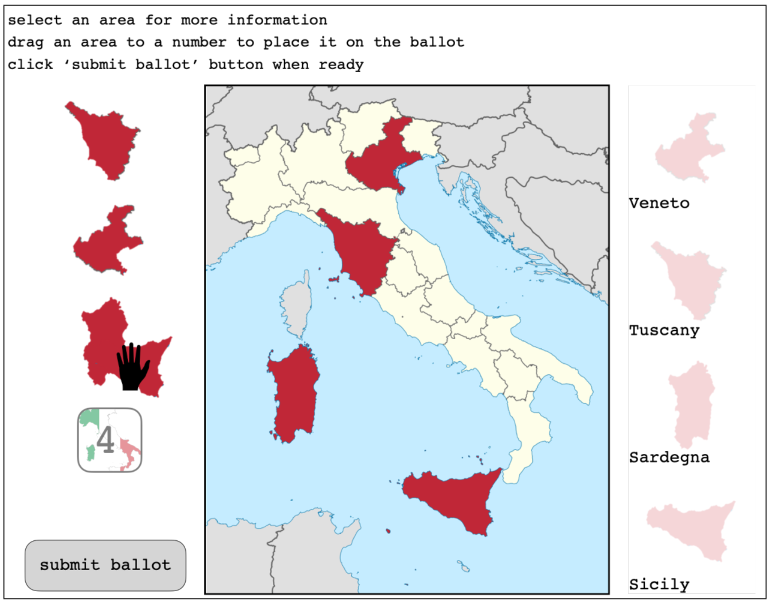

Figure B.24: Select and drag option (Sicily) from fourth preference towards other preference

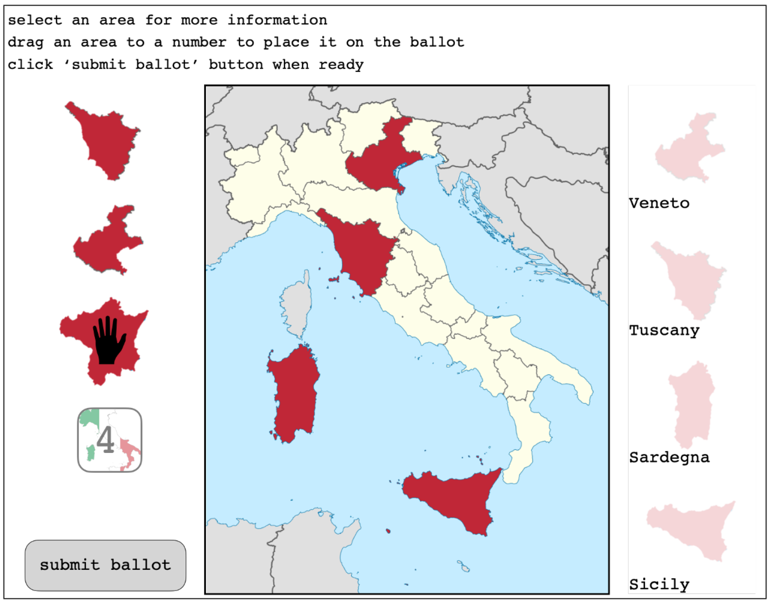

Figure B.25: Place selected option (Sicily) over third preference

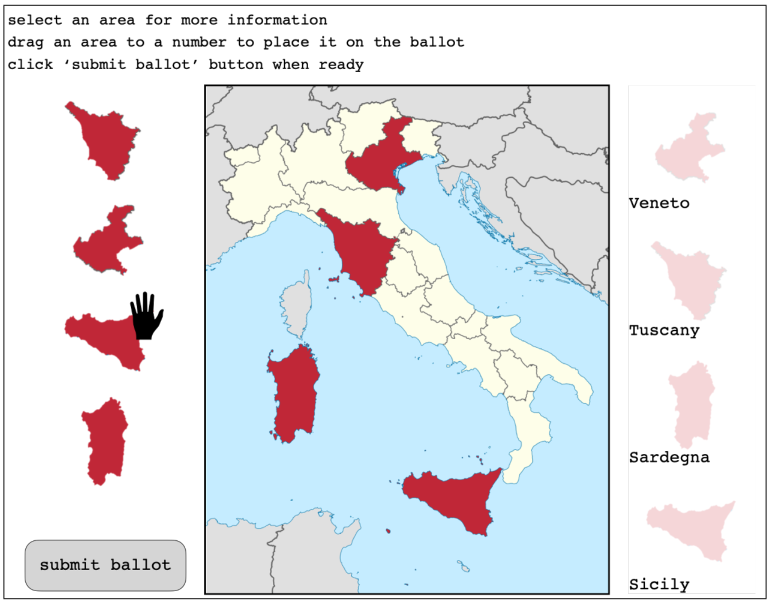

Figure B.26: Option (Sicily) released on third preference; option (Sardegna) on third preference moves to fourth preference

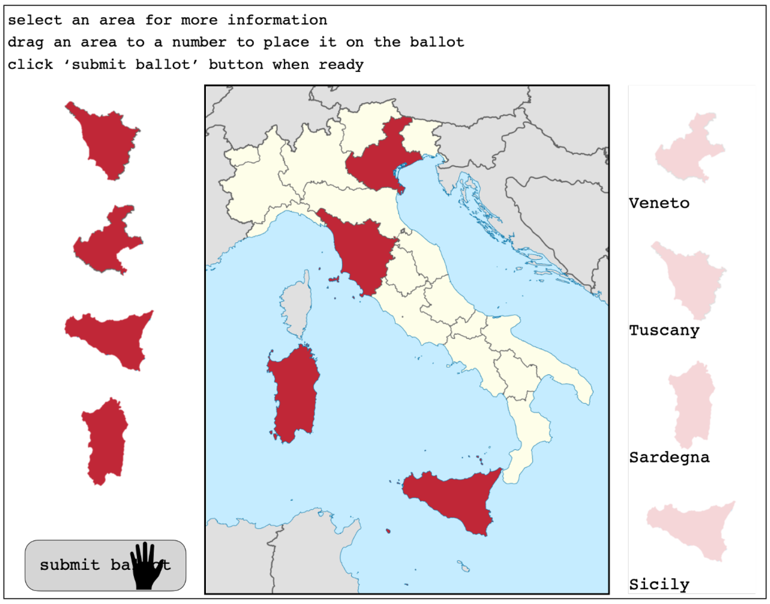

Figure B.27: Move and click submit button

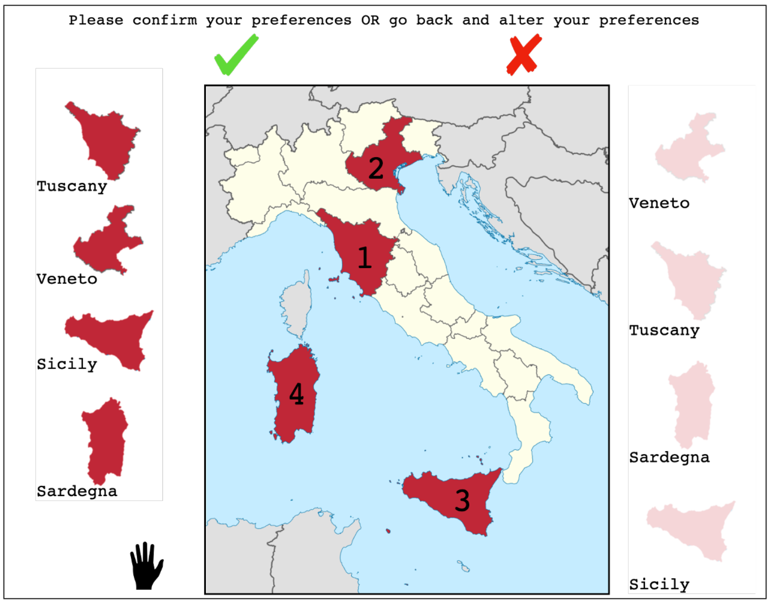

Figure B.28: Question for confirmation appears on top of screen together with preferences on the respective areas on the map

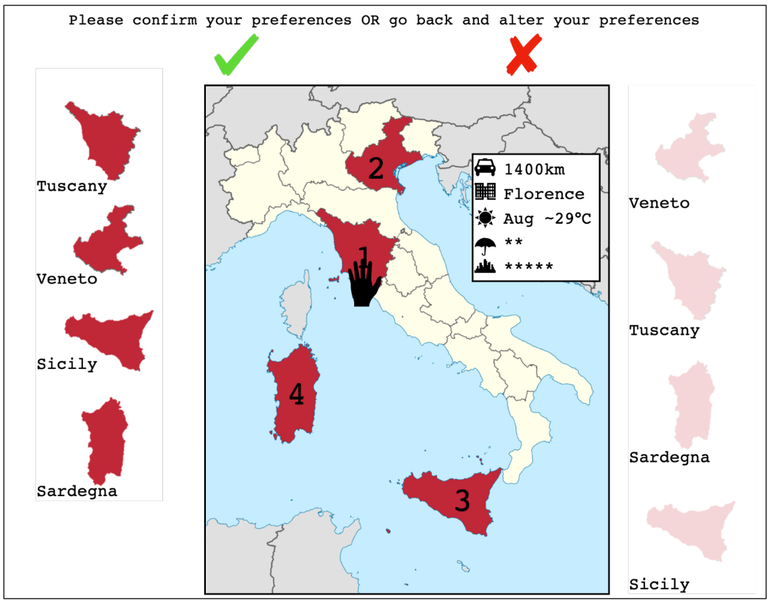

Figure B.29: Hoover over first preference (Tuscany) on the map to show additional information

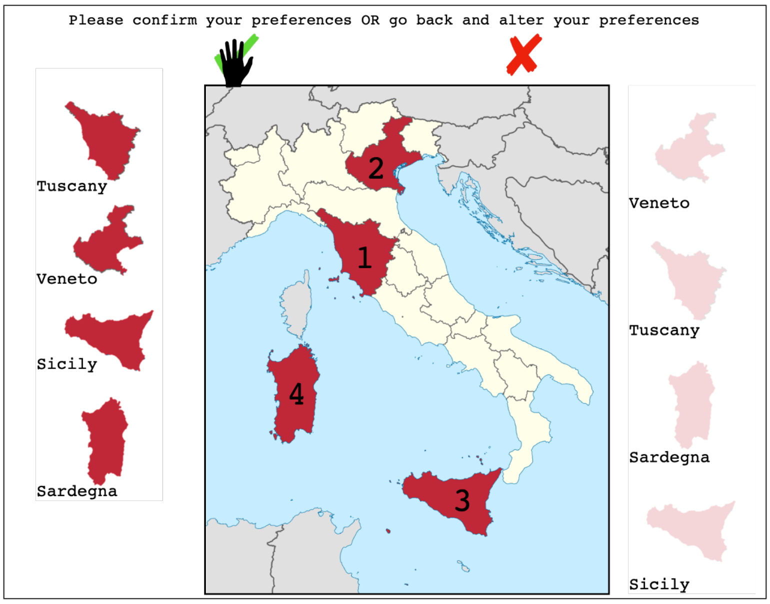

Figure B.30: Move towards and press acknowledge icon on top of screen to confirm ballot

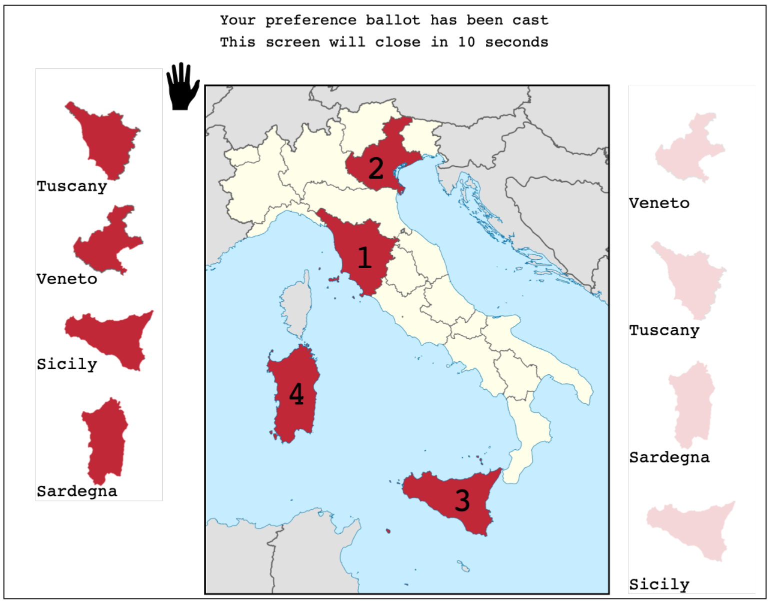

Figure B.31: Ballot confirmed. End of Interactive Preference Ballot