Tell Me Which Party To Vote For: A New Proposal ~~of~~ Voting Advice Applications

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VAAs have proliferated in the last years in many European countries, and ~~its~~ effects have been ~~thoroughly~~ discussed. One of their main goals is to increase voter's political competence by providing to the users their closest political party according to "their own preferences". For doing that, VAAs implicitly place users in a conceptual political space and compare and aggregate their positions within it to those of the political parties. In this paper, ~~we~~ argue that current VAAs are not adequate to increase voter's political competence even in the narrow conception of political competence that VAA application assumes, and propose a different method based on machine learning techniques. First, we define four normative criteria to evaluate VAAs: informativeness, respect of users' architecture of election, realism and transparency. Second, we argue that in current VAAs the experts choose deductively the user's architecture of election in an unjustifiable way. Although the model is theoretically informative, the recommendation is not based on a realistic combination of the users' most important policy preferences. Third, we argue that the only alternative proposed so far, a social VAA providing a recommended party based only on other users' preferences, is unable to increase voter's political competence. Lastly, we propose a new VAA using machine learning techniques which considers a different model of comparing and aggregating voter's policy preferences to provide a recommendation. Our model is more adaptive to the users' own way to compare and aggregate policy preferences because it weights inductively the importance of each of the policy issues and uses an inductive distance function to emulate how users compare their policy positions with those of the political parties. We argue that our VAA is more informative, respectful of users' architecture of election and realistic than previous methods. However, we acknowledge that the main limitation of our proposed VAA is the lack of transparency.

Contents

1 Introduction

The aim of this paper is to evaluate critically the current models of Voting Advice Applications (VAAs) and propose a different VAA based on a learning algorithm. The discussion on the methodology and its normative implications behind VAAs is important because these applications have proliferated in the last years in Western democracies [Marschall and Garzia, 2014]. VAAs have become a part of the electoral process in many countries, reaching a considerable part of the electorate in most of the European elections, and its roles have diversified [Alvarez et al., 2014]. According to the main line of VAA literature, one of their main goal is to increase users' political competence by allowing them to acknowledge the disagreement between their own political preferences and "the policy standpoints of political parties" [Garzia and Marschall, 2014, 233]. Our start-point is that VAAs are considered to play a role on the electoral process in many countries, and therefore it is important to evaluate the empirical validity and the normative implications of its methodology [Fossen and Anderson, 2014].

VAAs have been the subject of research in different fields [Alvarez et al., 2014]. On the one hand, there is a branch of literature focused on the different effects of these applications [Marschall and Schultze, 2012]. While majority of research shows that VAAs have an effect on increasing turnout and political knowledge in the aggregate level [Garzia et al., 2017], those experiments discounting users' self-selection bias found scarce impact on increasing turnout at the individual level [Mahéo, 2017]. Another branch of literature studies the socio-demographic characteristics of VAAs' users. Usual conclusion is that average VAA user "is young, highly educated and keenly interested in politics" [Cedroni, 2010, 253]. Our paper addresses a nascent area on VAA' literature, mixing a methodological and a normative approach. Regarding the former, there has been a discussion on the methods used by VAAs to provide recommendations [Mendez, 2017], the importance of the statement selection [Walgrave et al., 2009] and the treatment of the data [Djouvas et al., 2016]. With respect to the normative implications of VAAs' current methods, the few philosophical papers on VAAs normally have focused on the influence of the application on citizen's conception of democracy, but not on the different methods to provide a recommendation [Anderson et al., 2014]. Only exceptionally some authors have pointed out from a normative perspective the importance of VAAs' methods to increase voter's political competence [Fossen and Anderson, 2014].

Our research has an ambitious long-term practical goal: the substitution of current VAAs' methods of recommendation. Furthermore, we argue that it can lead to a completely new field of research on VAAs, as it opens new windows of opportunities regarding deeper political science questions that VAAs so far have been unable to approach. In the short term, a version of our method should be tested in new VAAs, as it will be proposed in the ECPR General Conference in Hamburg 2018. As we use data from the EU-Vox 2014, a VAA launched in 2014 for the European Parliamentary Election, ideally we should test empirically our model in the EU-Vox 2019. Hopefully, as part of the team leading the EU-Vox 2019 in Spain we will have the opportunity of testing our proposed methodology. In any case, the data will not be available until 2019, so in this moment we are unable to fully test our proposal. Fortunately, our main contributions can be yet shown with the existing data.

In the following, we first present the problem of voters' lack of political competence and how VAAs pretend to alleviate it by assuming a narrow conception of democracy inspired by social choice theory. Second, we explain the normative conception of politics assumed by VAAs. Third, we analyze four criteria to evaluate VAAs' methods of recommendation: informativeness, respect of the users' architecture of election, realism and transparency. Fourth, we explain analytically the current and alternative methods of recommendation. We argue that both methods have structural failures in relation with the established criteria which undermines the reliability of their results. Lastly, we explain our proposed VAA methodology based on machine learning techniques. We argue that our proposal is superior regarding the informativeness, respect of users' preferences and realism, and confer that it has problems of transparency.

2 VAAs and the problem of citizen (in)competence

2.1 Democracy and voters' political competence

The question on the importance of voter's political competence for the correct functioning of democracy has been subject to unfinished controversies. As Dahl puts it, the very standpoint is the notion that "if democracy is to work, it would seem to require a certain level of political competence on the part of its citizens" [Dahl, 1992]. The concerns with voters' lack of political competence were present in some striking philosophers such as Plato, Cicero and Schumpeter and were explanatory of their concerns with democracy [Caplan, 2011]. For example, Mill, worried about possible undesirable consequences due to the extension of the universal suffrage, argued that giving additional weight to those politically competent voters would improve collective political intelligence and the outcomes from democratic elections [Stuart Mill, 1859]. He considered as politically competent voters those well-educated or vocationally well-positioned citizens, and believed that giving additional voting to them would be positive for everyone as they would have more chances of taking better political decisions [Stuart Mill, 1859]. Following partially Mill's insights, we define being a competent voter as being someone with the adequate capability and knowledge on the policy issues to cast a vote which can advance her own policy preferences [Carpini and Keeter, 1996].

Our definition leads open the following question: What does "adequate" knowledge on policy issues mean? In this paper, we do not evaluate the adequateness of voter' knowledge in function of any appreciation of preferences' "goodness" and neither on the rationality of the arguments displayed by the voter for defending her choice. VAAs are just incapable to do that without getting distorted [Anderson et al., 2014]. Instead, these applications evaluate adequate knowledge to make competent political choices taking voters' preferences in policy issues as granted [Anderson et al., 2014]. VAAs map policy preferences of users and political parties on a set of issues, and recommend the party which best fits with the users' policy preferences according to a criteria of comparison and aggregation of policy issues [Mendez, 2012]. Therefore, VAAs implicitly define political competence as having 1) adequate knowledge on the levels of agreement between voter's preferences on policy issues and the positions of political parties and 2) ability to compare and aggregate these policy issues into a single agreement coefficient which determine the voted party [Mendez, 2017].

For having knowledge on the level of agreement between her preferences on any policy issue and the positions of the political party within it, a voter must know the existence of this policy issue and the position of political parties [Campbell and Philip, 1960]. These knowledge conditions are expected to be satisfied by VAAs: the very same questionnaire gives an approximate idea on the prominent policy issues at stake, and after receiving the recommended party users normally can see the position of political parties in any policy issue and compare them with their own positions [Garzia and Marschall, 2014]. There are more complexities involved into the aggregation of these policy issues which leads to the main VAAs' outcome: the agreement coefficient which determines the recommended party [Louwerse and Rosema, 2014]. This agreement coefficient refers to one of the conditions stated as fundamental for voter's political competence in VAAs: the aggregation of the levels of agreement with the political parties in the set of policy issues to offer a recommended party to the user to vote for [Mendez, 2017]. The agreement coefficient aims to increase voter's political competence by simplifying in a meaningful way the complex process of comparing and aggregating policy preferences [Marschall and Schmidt, 2010]. From this perspective, a VAA aims to be like "a computerized expert system" which "assist an architectural engineer in navigating complex decisions about the construction of a building" [Fossen and Anderson, 2014, 246].

The first question to determine is what conception of democracy is presupposed by VAAs with this understanding of voter's political competence. VAAs' approach fits closely with the normative conception of democracy defended by social choice theory, in which democratic process can be understood as a mean of aggregating preferences in policy issues to come up with a political party that respect and consider fairly these policy preferences [Anderson et al., 2014]. According to this view, a competent voter "is well informed about the options on the electoral menu, and therefore competent to choose a political party that matches his or her preferences" [Fossen and Anderson, 2014, 247]. However, the vision displayed by VAAs on democracy and political competence is disputed. Different conceptions of democracy and citizenship casts the problem of citizen competence in a different light than social choice theory [Fossen and Anderson, 2014]. For example, advocates of deliberative democracy are more worried about how voters form their policy preferences than about their lack of knowledge about the disagreement between their policy positions and the positions of the political parties [Caplan, 2011]. This discussion is a deeper one which goes beyond the objective of this paper: VAAs seem unable to inform a citizen on the genuine goodness of a specific position on any issue, and any design of the application assumes that citizens have legitimate policy preferences in a set of policy issues which should be compared with those of the political parties to decide which party to vote for [Anderson et al., 2014]. VAAs are only concerned with matching citizens and political parties using a similarity criteria: the closer the party and the citizen on the policy issues, the greater chances of being the adequate voting party for the citizen [Mendez, 2012]. Therefore, VAAs treat given policy-preferences on a set of issues as a good way to choose one's voting party [Fossen and Anderson, 2014]. In the following, we assume the arguable and narrow conception of political competency that every VAA so far has assumed [Anderson et al., 2014]. The goal of our paper is not challenging it. Instead, we argue that current VAAs' methods are insufficient to advance even this narrow conception of political competence.

2.2 Advancing VAAs' vision of voters' political competence

According to the main line of literature, low levels of political knowledge are exhibit widespread by most of the citizens [Carpini and Keeter, 1996]. For example, Ferejohn et al. stated that "nothing it is certain (to) the student of public opinion and democracy more forcefully than the paucity of information most people possess about politics" [Ferejohn and Kuklinski, 1990, 3]. Certainly, it has been empirically tested that voters lack knowledge on the policy issues, suffer predictable biases due to their lack of information regarding how they place their political parties in these issues and experience cognitive dissonance when explaining the reasons to vote for a party [Caplan, 2011]. Moreover, citizens' lack of knowledge on the policy issues at stake and the position of the political parties within them is not normally an impediment to go to the polls [Caplan, 2011]. Certainly, few researchers deny that there is "room for improvement" [Fossen and Anderson, 2014, 245] regarding the notion of voter's political competence advanced by VAAs. If this is true, there would be a gap between what might be desirable for meeting the standards of being a competent voter according to VAAs and current level of voters' political competence [Fossen and van den Brink, 2015]. This political competence gap has been seen as a unavoidable reality to which political systems can respond in different ways like enforcing politically independent authorities or increasing the role of experts [Caplan, 2011]. Another typical alternative, which was proposed by Mill as complementary to the plural voting system [Stuart Mill, 1859], is increasing voter's political competence to bridge the gap between what they should know to vote competently and what they actually know [Dahl, 1992]. As we have seen before, VAAs are supposed to meet this problem by offering to the users knowledge on the policy issues at stake, the positions of the parties within it and an agreement score based on a comparison and aggregation of the preferences of the user and the positions of the political parties [Fossen and Anderson, 2014].

From our perspective, if VAAs can make citizens more competent, even in the narrow sense of political competence that VAAs advance, they can play a positive role for individuals and society. Voters' lack of political competence supposes a problem because politicians are responsible of a large part of the budget of a country, and they take fundamental decisions to the life of their governed in many policy issues [Somin, 1998].

Therefore, it seems problematic to cast a vote based on mistaken beliefs about the policy issues or the political positions of the parties because it would mean that ballots may have no relationship with what voters care [Garzia and Marschall, 2014]. Brennan (2011) has argued that those people voting without knowing the policy issues or the positions of the political parties in them are engaging in a form of recklessness, as they act without acknowledging whether their voting behaviour cause harm to others. Following Carpini and Keeter, we can compare being a politically competent voter with having access to "the currency of citizenship": a politically competent voter acquires a significant resource "for meeting the role of the politically active and involved citizen" [Carpini and Keeter, 1996, 8]. VAAs are supposed to provide this political competence in a straightforward and transparent way which respects the preferences of the users [Marschall and Garzia, 2014]. They are expected to perform an important function to voters, especially for those considering multiple parties and not knowing exactly what is the total disagreement between their policy preferences and the positions of these political parties [Garzia et al., 2017].

In this point, we have to distinguish between ideal and real world for VAAs. In the former, voters are issue-voters as predicted by Downs' theory of 1957. In this world, a citizen is considered to be competent if she is able to place herself and political parties on a set of policy issues and aggregate distances in policy issues relying on the importance of each issue [Mendez, 2017]. In this case, VAAs appear as an optimal tool for increasing voter's political competence as it provides an expertise placement of the policy issues and the positions of political parties in them, and moreover it offers a supposedly scientific agreement method to offer an agreement score [van der Linden and Dufresne, 2017]. However, in the real world we cannot assume entirely issue voters. Certainly, many voters use different strategies to vote for a party beyond their position in the policy issues: it has been empirically tested that voters use party identification, charismatic leadership or social cues to decide which party to vote [Mendez, 2012]. If there are voters not worried with their agreement with the political parties in the policy issues, it is certainly difficult to think that VAAs can increase their political competence in the sense we previously define it [Anderson et al., 2014]. The correct question regarding these voters would be to ask whether they are engaging in any kind of competent voting according to VAAs: the answer seems to be negative. These voters do not fit in the conception of political competence that VAAs advance, and therefore they are beyond the scope of the application (see figure 1). Fortunately, some VAAs are able to distinguish between "issue voters" and "non-issue voters" relying on the answer that users provide to some supporting question on the very reasons to vote for a party.

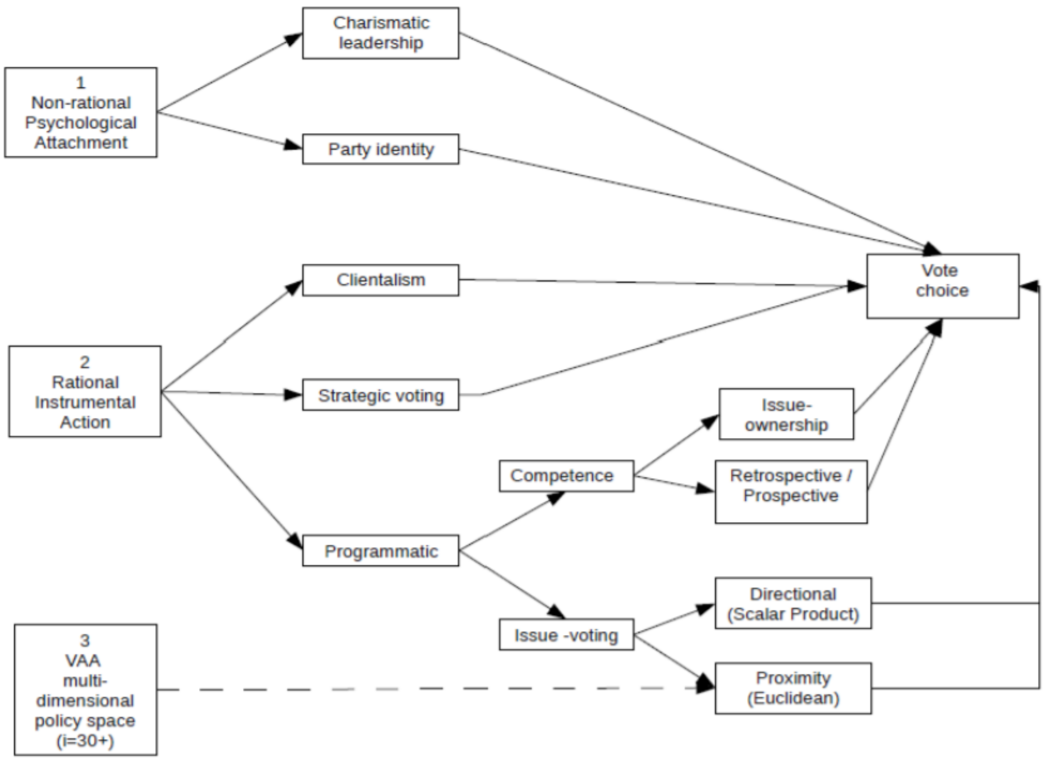

Figure 1: Theoretical linkages in models of voting [Mendez, 2017]

3 VAAs' spatial conception of politics

VAA normative conception of political competence is heir to the spatial conceptualization of politics popularized by Downs in 1957. Spatial ideas of politics have been woven into the mainstream and academic political discussion since at least the French Revolution, where a liberal-conservative dimension was used for the parties to gain the support of voters distributed along that dimension [Stokes, 1963]. In this model, it is considered implicitly as the heart of being politically competent the capability of mapping the political terrain [Downs, 1957]. Many political theorists have always assumed that a voter should be able to situate herself and the political parties in the set of policy issues which are important to determine the sense of her voting [Downs, 1957]. Once she is situated in this conceptual space [Gärdenfors, 2004], she can determine according to her own preferences which is the best party to vote for. The attribution of spatial characteristics to policy differences is essentially a metaphor, defined by Lakoff and Johnson (1980: 455) as "understanding and experiencing one kind of thing or experience in terms of another". The usage of the language of space, direction and distance to discuss political competition is ingrained in our everyday political thinking, although the analogy of political competition with physical spaces relies on some conceptual spaces which may or may not be explanatory of the individual voting decisions [Benoit and Laver, 2012]. VAAs rely fundamentally on this conception of spatial politics and cannot work without this logic of comparing and aggregating political preferences which is reliable to a world of dimensions and distance functions [Otjes and Louwerse, 2014].

3.1 A world of dimensions and distance functions

VAAs must consider the number of political dimensions it uses to provide a recommendation [Louwerse and Rosema, 2014]. VAAs can aggregate policy issues into dimensions to offer a comprehensible view of the political space [Louwerse and Rosema, 2014]. For example, it can use the well-known 'left–right' dimension, which mostly everyone is able to roughly understand it, to contrast a protectionist state and socially liberal values on the one hand with a conservative social vision and more laissez faire economics on the other [Benoit and Laver, 2012]. The EU-Vox 2014 allows any user to compare herself with the political parties in three dimensions: Economic (state-individual role in the economy), Society (liberal-conservative social views on society) and European (more or less support to the European Union). User can choose two of them to see a displayed graphic (figure 2).

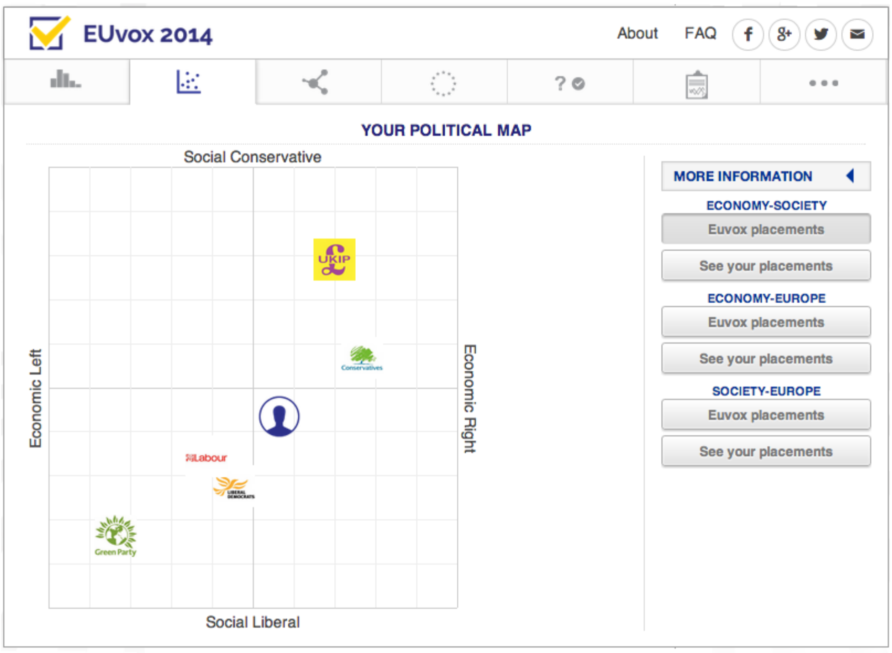

Figure 2: Party ranking in the EU-Vox 2014 [Agathokleous and Tsapatsoulis, 2016]

However, as most VAAs, the EU-Vox 2014 offers the recommendation based on a high-dimensionality approach, in which every policy issue constitutes a dimension on her own [Louwerse and Rosema, 2014]. For each policy, VAAs must decide a function of distance to weight the level of agreements between users and political parties. This discussion echoes one of the fundamental disagreement on theories on issue voting which confront proximity and directional logic [Merrill III et al., 1999]. A proximity logic would mean that recommendations are based on voter-party distances, usually measured on a continuous scale [Downs, 1957]. In contrast, directional logic is indicated by three features: each policy issue has two different 'sides': for and against; it is possible to express intensity of preference in each of the sides of the spectrum (i.e. "Agreement" and "Complete agreement"); and parties are not punished for holding more intense positions than voters [Rabinowitz and Macdonald, 1989]. The differences between the two are easy to understand graphically in low-dimensionality spaces such as the displayed in figure 3.

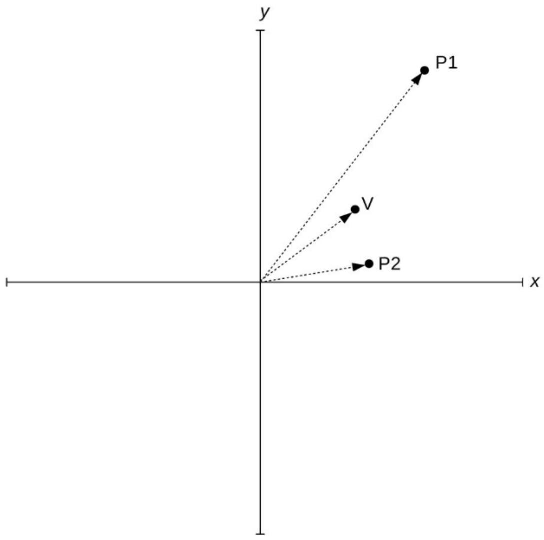

Figure 3: Voter choice in a two-dimensional space [Mendez, 2017]

In such a space, a voter can use two different approaches to compare herself with political parties. In proximity model, disagreement between voter V and parties P1 and P2 will be defined by the distances between them. Therefore, we can calculate them with the following equation including weights that confer more importance to some dimensions than others:

$$d = \sqrt{w_v(x_v - x_p)^2 + w_y(y_v - y_p)^2}\ , \tag{1}$$

In this case, according to proximity model V should choose P2 because is closer than P1 (taking as granted that the two dimensions are equally important). However, if we use a directional model the result would be different. In this case, we focus on the angles that the vectors of each of the parties form with V. As it can be seen in figure 3, the angle formed between the dashed lines representing V and the parties is smaller in the case of P1. Therefore, P1 would be closer according to directional logic.

In VAAs models of recommendation, which rely mainly on high dimensionality approaches, the concepts of proximity and directionality used are similar although there are some calculus differences due to the high-dimensionality spaces. Normally, distance matrix between users and parties' positions following either proximity or directional logic are created to weight the disagreement between them for each of the policy issues.

3.2 Basic operation of every VAA

VAAs compromise a set of questions of size N. Answers to the questions are typically restricted to a Likert scale, expressing agreement in five degrees plus a *No opinion* answer: $\mathcal{L} = \{ SD, D, N, A, SA, NO \}$[1]. Each user gives an answer belonging to $\mathcal{L}$ for each question. A user *profile*, $\vec{u_i}$, is the vector containing the answers of user i for all N questions. VAAs give recommendation among K parties. Each party has also an answer for each question, leading to K analogous profiles, $\vec{p_k}$. The questions relate to the set of policy issues which should determine the chosen party (figure 4).

Figure 4: A question in the EU-Vox 2014 [Agathokleous and Tsapatsoulis, 2016]

VAAs need to provide some distance function, $f : \mathcal{L}^N \times \mathcal{L}^N \longrightarrow \mathbb{R}$, that represents proximity between a user and a party profile in the conceptual space. Distances are usually re-scaled into a bounded *agreement coefficient*, which gives higher scores to closer parties (inverse of the distance). The output of a VAA session is the vector of scores, $\vec{s_i}$, for user i, containing her scores for the K parties, often sorted by descending order. The main outcome of the VAA is the recommended party, which is the one with the highest agreement coefficient (see figure 5). Furthermore, after fulfilling the questionnaire most VAAs offer the user the opportunity of checking the parties' position on the policy issues.

[1] Strongly disagree, disagree, Neither agree nor disagree, Agree, Strongly Agree, No Opinion.

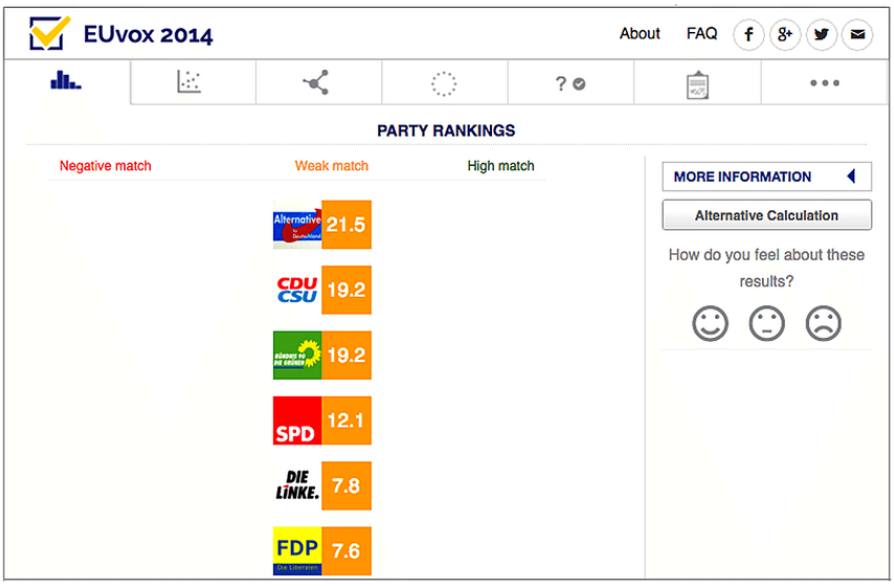

Figure 5: Party ranking in the EU-Vox 2014 [Agathokleous and Tsapatsoulis, 2016]

In every VAA, developers must unavoidably take some decisions which affect the agreement coefficient [Fossen and van den Brink, 2015]. First, they decide the set of policy issues considered to provide the agreement coefficient. Second, they place the political parties in these issues. Third, they elaborate a distance matrix for weighting the levels of agreement between users and parties' preferences in the issues. Lastly, they decide the weight of each of the policy issues for the final recommendation. Therefore, even the best imaginable developed VAA will not simply reflect "what is at stake in the election by neutrally passing along information" [Fossen and van den Brink, 2015, 341]. Rather, political information is structured by developers' decisions, which can be taken deductively or inductively. Deductive approach involves establishing ex ante the most important policy issues and giving them a weight according to any determined criteria [Gemenis, 2013]. Furthermore, it would imply establishing a distance function according to a previous theory of issue-voting like proximity of directionality [Mendez, 2012]. In this kind of reasoning, the key issue is to be able to justify ex-ante decisions without empirical research validating them [Benoit and Laver, 2012]. In contrast, ex-post inductive methods would make these kind of decisions "from some set of measurements that have already been made" [Benoit and Laver, 2012, 196]. Therefore, weights and distance functions would fit the data and not a previous voting theory. In this method, the challenge is to interpret the outcome in a meaningful and reliable way [Benoit and Laver, 2012].

4 Evaluating VAAs

There are at least four criteria which can serve us to evaluate whether a VAA is akin to increase voter's political competence: informativeness, respect of the users' architecture of election, realism and transparency. Some of them, such as the criteria of informativeness and transparency can be directly derived from most of the statement of purposes of VAAs' developers [Marschall and Schmidt, 2010]. The other two are direct consequences of the VAAs understanding of political competence and its aim to be a neutral mirror of the political reality [Dinas et al., 2014].

4.1 Informativeness

To increase voter's political competence, VAAs must be informative on those things which can increase their notion of voter's political competence. We argued previously that for a VAA a competent voter should 1) compare their policy preferences with the positions of the political parties in a set of prominent policy issues and 2) aggregate the disagreement with the political parties in the set of policy issues in a meaningful way to decide which party to vote for [Mendez, 2017]. Therefore, for being informative a VAA must provide information on the policy issues at stake, the position of the parties on these issues and a single outcome in the form of recommended party which is the result of an aggregation of the distances between the party and the users on these issues [Fossen and Anderson, 2014]. If VAAs provide that information to the user it will facilitate the process of comparing and aggregating their levels of agreement with the parties in the policy issues. Therefore, we can set three sub-criteria to assess whether a VAA is informative to increase political competence.

1. The VAA informs on the policy issues at stake.
2. The VAA informs on the position of the political parties running for the election in these policy issues.
3. The VAA informs on the total agreement between the user and the political parties on these issues.

4.2 Respect of users' architecture of election

Ideal VAAs are supposed to offer to the users "an unobstructed view of the European political landscape, and their place within it" [Dinas et al., 2014, 291]. In this sense, unobstructed means that the recommendation is just dependable on the users' own preferences on policy issues. We can consider the idea of respecting users' own preferences in different ways. For example, as making all the process of recommendation without changing where the user has placed herself; this is incontroverted as every VAA actually makes this operation because it takes the policy preferences of the users as granted [Anderson et al., 2014]. However, this understanding of the respect to the users' own preferences does not fully inform on the way in which users truly form their voting decisions by comparing and aggregating their preferences in the policy issues with the political parties. For example, a VAA might not recommend the closest political party according to users' own preferences if it does not give enough weight to a decisive policy issue according to the users. In that case, instead of adjusting to users' own preferences for giving the recommended party, VAAs would evaluate how users should compare and aggregate their level of agreement with the political parties. This is not what VAAs are supposed to do. If there is a systematic bias on VAAs' way to compare and aggregate policy preferences, the goal of increasing voters' political competence would be critically undermined, as the recommendation would complicate instead of facilitate the already complex process of voting competently. In that case, users would have very good reasons for not considering the recommendation.

Unfortunately, it is impossible to expect a VAA offering a fully unobstructed view of users' architecture of election. VAAs' developers must unavoidably confront a set of decisions which will affect the way in which the application represents the user in the conceptual political space and provides a recommendation [Fossen and van den Brink, 2015]. However, there can be levels of respect of the users' architecture of election relying on the method used. As we have seen, user's architecture of election relies principally on the weights of the questions and the function distances between the policy positions of the users and the political parties. A VAA can depend entirely on the experts for deciding these features or can consider how users' compare and weight the policy issues by using inductive methods. For example, the weighting of each policy issue can be a) deductively defined by experts for all users based on what they consider, b) deductively defined by the users of the application, and c) inductively calculated relying on the answers of the users to the policy issues and their preferred political parties [Tsapatsoulis et al., 2015]. From our position, the two last options combined are more respectful with users' architecture of election than the first one. A similar case can be made with the distance function.

Moreover, another way to evaluate whether a VAA is respectful of the users' architecture of election is to consider the percentage of users declaring that the application was giving them a valuable recommendation. We understand that most users can evaluate whether the recommendation is respectful with their own architecture of election. Certainly, this is not the case for every user as some of them might be obfuscated by receiving a totally unexpected recommendation because of their lack of knowledge on the agreement between their policy preferences and the parties' position. However, this should not happen in most cases: the imperfect knowledge that VAAs try to improve is not a total ignorance on the political arena, and in this case most users are akin to judge the VAA relying on whether it can represent them accurately to provide a valuable recommendation.

1. It weights policy issues considering the importance that users gives to them.

2. It operates with distance functions between users and political parties' policy preferences created according to the users' way to compare policy issues.

3. Users consider that the recommendation is valuable.

4.3 Realism

To increase political competency, VAAs must try to reflect the political reality of the world and being able to offer a (simplified) picture of the real world [Dinas et al., 2014]. If VAAs do not capture a realistic disagreement between users and political parties, they are unable to offer a recommendation worth to be considered by the user [Dinas et al., 2014]. This recommendation would be incapable of increasing voter's political competency on the real-world, and thus it could not be applied into any practical decision: it would only be valid for the imaginary-world of VAAs' developers. As a result of the importance of the realism of the application, it has been often claimed that VAAs must be a mirror of the political landscape in which the user can get a complete look of the political landscape and her place within it [Dinas et al., 2014]. This claim is clearly an oversimplification of VAAs which can lead to misunderstandings, because as we have seen the application has a very narrow conception of democracy and voting informed by social choice theory, spatial politics and issue-voting which cannot claim to be a entirely realistic version of politics [Fossen and van den Brink, 2015]. Because many important voting factors are not considered by the application, VAAs will always fail to be an entirely pure representations of political reality [Fossen and van den Brink, 2015]. For that reason, some authors have argued that, instead of mirrors of the electoral reality, VAAs should be understood as dioramas [Fossen and van den Brink, 2015]. From our point of view, understanding VAAs are dioramas pictures more accurately the scope of VAAs: this application cannot aspire to capture all the complex aspects of the reality and must necessarily picture a non-entirely realistic political landscape. Having said that, if VAAs aim to increase political competence they must aspire to be as realistic as possible and cannot offer a political landscape to the users without any correspondence with reality.

The criteria of realism has relationship with the previous one: a VAA considering users' architecture of election in a biased way will hardly be realistic. The main difference is that this criteria takes into consideration the political landscape that VAAs try to emulate. It accounts on whether VAAs offer a realistic matching to the users, and therefore it does not over-represent any political party without a sound justification. For example, we believe that a VAA will hardly be realistic if mostly recommending marginal parties to a representative sample of users. It is true that VAAs should not always recommend the same users' previously preferred party, as in that case VAAs would be useless to increase political competence, as they would not be informative on the disagreement between users and political parties. However, a realistic VAA must consider whether it mostly gives a set of parties which can be realistically expected to be feasible for the users according to her expectations. Otherwise, the odds are that the problem is with the VAA and not with most users, which we have argued that have imperfect knowledge but not total ignorance on the political realm. Therefore, a VAA cannot claim to be realistic if it is mostly recommending a set of political parties which has no relationship with the users' expectations, and neither if it over-represents outstandingly some political political parties.

As VAAs suffer from a self-selection bias, which are not purely representative of the voters [Cedroni, 2010], we cannot take other surveys as proxy to know whether the VAA is giving a realistic matching. We believe that it is better to take the voting intention from the users before of filling up the application, as other VAAs' studies have done [Tsapatsoulis et al., 2015]. There are at least two ways to empirically measure this condition of realism [Tsapatsoulis et al., 2015]. The accuracy measures the percentage of predictions in accordance with users' expectations: the VAA recommends the same party that the users expected to vote before of filling up the application [Tsapatsoulis et al., 2015]. Meanwhile, weighted mean rank measure evaluates how high the VAA placed the preferred political party of the users [Tsapatsoulis et al., 2015]. It offers complementary information to the accuracy measure, as it gives an idea on the position in which the previously preferred party is placed in the rank of recommended political parties according to the agreement coefficient.

1. It offers reasonable results in the accuracy and weighted mean rank method.
2. It offers an overall realistic matching with the political parties according to their importance.

4.4 Transparency

Lastly, it is important that VAAs are transparent in the sense of 1) allowing users and research an open-access to their methods and 2) being non-hidden by any opaque method. First, this criteria involves that the assumptions made by VAAs' developers should be accessible to both users and researchers [Gemenis, 2013]. This is important to make understandable to the users why they received a particular recommended party. Moreover, it can serve to advance on the accountability of VAAs' developers, which might have hidden interest or just rely on non-accurate methods. Not being transparent can avert any replication and improvement of the methods. The second horn of the criteria of transparency includes that the method used should be understandable for users and researchers. For an user, it is important to be able to understand the methods of recommendation, because otherwise the very goal of increasing her political competence by providing a meaningful aggregation of her disagreement with the political parties may be undermined [Louwerse and Rosema, 2014]. For other researchers, having an opaque method can hinder any improvement of it, and plus it can lead to accountability problems. For example, there can be problem of understanding any VAA method similar to black boxes: devices which can be seen in terms of its inputs and outputs without any knowledge of its internal workings [van der Linden and Dufresne, 2017]. Very sophisticated methods for recommending a party can suffer that problem by making impossible to really understand why a recommendation is given to an user.

1. VAAs' methods of recommendation are openly displayed to general public and researchers

2. The method is understandable by general public and researchers

5 Status Quo: Deductive Party-Distance VAA

5.1 Main idea

Most VAAs base on deductive logic their decisions of establishing the policy issues, weighting them and creating the distance functions for measuring the disagreement [Louwerse and Rosema, 2014]. These decisions are taken by the developers of the application ex ante relying on their own theories. Regarding the positions of the parties in each policy issue, there are important differences between VAAs [Gemenis, 2013]. In some VAAs, experts agreed upon the parties' positions and there is no concrete method [Wagner and Ruusuvirta, 2012]. However, other VAAs try to user more objective methods and procedures to place the political parties [Gemenis, 2013]. For example, in the EU-Vox 2019 the developers must first look into the party manifestos, a statement clearly indicating the position of the party. If there is no such a statement, they can go for official declarations of important party members, and if no information is found they can either agree upon a policy issue position or left the party as with "no opinion" on the issue. Since then, policy issues and parties' positions are not modified by any further consideration even if they are proven wrong [Mendez, 2017].

In the majority of VAAs, all the questions are equally weighted in the aggregation whose outcome is the agreement score [Mendez, 2012]. Therefore, all the policy issues have the same importance for deciding the recommended political party. Current VAAs assume that users' architecture of election is the simplest ever imaginable: all policy issues are as important to decide which party to vote for. As much, some VAAs give users the opportunity of declaring that a question is non-important or very important for them [Louwerse and Rosema, 2014]. However, the effect of pointing out that a question is of particular importance is also deductively chosen, and normally its weight is halved or doubled depending on the user's declaration [Wagner and Ruusuvirta, 2012]. For example, if the user declares that a question regarding taxes is very important for her, the outcome from the distance function due to their degree of agreement with the political party in that question will be multiplied by 2.

Regarding the distance function, VAA developers choose deductively a matrix of distances between users and political parties, and use the same matrix along the questionnaire [Mendez, 2012]. VAAs' developers have discussed on whether use proximity, directional or an hybrid distance function [Mendez, 2017]. Although some VAA developers do not publicise their distance functions, most of them rely on a proximity logic [Mendez, 2012]. Therefore, recommendations are based on voter-party distances, usually measured on a continuous scale which can be seen in the next section. However, the test made to check which matrix of distances is more representative of the users' architecture of election show that hybrid models between proximity and directionality are better in representing users' preferred political parties [Mendez, 2017].

5.2 Formalization

Deductive algorithms compute agreement scores between user $\vec{u_i}$ and party $\vec{p_k}$ independently per each question: $f : \mathcal{L} \times \mathcal{L} \longrightarrow \mathbb{R}$. The answers are typically *one-hot encoded*, i.e. transformed into a vector with 1 on the chosen answer and 0 on the others: $f' : \mathcal{B}^{|\mathcal{L}|} \times \mathcal{B}^{|\mathcal{L}|} \longrightarrow \mathbb{R}$. The score, s_{ikj}, for question j between the the user and the party encoded answers ($\vec{u_{ij}}$ and $\vec{p_{kj}}$, respectively) is then evaluated according to a *distance matrix* D that models the conceptual space:

$$s_{ikj} = f'(\vec{u_{ij}}, \vec{p_{kj}}) = \vec{u_{ij}} \times D \times \vec{p_{kj}}^T \ . \tag{2}$$

The values for the distance matrix are deductively chosen according to proximity or directional models. An example proximity matrix (without the *No Option* choice), from [Mendez, 2012], is

$$\left(\begin{array}{cccccc} & CA & A & N & D & CD \\ CA & 1 & 0.5 & 0 & -0.5 & -1 \\ A & 0.5 & 1 & 0.5 & 0 & -0.5 \\ N & 0 & 0.5 & 1 & 0.5 & 0 \\ D & -0.5 & 0 & 0.5 & 1 & 0.5 \\ CD & -1 & -0.5 & 0 & 0.5 & 1 \end{array}\right) . \tag{3}$$

The model based on directional logic is the following matrix [Mendez, 2017]:

$$\left(\begin{array}{cccccc} & CA & A & N & D & CD \\ CA & 1 & 0.5 & 0 & -0.5 & -1 \\ A & 0.5 & 0.25 & 0 & -0.25 & -0.5 \\ N & 0 & 0 & 0 & 0 & 0 \\ D & -0.5 & -0.25 & 0 & 0.25 & 0.5 \\ CD & -1 & -0.5 & 0 & 0.5 & 1 \end{array}\right) . \tag{4}$$

Finally, a third distance function based on a hybrid model has been also tested:

$$\left(\begin{array}{cccccc} & CA & A & N & D & CD \\ CA & 1 & 0.5 & 0 & -0.5 & -1 \\ A & 0.5 & 0.625 & 0.25 & -0.125 & -0.5 \\ N & 0 & 0.25 & 0.5 & 0.25 & 0 \\ D & -0.5 & -0.125 & 0.25 & 0.625 & 0.5 \\ CD & -1 & -0.5 & 0 & 0.5 & 1 \end{array}\right) . \tag{5}$$

The total score, s_{ik} between the user i and party k is then computed by squashing the scores for the N questions according to some weights, $\vec{w}$, that represent the importance of each question for the user:

$$s_{ik} = \sum_{j=1}^{N} w_j \, s_{ijk} = \vec{w} \cdot \vec{s_{ik}} \ . \tag{6}$$

In current VAAs, all the policy issues are equally weighted, so it is assumed that they have the same importance for the agreement score. This is done between the user and all the K parties, producing the final vector of *agreement scores*, $\vec{s_i}$, which is the final recommendation output given to the user in descending order, with the first one being the recommended party.

5.3 Assessing the criteria

Current VAAs ~~are dependable~~ on deductive methods, which to be consistent need to be reasonably justified ex-ante without empirical research validating them. From our perspective, this is the case for choosing the policy issues at stake and the positions of the political parties within them. Taken as granted that VAAs' developers are policy experts acting in good faith, they can provide to the users a knowledge on the issues at stake and the positions of the parties within them: that's one of the very reasons of filling up VAAs [Garzia and Marschall, 2014]. Empirical research has shown that current VAAs are able to place the political parties quite accurately in the policy issues, specially when they consider as the benchmark the policy manifestos [Wagner and Ruusuvirta, 2012]. Therefore, there are reasons to conclude that experts are better positioned than users to decide the policy issues and the positions of the parties. For that reason, current VAAs can be informative: they inform to the user on the policy issues, the positions of the political parties within them and offer an agreement based on these differences which simplify the voting decision. Furthermore, we consider that most current VAAs are transparent as they have open methods which can be roughly understood by general public and experts [Gemenis, 2013]. It is true that some VAAs are not publicizing their distance matrix, but this is a failure which could be easily solved by putting them at disposition of the public [Gemenis, 2013].

However, current VAAs do not respect users' architecture of preferences. More specifically, the way in which VAAs weight policy issues and create their matrix functions by a deductive method is problematic. First, let's focus on the most controversial decision that VAAs' developers are taking: giving exactly the same weight to any question. From our perspective, this is far from being respectful of users' preferences: it relies on an imaginary world in which voters give the same importance to every policy issue to cast a vote. This assumption is empirically flawed in issue-voting as many studies have shown that voters give consistently more importance to some issues [Wlezien, 2005]. Beyond any empirical study, it is common-sense to think that a VAA weighting equally all the issues will have problems in respecting users' own preferences. Certainly, we can take as granted that voters care more about some specific policy issues to cast their vote, and this is not something that VAAs' vision on political competence should challenge. There is no way in which voter's political competence should be understood as the equalization of every policy issue to find which political party is closer to the user preferences "if aggregated in such a way". Therefore, current VAAs, instead of declaring that they recommend political parties to the users according to their own preferences, should claim that "given a world in which everyone cares exactly the same about a policy issue regarding euthanasia, a one on taxes and another on immigration", VAAs can increase political competence. This is not solved by giving users the opportunity of adding more/less weight to a question, as the multiplication/division by 2 is still arbitrary and can only marginally improve the respect toward the users' own preferences. Is there any specific reason to multiply/divide by 2 and not another number?

A similar thing occurs with matrix distances. The deductive method used to establish the same matrix for every question according to a voting theory is criticizable. First, it is not clear that proximity and directional models are liable to explain voting behaviour. For example, recent empirical studies have found that "key statistical assumptions (on proximity and directionality models) have not been empirically tested and, indeed, turn out to be effectively untestable with existing methods and data" [Lewis and King, 1999, 21]. Therefore, VAAs' developers are building distance matrix based on some theories which are empirically contestable. Second, even assuming that these theories are sound to build the matrix, it is not really clear that we can use the same matrix for every policy issue. From our understanding, each policy issue can follow their own logic, as they potentially respond to different pattern of behaviour which are difficult to disentangle ex-ante. For example, it is quite imaginable that users can be driven differently in their disagreement in visceral policy issues (such as some regarding social rights. i.e homosexuality rights) in which directional logic is more sound than in other regarding taxes, in which maybe a proximity logic can be expected. In any case, the important point is that it is difficult to know ex-ante which theory of voting is better fitting. This can be seen in those studies which have been trying to evaluate the distance matrix, such as those of [Mendez, 2012] and [Mendez, 2017]. Their main conclusion is that a hybrid matrix, not following any clear voting logic, fits better to users' policy preferences [Mendez, 2017]. Once accepted that an ex-ante established hybrid matrix better fits users' architecture of election, the main question which remains unanswered is the following: Why other distance matrix have not been tested?

As a consequence of their equal weighting and way to establish the distance matrix, we believe that current VAAs are not respectful of the users' own preferences. Furthermore, they are neither realistic. For example, it has been found that in current VAAs "some parties may find themselves in the beneficial position of receiving more voting recommendations because of artefacts in the VAA construction" [Gemenis, 2013, 281]. We found the same outcome in the EU-Vox 2014 when we emulated the method used by the application to recommend a political party. The Eu-Vox 2014 is over-representing parties such as Podemos or ERC in a total unrealistic way, as it recommends them to an outstanding higher percentage of those users who declared that they intended to vote for that party (figure 6). Plus, it under-represents other parties in the same side of the political spectrum such as IU. As it can be imaginable, a VAA with this characteristics have low percentage of accuracy and weight mean rank, so the realism criteria is clearly not accomplished. This is a grave problem to be solved by future VAAs, as it undermines their goal of increasing political competence.

Starting Preferred	Recomended BNG_Bildu	ERC	IU	PNV_CiU	PP	PSOE	Podemos	UpyD	Total
BNG_Bildu	349	659	105	2	0	32	826	2	1,975
	17.67	33.37	5.32	0.10	0.00	1.62	41.82	0.10	100.00
ERC	65	1,178	18	15	3	148	279	5	1,711
	3.80	68.85	1.05	0.88	0.18	8.65	16.31	0.29	100.00
IU	578	3,628	809	2	2	637	4,481	17	10,154
	5.69	35.73	7.97	0.02	0.02	6.27	44.13	0.17	100.00
PNV_CiU	19	414	9	72	33	140	62	10	759
	2.50	54.55	1.19	9.49	4.35	18.45	8.17	1.32	100.00
PP	8	100	8	93	783	227	58	362	1,639
	0.49	6.10	0.49	5.67	47.77	13.85	3.54	22.09	100.00
PSOE	45	1,523	96	1	11	786	821	54	3,337
	1.35	45.64	2.88	0.03	0.33	23.55	24.60	1.62	100.00
Podemos	421	2,732	189	4	4	680	4,370	37	8,437
	4.99	32.38	2.24	0.05	0.05	8.06	[illegible].80	0.44	100.00
UpyD	25	623	25	14	71	921	329	539	2,547
	0.98	24.46	0.98	0.55	2.79	36.16	12.92	21.16	100.00
Total	1,510	10,857	1,259	203	907	3,571	11,226	1,026	30,559
	4.94	35.53	4.12	0.66	2.97	11.69	36.74	3.36	100.00

Figure 6: Starting preferred and recommended political parties

We need to find out why, in spite of these critical problems, VAAs are equally weighting the questions and choosing deductively a matrix distance. In particular, it is particularly difficult to find a reasonable justification for their weighting decision because there is no single theory of voting pointing out that a competent voter must give the same importance to all policy issues. A possible justification is that they did not found any other way to do it better. If it is accepted that weighting policy issues must be done following a deductive logic, every possible weighting decision will be liable to the same critic made before. Certainly, there is no clear way to establish ex-ante what should be the weight of the questions because this is something related to the own users' preferences and cannot be easily pre-established. In that case, it seems logical to weight equally all the questions to give an "appearance of neutrality" to the deductive method. If other weighting is used, i.e adding special weights to economic issues, it could be argued that experts are choosing the topics which must be important for the voters while the former criticism would not be resolved. Therefore, it can be argued that giving the same weight to the questions is preferable to any other deductive weighting decision, and following that argument the problem is intrinsic to the deductive logic employed by VAAs. The remaining question is whether inductive methods can solve the problem.

6 ~~Alternative in dispute:~~ Inductive Social VAAs

6.1 Main idea

In contrast to deductive VAAs, inductive social VAAs dispense with the party profiles, and recommendations are purely based on other users' profiles [Tsapatsoulis et al., 2015]. Before of filling up the questionnaire, users are requested to indicate which party they plan to vote for. Inductive VAAs recommend the parties more prevalent in the user's vicinity, i.e. the parties that like-minded users already declared they planned to vote for. This setting can be seen as typical multi-class classification problem when taken from the perspective of the *machine learning* field. The goal is to assign user i to the correct class k, based on previous cases from which the class is already known [Katakis et al., 2014]. In the case of VAAs this implies assigning to a user a party having as a reference previous users and their voting intentions.

A typical approach for solving the problem involves dividing the space in k regions, one per party, and give recommendations according to which region the new user falls into. One way of doing this is by *naive Bayes classification* [Tsapatsoulis et al., 2015]. This method computes the "average voter" of each party by averaging the answers of users that share the same voting intention. Then, the class to which a new user belongs is the one with the smallest *Mahalanobis distance* to its average voter, which is the Euclidean distance modified by the covariance of the data points belonging to that class. Other classifiers implemented by [Katakis et al., 2014] are decision trees, neural networks and support-vector machines.

A different approach to the classification problem is using probabilistic generative models. One of such methods is the *Hidden Markov Model (HMM)*, implemented on VAAs by [Agathokleous and Tsapatsoulis, 2016]. These are probabilistic models containing a certain amount of states, probabilities of observing different outcomes in such states, and probabilities of switching states. These probabilities are chosen as the ones that best predict the available data and can then be used for predicting new users. Lastly, it is possible to recommend a party purely based on the local environment, on the party that the nearest neighbours intended to vote for. The simplest implementation, the *K-nearest neighbour* algorithm, would look at the K closest neighbours to the user in the answer space and recommend the party that is most prevalent between them. A more complicated alternative would be to perform clustering on the existing users and assign to the user the party most prevalent in the cluster [Katakis et al., 2014].

6.2 Formalization

User profiles, $\vec{u_i}$, are embedded in the N-dimensional space $\mathcal{L}^N$ (input space). Users also provide their voting intention, i.e. the party they declare they intend to vote for, $c_i \in \{1, 2, ..., K\}$, which is the output class that the algorithm has to predict. Each pair profile-class forms a training sample that can be used for learning better predictions of outputs, $P(c_i|\vec{u_i})$. This probability of a user belonging to a party can be likened to the agreement score from the deductive VAA, so the output scores $\vec{s_i}$ from inductive VAAs are constructed by these predictions, such that

$$s_{ik} = P(c_i = k|\vec{u_i}) \,. \tag{7}$$

For the naive Bayes approach, for instance, the predictions correspond to

$$s_{ik} = P(c_i = k|\vec{u_i}) = e^{-\frac{1}{2}(\vec{u_i}-\vec{u}_{c_k})^T C_k^{-1}(\vec{u_i}-\vec{u}_{c_k})} \,, \tag{8}$$

where $\vec{u}_{c_k}$ represents the average voter of party k and both $\vec{u_i}$ and $\vec{u}_{c_k}$ are encoded linearly instead of one-hot, with answers linearly placed from -2 (Completely Disagree) to $+2$ (Completely agree).

6.3 Assessing the criteria

Some inductive social models have been very successful in being respectful with users' architecture of election [Tsapatsoulis et al., 2015]. In all inductive social models, VAAs recommend according to a users-based method [Agathokleous and Tsapatsoulis, 2016]. Moreover, users declare more often that the application respected their own preferences when VAAs follow this method. For example, in an experiment by [Tsapatsoulis et al., 2015], in which users did not know what kind of VAA was recommending to them, a quite remarkable higher percentage of users declared that the recommendation made by social inductive model of VAAs was more useful [Tsapatsoulis et al., 2015]. Probably, the fact that they have a better consideration on these recommendations have relationship with the higher realism of this model. These VAAs have higher percentages of accuracy and weighted mean rank [Tsapatsoulis et al., 2015]. Moreover, they do not suffer the problem of over-representing political parties in the same degree than normal VAAS [Agathokleous and Tsapatsoulis, 2016].

However, we believe that inductive social VAAs are not a valid alternative to current VAAs. Their main problem is their lack of informativeness. To provide a recommended party, they do not compare positions in policy issues of users and political parties [Katakis et al., 2014]. Therefore, they do not inform on the positions of the political parties and neither offer a total disagreement based on this comparison and aggregation on the policy issues. As a conclusion, they are unable to increase voters' political competence because they cannot map the disagreement between users and parties to offer a recommendation [Agathokleous and Tsapatsoulis, 2016]. Their recommendation can inform on where the voters of the parties are, but this cannot increase the notion of political competence that VAAs advance.

7 Our proposal: Inductive Party Distance VAA

7.1 Main idea

Our approach is a combination of deductive and inductive methods. It takes the approach of deductive methods for calculating agreement scores between user and parties.

The main difference resides in the distance matrix and the weighting system, that instead of being fixed are inductively adapted in order to improve class prediction. This is done by using an approach as described in inductive VAAs, by which an algorithm gets some inputs (user profiles in this case) along with desired outputs (vote intentions) and tries to adjust its parameters (distance matrices and weights) in order to produce an output (agreement score) equal to the desired output (vote intention).

7.2 Formalization

We have M users, each with a user profile, $\vec{u_i}$, and a voting intention, c_i, and K parties, each with its corresponding profile, $\vec{p_k}$. The agreement score for question j between user i and party k is computed with a distance matrix, as in the deductive model:

$$s_{ikj} = \vec{u_{ij}} \times D_j \times \vec{p_{kj}}^T \; . \tag{9}$$

The main difference is that there are N distance matrices now, each only employed for a single question. Matrices are symmetrical in their parameters, as distances from users to parties should be the same as the ones from parties to users. A symmetry in the secondary diagonal is also introduced, corresponding to the logical symmetry between agreement and disagreement: it is enough for reformulating the question into a negative version of it for flipping the axis. Distance matrix for question j can be written as

$$\begin{array}{cc} & \begin{array}{cccccc} CA & A & N & D & CD & NO \end{array} \\ \begin{array}{c} CA \\ A \\ N \\ D \\ CD \\ NO \end{array} & \begin{pmatrix} \boldsymbol{d_{11}} & d_{21} & d_{31} & d_{41} & d_{51} & d_{61} \\ \boldsymbol{d_{21}} & \boldsymbol{d_{22}} & d_{32} & d_{42} & d_{41} & d_{62} \\ \boldsymbol{d_{31}} & \boldsymbol{d_{32}} & \boldsymbol{d_{33}} & d_{32} & d_{31} & d_{63} \\ \boldsymbol{d_{41}} & \boldsymbol{d_{42}} & d_{32} & d_{22} & d_{21} & d_{64} \\ \boldsymbol{d_{51}} & d_{41} & d_{31} & d_{21} & d_{11} & d_{65} \\ \boldsymbol{d_{61}} & \boldsymbol{d_{62}} & \boldsymbol{d_{63}} & d_{62} & d_{61} & \boldsymbol{d_{66}} \end{pmatrix} \end{array} , \tag{10}$$

with all unique parameters in bold. The aggregated scores of the N questions are aggregated in the same way as deductive models:

$$s_{ik} = \sum_{j=1}^{N} w_j \, s_{ijk} = \vec{w} \cdot \vec{s_{ik}} \; , \tag{11}$$

Although these weights are flexible in our model, they will gradually decrease or increase as the model learn from users' answer, as they are parameters that will be learned from them. In order to have a more interpretable output, the agreement scores should be placed in the range $[0-1]$, which can be done by applying the *softmax* function to the output agreement score:

$$s'_{ik} = \frac{\mathrm{e}^{s_{ik}}}{\sum_{l=1}^{K} \mathrm{e}^{s_{il}}} \tag{12}$$

The goal of the inductive part is to find which parameters — which values for the distance matrices and squashing weights — lead to best party prediction. This is achieved when the party of the voting intention c_i gets the maximum agreement score. So the goal output for user i is to obtain an agreement score $\vec{s_i}$ with a 1 for party c_i: $s_{ik} = 1 | k = c_i$. How well the goal is met can be quantified by the *log loss* function, a common performance measure for multi-class classification tasks. It gives us the classification error for user i, ce_i, which will be the goal function that the algorithm needs to minimize with respect to the parameters:

$$\min_{\mathbf{D},\vec{w}} \sum_{i=1}^{M} ce_i = -\sum_{i=1}^{M} log(s_{ik}) \quad | \quad k = c_i \; . \tag{13}$$

Finding the parameters that minimize the error could theoretically be achieved in the same way as any optimization problem: by computing the partial derivatives in the parameter space and finding the critical points (the ones whose partial derivatives are equal to zero). Nevertheless, the inclusion of more complex functions (softmax) prevents us from easily computing a closed-form solution of such points, so numerical methods must be used. A common method that performs local search in the parameter space is *gradient descent*. This method rely on the information carried by the derivatives. The gradient of a function at a certain point shows the direction in the parameter space in which the error diminishes the fastest. By taking a step (changing the parameters) in that direction, the new state (parameter set) should[2] have a lower error. By iterative steps, the algorithm would eventually reach a local minimum (figure 7). The size of the step is determined by the learning rate, μ, —chosen by the developer, many different techniques allow for an efficient selection [Goodfellow et al., 2016, 84]— and the gradient of the function:

$$w_{t+1} = w_t - \mu \sum_{i=1}^{M} \frac{\partial ce_i}{\partial w} \tag{14}$$

An online learning scheme would update the parameters in real time as the users fill the VAA, performing new iterations of the gradient descent algorithm as new user points are added. Although first users may have altered results, the algorithm should stabilize fast and work realistically for the vast majority, as showed by inductive VAA approaches [Katakis et al., 2014].

7.3 Results

(Still working on the results with the EU-VOX 2014) (Of course, I will not put anything on the EU-Vox 2019 because the election will not have taken place at the moment of the dissertation) (Results' part will be very brief and will give the outcomes on the level of accuracy, mean weight rank and some information on the weights and matrix of distances).

[2] Steps are small to ensure that local properties are conserved. Too large steps could lead to divergence.

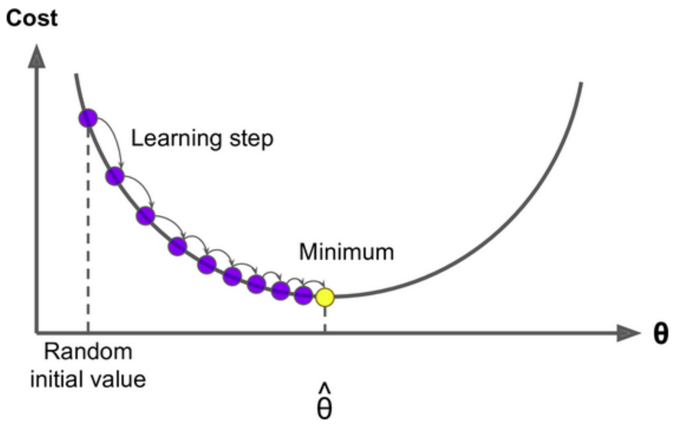

Figure 7: Gradient descent algorithm [Géron, 2017, Ch. 4]. By taking small steps in the direction of lowering errors, the optimal set of parameters, $\hat{\theta}$, can be found.

7.4 Assessing the criteria

Our VAA is informative for the very same reasons that current VAAs are. From our perspective, it can be even more informative because it provides a more reliable agreement score. Regarding the respect of the users' own preferences, our VAA tries to adapt to users' architecture of election. It weights policy issues and create distance matrix following a user-based method. We cannot yet know whether users consider that the recommendation respect their policy preferences as it is impossible to retrospectively measure that with the data from the EU-Vox 2014. (I need to wait to the results' part to evaluate the realism criteria, but the preliminary results have been positive in this regard as the accuracy and weighted mean rank improve considerably as expected).

However, the main problem of our proposal is the lack of transparency. Even if all the methods used are open to public and researchers, there will be problem regarding the opaqueness of the method. Users can find difficult to understand the mechanism behind the recommendation. Even if the weights of the questions and the distance functions are displayed in a screen, there will be difficulties to understand why some issues are given more importance than others, and why a complicate matrix distance without any straightforward meaning is used. In that circumstances, VAAs' goal of increasing political competence can be undermined by the fact of providing to the user with a total disagreement provided with a method difficult to understand. For researchers, we have the problem of inductive methods: Being able to interpret the outcome in a meaningful and reliable way. This can be a problem with methods relying in sophisticated machine learning which can have similarities with black boxes. In them, the internal mechanism producing the output from the set of inputs is not known. In that cases, researchers may have difficulties to provide a meaning to the output of the application, undermining any valuable outcome of the VAA.

8 Conclusion and further research

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