Valuation of Ecosystem Services and Social Choice: The Impact of Deliberation in the context of two different Aggregation Rules

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Abstract

This paper describes an empiric study of aggregation and deliberation used during citizens' workshops for the preference elicitation of 20 different ecosystem services (ESs) delivered by the Palavas coastal lagoons located on the shore of the Mediterranean Sea close to Montpellier (S. France). The impact of deliberation for the preference elicitation of 20 different ecosystem services (ESs) was studied by gathering and aggregating individual preferences before deliberation that were compared to the collective aggregation after deliberation. The same aggregation rules were used before and after deliberation and we compared two different aggregation methods, i.e. Rapid Ecosystem Services Participatory Appraisal (RESPA) and Majority Judgement (MJ). RESPA had been specifically tested for ESs, while MJ evaluates the merit of each item, an ES in our case, in a predefined ordinal scale of judgment. The impact of deliberation was strongest for the RESPA method. This new information acquired from application of social choice theory is particularly useful for ecological economics studying ES, and more practically for the development of deliberative approaches for public policies.

Keywords: ecosystem services, preference elicitation, non-monetary methods, deliberation, social choice theory, coastal lagoons.

JEL codes: D71, Q57.

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1. Introduction

How can we construct a social preference for ecosystem services (ESs) based on individual preferences? The issue is particularly important for public policies focused on environmental management and spatial planning. In this context, the ambition is to provide a "means of improving the choices our societies and the public bodies make to frame our relation to nature" (Salles and Figuieres, 2013). It is an important and recurrent practice when valuing ESs and choosing among alternative management options (e.g., designating protected areas, ecological restoration projects, spatial planning and other public policies) that lead to different outcomes (Dendoncker et al., 2014). The development of participatory approaches in this area involves examining the methods of collecting and aggregating preferences. Interestingly, these real approaches often present mixtures of deliberations followed by rankings of ESs. What can be expected from such mixtures? From a more general perspective, a wealth of potential clarifications - originating from various traditions and scientific disciplines, e.g., economics, political science, political philosophy and ecology – are helpful. Among this diversity, two approaches can be distinguished (Dryzek and List, 2003).

The first approach is based on the aggregation of individual preferences. Emphasis is placed on the properties associated with the aggregation methods (e.g. Condorcet, 1785; Borda, 1781; Weber, posthumous edition of 2013; Hare, 1857). A milestone of this approach is of course Arrow's famous impossibility theorem (Arrow, 1951), the starting point of the modern theory of social choice. In this search for a 'good' aggregation of preferences, deliberation is either absent or implicit, and to our knowledge it is not the central concern.

By contrast, the second approach relies explicitly on a deliberation process among individuals. It has been particularly promulgated by the so called 'deliberative turn' in the eighties. Nowadays this is an eminent approach in political science, which spills over into other social sciences, such as anthropology geography and sociology. It is based partly on *Discourse Ethics* (Habermas, 1990), and builds on the idea that public deliberation is the essential key of a new articulation between three democratic objectives: *i)* the common good, *ii)* justification and *iii)* legitimacy (Cohen, 1989; Elster, 1998; Sunstein, 2007).

Although deliberation is defended as a prerequisite for democracy (Dewey, 1927), it is not recognized as a flawless panacea. Several decades of empirical research paint a mixed picture of the merits and/or weaknesses of deliberation (e.g., Fishkin and Mansbridge, 2017),

presumably because different factors play in opposite directions. Many of these factors still remain poorly understood. This lack of knowledge is an obstacle in the quest for deliberation capable of approaching the democratic ideal. This issue, which appears of paramount importance for public policies seeking public support, appears particularly pertinent in the field of ecosystem services valuation. For our scientific analysis, we assume that any deliberative process is based, implicitly or explicitly, on a particular aggregation procedure of individual preferences. How can we hope to understand the effects of deliberation when the aggregation rule remains implicit, or when its properties are not well known? Therefore, we propose that an explicit aggregation rule should be used during deliberation, as the expectations are well known for many rules in social choice theory[6]. This approach also has the advantage that it provides a framework for assessing the impact of deliberation alone by comparing the aggregation of the individual preferences before deliberation with the subsequent outcome of the deliberation process, provided that the same aggregation rule is used during both phases. Therefore, this design requests that the individual preferences are collected at the beginning of the process and that both this collection and the deliberation process is designed according a selected aggregation rule. Hence, the impact of deliberation can be assessed in the context of the selected aggregation rule by a before/after deliberation comparison. Actually, this even suggests an entire research program, in order to assess, for each well-known aggregation rule, the potential interest of the deliberation stage.

There are several reasons to believe that adding a deliberation stage will have an effect. In many cases and particularly when dealing with ecosystem services, one can hardly consider that stakeholders' preferences are exogenous and well-informed objects for all the different ESs. Preferences are context-dependent and, to some extent at least, endogenous. Therefore, preferences must in some sense be formed during a process of consideration and/or discussion (Spash, 2007). This implies that deliberation facilitates information sharing among participants since they are exposed to a wide range of ideas, perspectives and viewpoints (Lienhoop et al., 2015). Deliberation explicitly gives participants the opportunity to revise their preferences after having explored the problem at hand (Parks and Gowdy, 2013). From a more ethical point of view, knowing that you are going to have to defend your preferences

[6] Of course there are obstacles to the 'good' properties of a deliberation other than those associated with the aggregation of preferences. Actual deliberative processes can sometimes be affected by power relations that reproduce systems of privilege and inequality. Two types of indicators can be used to assess the quality of a deliberation process. The first relates to the balance of speaking times and the transparency and traceability of the debates. The second type of indicator is related to the diversity and representativeness of the participants (Howarth and Wilson, 2006).

publicly encourages you to go beyond your individual interest to considerations of the general interest. In one interpretation, this involves purging one's private preferences of ethically indefensible components.

Hence, backing up deliberation with explicit aggregation rules would allow one to better explore two weaknesses pointed out in the literature on deliberation. A first weakness is that deliberation can be sensitive to the details of its organization[7], including of course the aggregation rule it encompasses (in the realm of environmental issues, see for instance Smith, Chapter 4, 2003). The nature of this dependence can only remain mysterious if the properties of the aggregation rule are themselves poorly understood. Going further, this suggests choosing aggregation rules that, by construction, are consistent with the ambitions assigned to deliberation. For instance, deliberation has obviously no chance of meeting the democratic requirement if it is based on an oligarchic or dictatorial aggregation rule. A second well documented weakness is *group polarization*, meaning that the debates within a group tend to radicalize the opinion of the members of the group in the direction of the initially dominant opinion, regardless of the merits of this opinion (Sunstein, 2007). This begs the question whether some aggregation rules are more or less sensitive to this polarization phenomenon. Answering this question requires testing and comparing on at least two aggregation rules. Hence, the final problem is which two aggregation rules should we choose among a wide range of possibilities?

In the study reported in this paper, we carried out an ESs social choice protocol allowing us to question the impact of deliberation, by comparing the collective rankings of ESs preferences before and after deliberation. The first aggregation rule we have selected in this study is called RESPA (for "Rapid Ecosystem Services Participatory Appraisal", see Rey-Valette et al., 2017) that has been tested for ecosystem services. Nevertheless, the impact of deliberation has not yet been assessed for this rule. Actually, RESPA is a variant of the famous Borda's rule, preceded by a selection phase of ESs in order to arrive at a smaller subset of ESs among which stakeholders' preferences remains to be aggregated. It has interesting properties in the context of ecosystem services. In fact, when it comes to prioritizing, classifying or evaluating a large list of objects, certain methods may lead to the phenomenon of survey fatigue. With an aggregation in two nested steps, the RESPA method tries to overcome this problem. Apart from that, Borda's method is very old. Its first uses date back at least to the 2nd century AD

[7] For example, an unstructured process might be dominated by the powerful participants, particularly if they are in agreement. In contrast, a facilitated process might amplify the voices of people in the minority, forcing engagement and social learning on matters of disagreement (Howarth and Wilson, 2006).

by the Roman Senate. Its formalized study began with the Frenchman Jean Charles de Borda in the 18th century (Borda, 1781). Closer to us, some variants of this rule have been axiomatized (Young, 1974). In its stripped-down version, it is a simple weighted voting system. Stakeholders attribute points to each ES; the Borda score of each ES is the sum of all its points and the social ranking of ESs is then given by the order of these scores. A textbook presentation is in Mueller (Chap. 7, 2003). It has a notorious weakness: it does not abide by Arrow's Independence of Irrelevant Alternatives axiom (IIA). It is then subject to strategic manipulations, and it may also fail to rank at the top a Condorcet winner, when it exists.

The second rule we selected, the Majority Judgment ("MJ" for short; Balinski & Laraki, 2007, 2010, 2014, 2017), has never been used in this context. The principle of MJ is that stakeholders do not rank ESs directly, but they evaluate the merit of each ES in a predefined ordinal scale of judgment, called mentions. For instance in our case: "high priority", "priority", "neutral", "low priority" and "not a priority". One then determines the median mention for each ES, and the winning ES is the one with the highest median mention. Eventually, one not only has a winner and a ranking of medians, but also a picture of what stakeholders think about ES via the ordinal scale. It was chosen in particular because it minimizes strategic manipulation (Balinski and Laraki, 2007). This property suggests that it could be less subject to the phenomenon of polarization presumably associated with a deliberation.

It is worth noting that both RESPA and MJ are consistent with the democratic ideal one may expect from deliberation, at least in the specific sense that they respect the Unanimity requirement (a unanimous strict preference of ES "x" over ES "y" should aggregate into a strict social preference of ES "x" over ES "y"). Also, both have an advantage when it comes to ecosystem services: they are non-monetary methods. For good or bad reasons, monetization produces rejection phenomena when it is applied to the evaluation of nature. And we want to eliminate this noise from the equation.

Moving to practical details, our field of study is the Palavas lagoons complex located near the urban agglomeration of Montpellier (about 500,000 inhabitants) in Southern France. This lagoon complex comprises 25 km of Mediterranean coastline with seven coastal lagoons and their immediate surroundings. This area is recognized as an internationally important wetland area according the Ramsar convention and is included in the EU Natura 2000 network because of its biodiversity and habitat values, while at the same time representing cultural and recreational values for the resident population and as a holiday resort for tourist mainly during

summer. More detail about the socioeconomic system is provided below together with details about the aggregation methods, with and without deliberation. The aim of the present study was to study the impact of different aggregation rules on defining collective preferences and how these preferences can change as a result of the deliberation process. Section 2 details the material and methods used. Sections 3 presents the results. Section 4 concludes with a discussion.

2. Material and methods

2.1. Study site

The study area (Figure 1) comprises the Palavas lagoon complex and its immediate surroundings located in South of France. It includes:

(i) Seven shallow coastal lagoons between 0.4 and 1.2 meters deep that covers a total of 3,880 ha: Ingril, Vic, Pierre-Blanche, Arnel, Prévost, Méjean and Grec lagoons,
(ii) The coastal barrier of these lagoons of 25 km of which 11 is not urbanized and in a natural state,
(iii) Peripheral riparian, agricultural and wetland areas, and finally,
(iv) the Rhône-à-Sète canal running SW - NE through the lagoon complex.

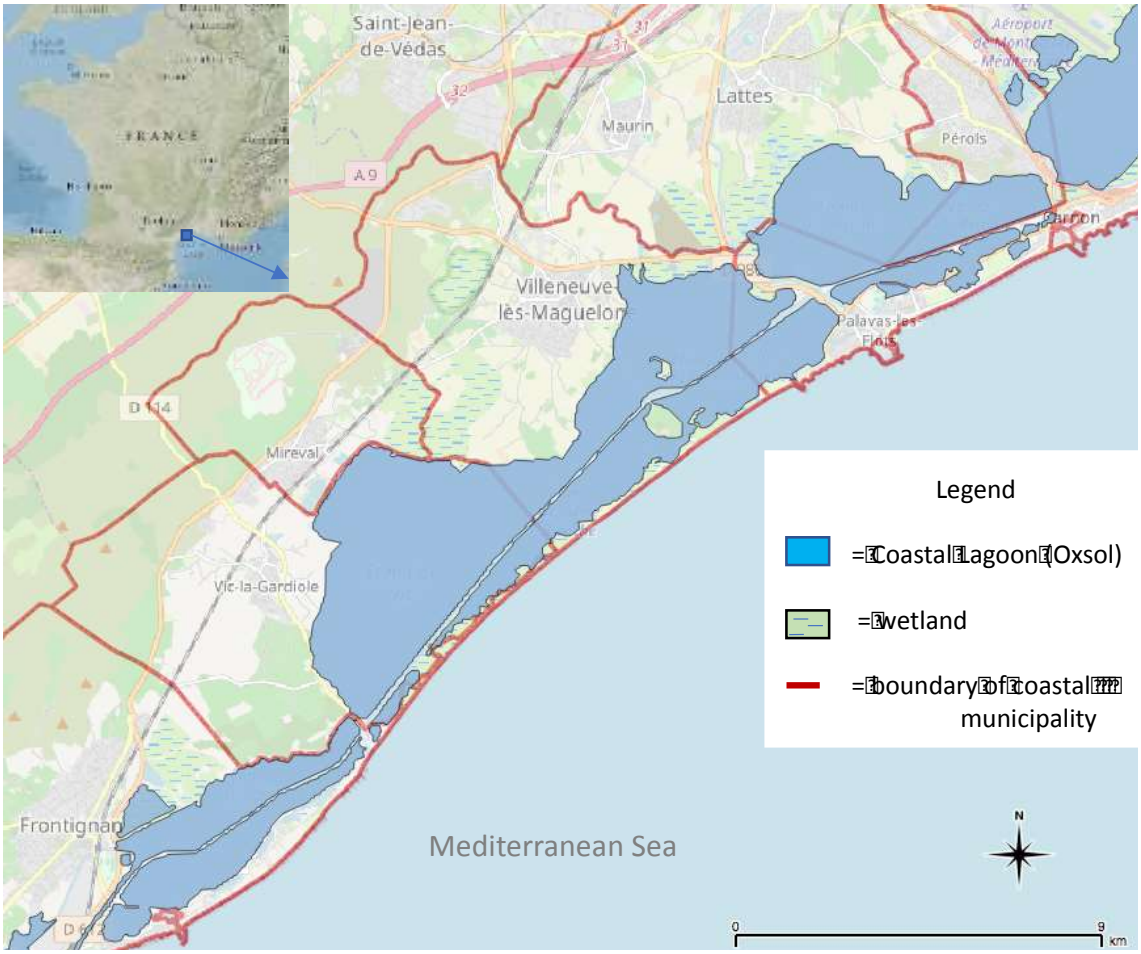

Figure 1. The Palavas lagoon complex in S. France on the Mediterranean Sea with its coastal barrier (25 km long running SW-NE) and its fringing wetlands. (Coastal lagoon area retrieved from Oxsol data base, which is a regional refinement of Corine Land Cover; background OpenStreetMap).

The lagoons of the complex suffered more than four decades of nutrient over-enrichment due to their proximity with the urban centers of Montpellier and Sète as well as important suburban areas (De Wit et al., 2017). However, awareness of the risks associated with their degradation resulted in policies focusing on the improvement of water quality (Leruste et al., 2016), ecological restoration (De Wit et al., 2017; De Wit et al., 2020) and nature conservation measures (Sy et al., 2018). Moreover, there is a dynamic of involving stakeholders' preferences including those of local residents for a better acceptability of these restoration and conservation policies.

2.2. Data collection, preference elicitation and aggregation processes

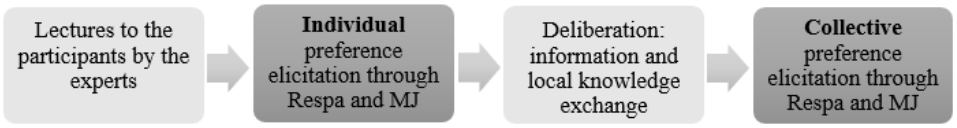

Figure 2. The overall steps of the data collection during the citizens' workshops.

The data were collected during three citizens' workshops that took place in May and June 2017 and 2018 with local residents selected randomly in the municipalities nearby the Palavas lagoon complex. There was a total of 42 participants that showed up during the workshop sessions. Each of the three citizens' workshops lasted around 3 hours. The overall steps of the data collection during the workshops is depicted in Fig. 2. Participation at the citizen workshop was based on voluntary basis and the data have been treated anonymously in compliance with the EU General Data Protection Regulation (GDPR) as recommended by the Universities of Montpellier and Aix-Marseille. All participants were informed about the anonymity of their answers.

For each citizens' workshop, after welcoming the participants, a brief introduction about the overall process of the session was realized by the co-authors of the paper. There were between 3 and 6 experts for each session, including three co-authors of the paper. The workshop session comprised lectures given by the experts using a PowerPoint support. The oral presentations, which lasted about an hour, were about ecological functioning, socio-economic dynamics and management of the Palavas lagoons complex. More precisely, the supplied information included:

(i) General information on the lagoons (definition, Mediterranean lagoons, and natural history), ecological information (salinity, hydrogeological functioning, ecological interest), issues (global warming and sea level rise related issues, eutrophication, artificialization of the coast, the costs of restoring the lagoons) and a lecture about emblematic species of the study area.

(ii) Economic value (definition of the concept of value, the distinction between use and non-use values and the total economic value), the evolution of the lagoons' management policies (the effects of the management policies, from causes at sectoral scales to ecosystem-based and concerted approaches), frameworks for analyzing interactions between nature and society: DPSIR (drivers, pressures, state, impact and

response model of intervention), ecosystem services and well-being (local well-being assessment frameworks and the contributions of the lagoons to territorial well-being).

The second part of the citizens' workshop consisted of filling out individually a questionnaire focused on ES preference elicitation and questions about general sociodemographic characteristics. Preferences were elicited using the MJ and RESPA methods (see below). There was a section in the questionnaire dedicated specifically to preference elicitation through these two methods. The preference elicitation exercise was done separately for both methods. We chose these methods because we had a long list of twenty ESs to be graded and ranked. Indeed, they were designed in order to avoid long tiresome preference elicitation exercises. The list of the twenty ESs we used, were selected from an original list comprising 31 ESs (see Sy et al., 2018). These twenty ESs were judged as a priority for public policy during a focus group meeting with a diversity of stakeholders of the Palavas lagoons complex area (see Table A in Appendix A for the general definition of the considered ESs).

Groups of participants were formed for the third and fourth parts of the citizens' workshop, representing in total 8 different groups for the three workshops. These groups were asked to achieve consensus rankings for both aggregation procedures. Two of the eight groups were discarded because they did not reach such an agreement. Hence, only the remaining six groups out of eight that successfully engaged in deliberation and reached an agreement were analyzed (see Table 1), representing 31 participants in total. Each group of participants had a different set of sociodemographic characteristics. A show-up fee of fifteen euros was offered to each participant.

Table 1. Characteristics of the analyzed groups of participants

Group	Participants	Age	Gender (%)	Education (%)	Income (%)	Association (%)	Knowledge (%)	Housing (%)
		Mean	Women	Master and up	3 000 euros and up	No	Good	Owner
Group 1	6	56	33	33	67	100	0	83
Group 2	5	50	60	40	40	60	20	40
Group 3	4	59	50	25	25	75	25	50
Group 4	6	41	33	17	67	83	17	67
Group 5	5	64	40	20	60	100	0	100
Group 6	5	53	0	20	40	100	20	80
Total	31	53	35	26	52	87	12	71

Note: The columns "Association", "Knowledge" and "Housing" stand for, respectively, member of a French environmental NGO (law association-1901), the level of knowledge of the Palavas lagoons in terms of familiarity (i.e. acquired through experience) and whether or not the participants own the house she or he is living in the Palavas lagoons area.

The Rapid Ecosystem Services Participatory Appraisal (RESPA)

The preference elicitation exercise using the RESPA method included two main steps. The respondents of each workshop were first asked to select a subset of ESs they considered as important from the original list of the twenty ESs. Then, they ranked the six ESs they judged as the most important from the subset of services using a scale from one to six (1 = High priority, 6 = Not a priority), in the same manner as the Borda count. More precisely in the questionnaire, each respondent had a table (see Table 2) with a list of the considered twenty ESs as the first column where the respondents checked the ESs they judged as important. The last column was used to rank the six most important ESs. The six ESs were ranked relative to each other. Preferences were aggregated by summing up the scores attributed to each ES. Hence, the ranking of the ESs was done based on the associated sums of the scores.

Table 2. Preference elicitation table using the Rapid Ecosystem Services Participatory Appraisal (RESPA) method

ES	Please check the ESs you consider important	Please rank the 6 most important ESs from 1 (High priority) to 6 (Not a priority)
ES1	✓	4
ES2	✓	6
ES3		*NS*
ES4	✓	1
…	…	…

Note: "NS" stands for "Not selected". It is about ESs that were not judged as important and thus not ranked during the preference elicitation process

Majority judgment (MJ)

The principle of MJ is that the respondents explicitly express their opinions on the merit of every ES on a common ordinal scale of measurement, or language of grades, which were in our case: "high priority", "priority", "neutral", "low priority" and "not a priority" (Balinski and Laraki, 2007, 2010, 2017). MJ does not require pairwise comparisons of ESs as every ES is assigned a grade independently to the others. The detailed formulation of the MJ method is presented in Box B (Appendix B). Preferences were elicited using a table (see Table 3) where the ESs were listed in the first column and the grades in the following columns. Each respondent checked the grade she or he attributed to each ES. These grades were then coded in order to facilitate the aggregation of the individually elicited preferences.

Table 3. Preference elicitation table using Majority judgement method

ESs	High Priority	Priority	Neutral	Low Priority	Not a Priority
ES1	✓				
ES2				✓	
...					

The aggregation and ranking processes using MJ consisted first of computing the *majority grade* of each ES (see Balinski and Laraki, 2010, pp. 254-255) attributed by stakeholders. It corresponds to the middlemost or median grade, the number of observations being odd in our case (N = 31). MJ then orders ES according to their majority grade.

A potential difficulty with MJ is to deal with *ex-aequo*. This is simply overcome by using additional and available pieces of information. Intuitively, an ES could be ranked higher than another with the same majority grade if its proportion of grades above the majority grade is larger, or if its proportion of grades below the majority grade is smaller. More formally, the *majority gauge* of an ES is a triplet $(p, \alpha*, q)$, where: (i) p is the number or percentage of the ES's grades above the majority grade and (ii) q is the number or percentage of the ES's grades below the majority grade, (iii) α is the ES's majority grade and $\alpha* = \alpha+$ if $p > q$, $\alpha* = \alpha-$ if $p \leq q$ and $\alpha* = \alpha°$ if $p = q$. Of course $\alpha+$ is better than $\alpha°$, which is better than $\alpha-$.

Overall, considering two ESs: ES1 and ES2 with, respectively, majority gauges $(p, \alpha*, q)$ and $(r, \beta*, s)$. The MJ ranking process places ES1 ahead of ES2when: (i) $\alpha* \succ \beta*$ or, (ii) $\alpha*=\beta*=\alpha+$ and $p>r$ or, (iii) $\alpha*=\beta*=\alpha-$ and $q<s$ or, (iv) $\alpha*=\beta*=\alpha°$ and $p<r$.

In the third part of the session, the lectures were followed by a deliberation process within each group of participants. This process involved a discussion and local knowledge exchange about the relative importance of the listed ESs. Finally in the last step of the session and after the deliberation process, each subgroup of participants agreed collectively on the level of priority of each ES using both MJ and RESPA methods. The same tables filed individually were used (see Table 2 and Table 3). Groups that did not reached a consensus were discarded. Participants were free to ask questions, during the whole process, when in doubt about a particular subject.

2.3. Data analysis

After the workshops, individual preferences issued from the MJ and RESPA methods before deliberation were aggregated both at the level of the ensemble of the 31 participants as well as

for the different groups. In addition, the collective preferences were recorded for each of the six groups of respondents after the deliberation process.

The first step of the data analysis consisted of aggregating individual preferences following the MJ and RESPA methods. Thus, we computed the majority grade (i.e. the median score) associated with each ES in the case of MJ and summed up the scores attributed to each ES in the case of RESPA. Based on these aggregated scores, the ranking of the ESs according to each method was also established. In the second step of the data analysis, for each of the six groups of respondents, we compared the rankings of the ESs obtained before and after deliberation. The comparisons were made by computing the differences between the ranks of the considered ESs. It is important to note that, for each group of respondents, the collective preference generated through the RESPA method contains only six ranks associated to the six ESs that were judged collectively as the most important ones. Therefore, the before and after deliberation comparisons were only reported for these six most important ESs. Likewise, for each group of respondents, we retained only those six ESs in the case of the MJ method. The aim being, for each group of respondents, to simultaneously analyze, according to MJ and RESPA, the differences between the ranks of the retained ESs before and after deliberation. In the following step of the data analysis, we carried out correlation tests between the ranks of the retained ESs issued before and after deliberation using the Kendall Tau-B test. The more the Kendall correlation coefficients are close to 1, the more the differences between the ranks of the retained ESs issued from the before and after deliberation were small.

In the last step, the perception of the participants regarding the deliberative process and the workshops in general were examined. Five variables were used:

(i) The quality of the supplied academic information, the freedom of speech during the deliberation process.
(ii) The composition of the groups (in terms of diversity).
(iii) The complexity of the questionnaire (in terms of understanding).
(iv) The convenience related to the organization of the workshops.
(v) And the satisfaction with the show-up fee.

3. Results

3.1. Aggregation of individual preferences for the ranking of ESs according to MJ and RESPA before deliberation

Table 4 presents the individual preferences aggregation and the ranking of the twenty ESs according to RESPA and MJ. The individual preferences were aggregated based on the scores attributed to the ESs by the 31 respondents retained for this study (see Methods). The results show differences between the rankings of the ESs issued from MJ and RESPA. However, these differences were small. Moreover, we observed a general pattern in the ranking of the ESs. More precisely, for both MJ and RESPA, the top five ESs were all regulation and maintenance services. Likewise, ESs related to relaxation (sentiment of relaxation), cognitive (environmental education and research opportunity) and contemplative activities (recreational hiking and walking, aesthetic value of landscapes; bird watching and aesthetic value of habitats or species) were ranked next in the top twelve, both for MJ and RESPA. Next ranked ESs related to patrimonial (historical sites), symbolic (local identity) and provisioning services (shellfish farming, biomass for grazing and fish resources), again both according MJ and RESPA. Finally, the ESs that were ranked last are those associated with sports (non-motorized water sports) and nature activities (recreational fishing and waterfowl hunting).

Table 4. Aggregation of individual preferences according to MJ and RESPA before deliberation for the whole set of participants (N= 31)

Ecosystem Services	Respa		Majority judgement			
	Sum	Rank	Majority gauge			Rank
			p(%)	*α±*	*q(%)*	
Flooding regulation and protection	134	***1***	*	High priority	0.23	***1***
Water purification	105	***2***	*	High priority	0.32	***2***
Nursery and biodiversity maintenance	74	***3***	*	High priority	0.35	***3***
Microclimate regulation	49	***5***	*	High priority	0.45	***4***
Banks reinforcement	65	***4***	0.48	Priority+	0.06	***5***
Sentiment of relaxation	39	***6***	0.29	Priority+	0.13	***6***
Environmental education	28	***8***	0.26	Priority+	0.19	***7***
Research opportunity	32	***7***	0.16	Priority+	0.13	***8***
Recreational hiking and walking	13	***10***	0.03	Priority-	0.42	***9***
Aesthetic value of landscapes	14	***9***	0.16	Priority-	0.39	***10***
Bird watching	14	***9***	0.13	Priority-	0.39	***11***
Aesthetic value of habitats or species	13	***10***	0.13	Priority-	0.23	***12***
Local identity	9	***11***	0.42	Neutral+	0.16	***13***
Shellfish farming	4	***13***	0.42	Neutral+	0.26	***14***
Historical sites	1	***14***	0.39	Neutral+	0.16	***15***
Biomass for grazing	6	***12***	0.35	Neutral+	0.23	***16***
Fish resources	6	***12***	0.32	Neutral°	0.32	***17***
Non-motorized water sports	*NS*	***NS***	0.03	Neutral-	0.48	***18***
Recreational fishing	*NS*	***NS***	0.03	Neutral-	0.42	***19***
Waterfowl hunting	*NS*	***NS***	0.23	Low priority-	0.45	***20***

Note: The order of presentation of the ESs followed their ranking according MJ, which is slightly different for RESPA . The two-step procedure for RESPA resulted in labelling three ESs as “NS”. This stands for “Not selected” and comprises the ESs that were never preselected as important by any of the 31 respondents in the first step during the RESPA preference elicitation process.

3.2. Differences between the rankings before and after deliberation in the different groups;

Figure 3 presents, for each of the six groups of respondents and both MJ and RESPA, the differences between the rankings of the ESs obtained before and after deliberation for the six retained ESs. These differences indicate the change in ranks when passing from before to after deliberation.

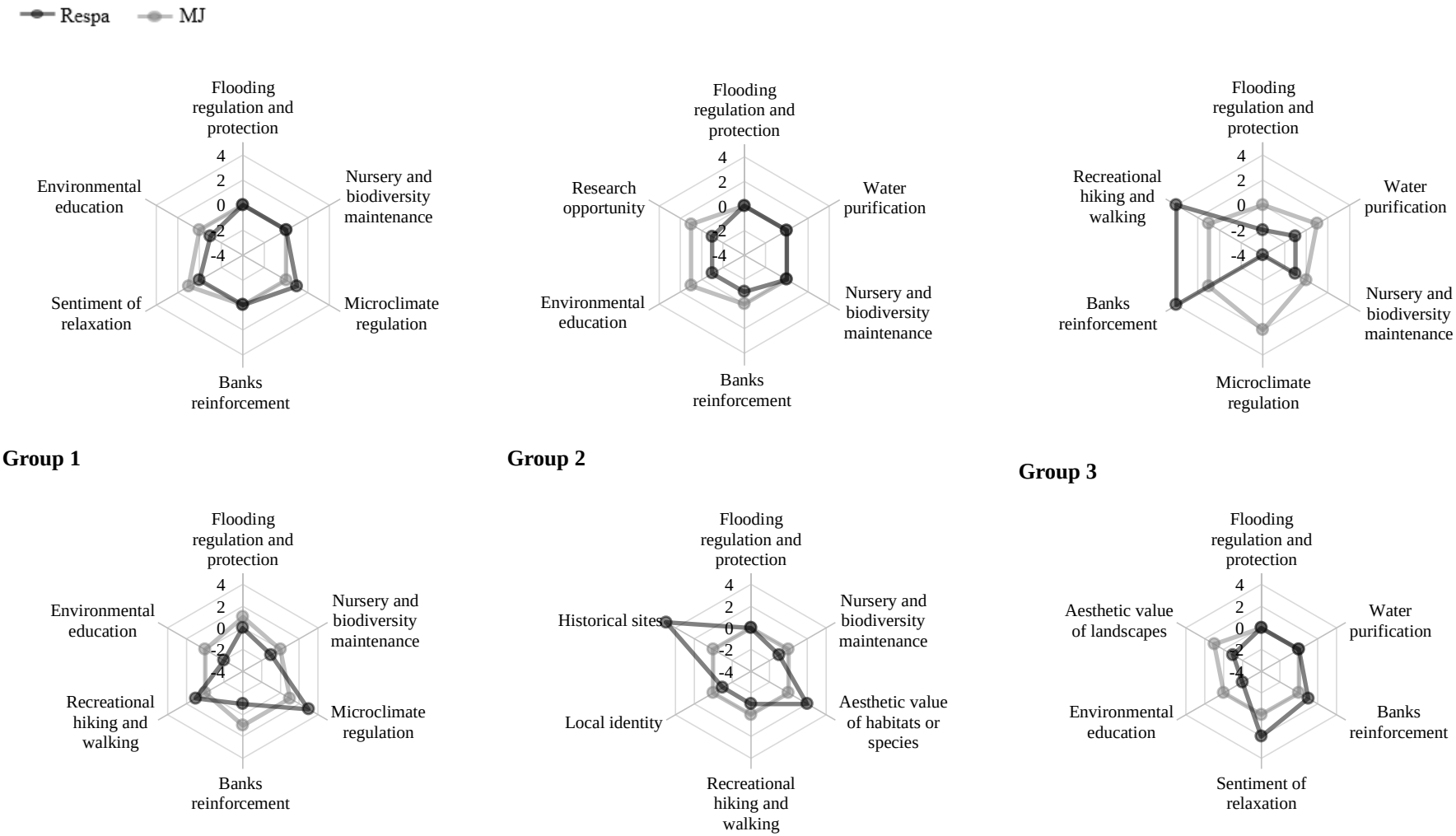

Figure 3. The Ecosystem Services selected as the six most important after deliberation in the six different groups according RESPA. The radar plots indicate the differences in their rankings after deliberation with respect to their rankings before deliberation (based on the aggregation of the individual preferences of the group members) both for the MJ and RESPA aggregation rules. (Note for the radar plots that starting at the top with the ES 'Flooding regulation and protection' selected by all six groups, the selected ESs appear clockwise in the order of their MJ ranking in Table 1)

Overall, we observe, for both MJ and RESPA and for all the six groups of respondents, differences between the ranks of the ESs before and after deliberation (see Figure 3). These differences were relatively smaller for MJ (i.e. closer to zero in Figure 3) than for RESPA. More precisely, in Table 5, the percentages of change in the ranks of the two valuation practices were higher for RESPA than for MJ. Similarly, the correlation coefficients were closer to 1 for MJ than for RESPA, especially for group 3 (0.52 for MJ and -0.33 for RESPA) and group 4 (0.67 for MJ and -0.47 for RESPA).

In addition, for both MJ and RESPA, the differences between the ranks of the ESs before and after deliberation were relatively small for regulation and maintenance services (see Figure 3). Also, we observe that the ESs "Flooding regulation and protection" and "Banks reinforcement" are considered as a priority in terms of conservation by 5 out of the six groups of respondents.

Table 5. Correlation coefficient and percentages of change in the ranking of ESs before and after deliberation in the different groups.

	% of change in ranks		Kendall's Tau-B correlation coefficient	
	MJ	*Respa*	*MJ*	*Respa*
Group 1	17	33	*	0.87
Group 2	33	50	*	0.97
Group 3	67	100	0.52	-0.33
Group 4	50	83	0.67	0.47
Group 5	0	83	1	0.60
Group 6	17	67	0.85	0.60

Note: the correlation coefficients were not generated for group 1 and group 2 (indicated by asterisks) because there was a perfect tie in the collective ranking of all the ESs.

In general, the results show that while the participants were satisfied with the two workshops (see figure 4), they found, however, the questionnaire moderately complex (in average).

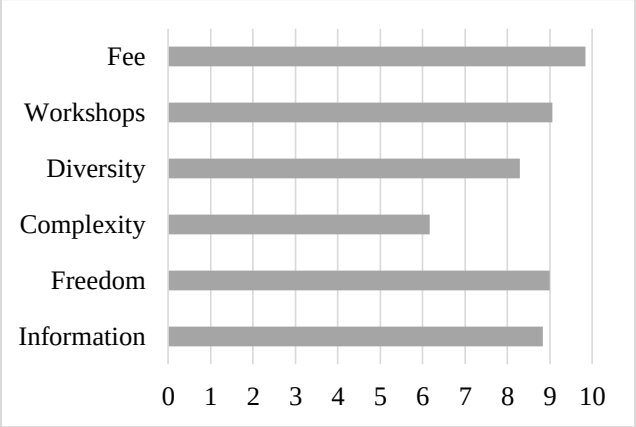

Figure 4: workshops valuation by the participants (averaged).

4. Discussion

4.1. The impact of deliberation differs according to the rules of aggregation used for the preference elicitation

Our before/after deliberation approach allows to study the impact of deliberation on the collective ranking of preferences, but does of course not reveal how the individual opinions by each participant were impacted by the deliberation process. Hence, we clearly observed an impact of deliberation by local citizens on collective preference elicitation of ecosystem services delivered by coastal lagoons. Similar impacts of deliberation on preference elicitation have been observed in other studies (e.g. Howarth and Wilson, 2006; Kaplowitz and Hoehn, 2001; Kenter et al., 2016a, Kenter et al., 2016b; Lo and Spash, 2013; Mavrommati et al., 2017). Nevertheless, while in this respect the impact of aggregation rules has been rarely studied (Murphy et al., 2017) so far, we compared two different aggregation rules, i.e., RESPA and Majority Judgement (MJ); see Methods for details. Remarkably, the differences in the ranking of the ESs before and after deliberation were generally higher for RESPA than for MJ. The differences before and after deliberation also varied among the different groups. Hence, the strongest differences were observed for groups 3 and 4 following RESPA, while in one case the impact of deliberation was null, i.e., group 5 according MJ. For MJ, the impact of deliberation on social ranking was relatively small for the five other groups (see Figure 3 and Table 5).

To explain these remarkable differences between RESPA and MJ, we hypothesize that while MJ was designed for consensus-seeking (Balinski & Laraki, 2007, 2010, 2014, 2017) it would be less susceptible to show changes during the deliberation process. On the other hand, the two-step procedure of RESPA, while it has the advantage of preventing fatigue, also introduces an outlier group that may result in more pronounced variability both among individual preferences as well as among different groups. Hence, we could expect a larger impact of deliberation for RESPA to level out this dispersion among individuals.

4.2. Does deliberation ensure convergence and stability?

It has often been alleged that deliberation produces a convergence of opinion. Several ideas have been forwarded to explain such a convergence of opinions. First of all, it might be explained by a better sharing of the local knowledge of the study site among the participants.

Indeed, we observed that during the debates within the groups more knowledgeable participants shared their local ecological knowledge (see e.g., Narchi et al, 2014) with the other participants (based on notes without using systematic recording). Such a process can lead to creation of so-called collective wisdom, which as such reduces the diversity of opinions as shown by Navajas et al. (2018). In addition, during the deliberation process, there is generally a preliminary phase of information sharing that is as objective as possible with experts offering contrasting arguments. During our citizens' workshops the participants received information from expert of ecological and socio-economic issues, respectively, through small lectures in the first part (Fig. 2) and further exchanged with these experts during the deliberation if they requested more specific information. Moreover, in the specific case of citizen juries, there is the possibility of self-referral among the participants about any lacking information on the subject. Furthermore, for deliberation to be successful it has been underscored that the choice of tools for deliberation processes is of paramount importance (Gasparatos, 2010) and some more ludic approaches can stimulate the participants as they should engage in a collective learning process. Hence, the participants need to possess the specific capabilities, feel comfortable and adapt their tools and methods for such an approach. This is not always the case as one of the groups adopted a voting system for the collective preferences stating that they wanted to go faster than possible by deliberation (one of the two groups not taken into account in our analysis, see Methods section).

These above-mentioned information inputs play an important role in the convergence of positions and constitutes a benchmark for the participants to argue their positions during the debates (Randhur and Shriver, 2009). This multiple information inputs (external and internal to the group) corresponds to the spirit of the contribution of Habermas' deliberation which gives a large place to information sharing with, nevertheless, the risk of a polarization of the exchanges (Hargittai et al., 2007; Lawrence et al., 2010; Wilhelm, 2000).

4.3 Which type of deliberation we need for scientific studies and practical cases?

While this empiric study was based on comparing the collective rankings before and after deliberation with the deliberation backed up by the same explicit aggregation rule, this does often not correspond to the procedures used in practical governance and court cases. For the United States there is an abundant social choice literature focused on court procedures (Iaryczower et al., 2018), while in France it is mainly linked to a strong interest for designing

participatory approaches for public policies. In both cases, it is more common to organize the deliberation prior to the pronouncement of individual or collective preferences. As mentioned in the introduction it is assumed that preferences are often constructed during discussions (Spash, 2007) as it relies on information sharing among participants (Lienhoop et al., 2015). Hence, the popular juries in court cases typically represents the case where deliberation precedes individual pronouncements, while the final decision of the court is then based on voting. If the objective is studying how the individual preferences are influenced by deliberation, it is needed to complement our approach with an additional gathering of individual preferences after the deliberation. Participative approaches for public policies often use deliberation prior to seeking a consensus that should represent a collective preference elicitation or ranking. The theory of public choice is thus very useful to study the value of argued and balanced debates beyond simple votes (Davis R., 1999; Delli Carpini et al., 2004; Talpin, 2013).

These results are encouraging for an interdisciplinary rapprochement of ecological economics based on social choice both with sociology and political sciences, with the aim to study participatory approaches in public policies. These public policies are very much dependent on the local context and many of the problems related to the management of ecosystems and their associated ESs have to be dealt with at the local scale by decentralized governance. Nevertheless, to the best of our knowledge the currently used participatory approaches in France have not yet directly addressed the ESs, but rather focus on spatial planning and hydrological measures. Hence, the implementation of participatory approaches for public policies would be better accepted by increased understanding of the deliberative process and the impact of the different aggregation rules, e.g. as those studied here (RESPA, MJ). Following our observation of a smaller impact of deliberation for MJ, one could argue that adoption of MJ aggregation of individual preferences would allow to pursue the participative process without deliberation. However, MJ shows the problem of *ex-aequo* and is more susceptible to fatigue then RESPA, which, in addition, has the advantage to produce highly standardized results that can be more easily compared among groups (see e.g. Fig. 3). Furthermore, the idea of participative approaches is to improve the quality and transparency of the decision process with the aim to achieve negotiated solutions (Madani et al., 2015). Finally, the important role of information supply during participatory approaches needs to be highlighted as this may result in raising awareness and willingness to participate in discussions not only for the highly-involved stakeholders. Restricting the participatory

approach to the latter group should be prevented as this creates a group of new experts with a restricted diversity of points of view.

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(i) Appendix

Appendix A: the list of the ecosystem services used in the study

Table A. The set of the twenty ecosystem services (ESs) used in this study. The ESs have been selected following (Sy et al., 2018) and categorized according to the classification designed for coastal and marine ESs by Liquete et al. (2013) and currently included in CICES version 5.1 (Haines-Young and Potschin, 2018).

ES category	ES subcategory	Ecosystem services	General definition
Provisioning	Food provision	Biomass for grazing Shellfish farming Fish resources	The provision of biomass for human consumption and the conditions to grow it. It mostly relates to cropping, animal husbandry and fisheries.
Regulation and maintenance	Water provision	Water purification capacity	Biochemical and physicochemical processes involved in the removal of wastes and pollutants from the aquatic environment.
	Coastal protection	Flooding and other extreme events regulation and protection Banks reinforcement	Protection against floods, droughts, hurricanes, erosion and other extreme events.
	Climate regulation	Microclimate regulation	Regulation of greenhouse and climate active gases. The most common proxies are the uptake, storage and sequestration of carbon dioxide.
	Life cycle maintenance	Nursery and biodiversity maintenance	Biological and physical support to facilitate the healthy and diverse reproduction of species.
Cultural services	Symbolic and aesthetic values	Aesthetic value of landscapes Local identity Aesthetic value of habitats or species Historical sites	Heritage and aesthetic values of the natural environment.
	Recreation and tourism	Non-motorized water sport Bird watching Waterfowl hunting Sentiment of relaxation Recreational hiking and walking Recreational fishing	Opportunities that the natural environment provide for relaxation and amusement.
	Cognitive effects	Research opportunity Environmental education	Trigger of mental processes like knowing, developing, perceiving, or being aware resulting from natural landscapes or living organisms.

Appendix B

Box B: Formulation of the Majority judgement method

Consider a set of a finite number of ecosystem services $S = \{SE_1, \dots, SE_m\}$; a finite number of voters $V = \{1, \dots, n\}$; and a common language of grades $\Lambda = \{\alpha, \beta, \gamma, \dots\}$ which is a totally ordered set. The grades or words are "absolute" (Balinski and Laraki, 2014) in the sense that every voter uses them to measure the level of priority of each ES independently.

The *matrix of inputs* is formulated as:

$$\varphi = [\alpha_{11} \cdots \alpha_{1m} \vdots \ddots \vdots \alpha_{n1} \cdots \alpha_{nm}]$$

Where $\alpha_{ij} = \varphi(ES_i, v) \in \Lambda$ is the grade assigned by voter $v \in V$ to $ES_i \in S$.

The *majority grade* attributed to an ES by all the voters correspond to its middlemost or median grade when n is odd and its lower middlemost when n is even (Balinski and Laraki, 2014).

Suppose an ES majority grade is α^*, and that $p\%$ of his grades are higher than α^* and $q\%$ are lower. Then its *majority gauge* is (p, α^*, q), where $p > q$ implies α^* is endowed with a "+", and otherwise it is endowed with a "-"(Balinski and Laraki, 2010, 2014). It is formulated as follow:

$$\alpha^* = \{\alpha^+ \ if \ p > q, \alpha^- \ if \ p \leq q\}$$

The majority gauge (p, α^*, q) determine the *majority-gauge-ranking* of ESs.

Consider two ESs ES_1 and ES_2 with majority gauges (p, α^*, q) and (r, β^*, s), respectively. The majority-gauge-ranking "$\succ_{mg}$" places ES_1 ahead of ES_2, $ES_1 \succ_{mg} ES_2$, or (p, α^*, q) ahead of (r, β^*, s), $(p, \alpha^*, q) \succ_{mg} (r, \beta^*, s)$ when:

- $\alpha^* \succ \beta^*$, or
- $\alpha^* = \beta^* = \alpha^+$ and $p > r$, or
- $\alpha^* = \beta^* = \alpha^\circ$ and $p < r$
- $\alpha^* = \beta^* = \alpha^-$ and $q < s$.

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