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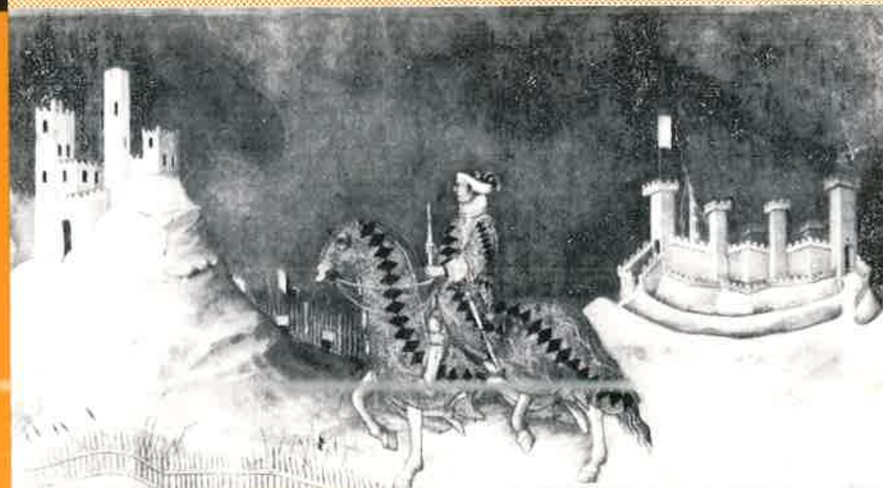
THE ARITHMETIC MEAN IS MILDLY STRATEGY-PROOF



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Stefano Vannucci

THE ARITHMETIC MEAN IS MILDLY STRATEGY-PROOF

ABSTRACT. A mild notion of strategy-proofness for probabilistic social aggregation rules which is based upon a suitable parameterized dissimilarity coefficient is proposed. It is shown that the arithmetic mean - also known as proportional lottery method or (uniform) random dictatorship in the voting literature- is individually but not coalitionally strategy-proof.

KEY WORDS: Proportional lottery, dissimilarity coefficient, strategy-proofness.

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1. Introduction.

Consider a n-person committee whose task is to provide an opinion on a given issue - i.e. a probability distribution on a certain sample space - by aggregating the individual opinions according to a well-defined procedure, while its members entertain deeply entrenched and different views concerning the "right" distribution. Can manipulation on the part of the members of the committee be prevented in a non-trivial manner?

A similar problem obtains if a population of probabilistic choosers are asked to submit estimates of their own choice probabilities on a given outcome set. Those estimates are to be aggregated according to a publicly known procedure in order to determine a social lottery on outcomes. What does "manipulation" mean in that setting ? Can it be prevented without renouncing the most widely accepted principles of nice aggregation ?

Thus, strategy-proofness requirements can be apparently of considerable significance both in opinion pooling problems and in probabilistic social choice. However, in the large body of literature on axiomatic opinion pooling (see e.g. Lehrer,Wagner(1981), Aczel,Ng,Wagner(1984), Rubinstein,Fishburn(1986), Wagner(1989)) the manipulability aspect of the aggregation problem is virtually ignored. Of course, the possibility of escaping the ubiquitous manipulation problem by using social choice lotteries has been largely explored in the game-theoretically oriented social choice literature, but this is done under the typical assumption of deterministic individual preferences and voting behaviour. In this setting, relatively straightforward notions of strategy-proofness are indeed available. The main suggestion of this literature is that the proportional lottery method -also called (uniform) random dictatorship- deserves special credit as the unique nicely symmetric, ex-post Pareto efficient and strategy-proof decision scheme (see e.g. Barbera'(1978)). By contrast, the polar case of probabilistic individual choices has been much less extensively studied (the rather few exceptions include Intriligator(1973), Nitzan(1975), Fishburn,Gehrlein(1977), Marley(1991), Clark (1992)) . Moreover, the emphasis of this literature is on Arrowian criteria as opposed to strategy-proofness requirements. In our opinion, it is by no chance that this is the case. In fact, there is - again - no obvious meaning of "strategy-proofness" when the individual attitudes towards the alternatives are represented by probabilistic choices, as opposed to deterministic preferences.

In this note, we shall treat manipulation under opinion pooling and manipulation under probabilistic social choice as isomorphic problems, without even attempting to distinguish between them. Then we try and define a suitable mild-looking notion of strategy-proofness for probabilistic social aggregation rules. The proposed notion is based upon a certain dissimilarity coefficient. The main result of this paper consists in showing that the proportional lottery method is the only nice aggregation rule which is individually (though not coalitionally) strategy-proof in that sense.

2. Definitions and results.

Let $N=\{1,..,n\}$ be the nonempty finite set of agents, and X the set of outcomes. We assume that $\#X \geq 3$. The attitude of any agent $i \in N$ towards the outcomes is represented by a probabilistic choice, i.e. a probability distribution p_i on X, where for any $x \in X$ $p_i(x)$ denotes the probability of i choosing x . A profile of probabilistic choices is a map $p: N \longrightarrow \mathcal{P}(X)$ where $\mathcal{P}(X)$ denotes the set of all probability distributions on X. The set of all profiles of probabilistic choices for (N,X) will be denoted by $\mathcal{P}^n(X)$. A **probabilistic social aggregation rule (PSAR)** for (N,X) is a map $F: \mathcal{P}^n(X) \longrightarrow \mathcal{P}(X)$. The following properties for PSARs are standard in the relevant literature (see e.g. Intriligator(1973), Lehrer,Wagner(1981), Aczel,Ng,Wagner(1984), Rubinstein,Fishburn(1986), Barrett,Pattanaik(1987), Aczel,Roberts(1989)).

α-Unanimity (α-UN) (where $\alpha \in [0,1]$): a PSAR F satisfies α-UN iff for any profile $p \in \mathcal{P}^n(X)$ and $x \in X$ if $p_i(\{x\})=p_j(\{x\})=\alpha$ for any $i,j \in N$ then $[F(p)](\{x\})=\alpha$.

Unanimity (UN) : a PSAR F satisfies UN iff it satisfies α-UN for any $\alpha \in [0,1]$.

Weak Unanimity (WUN): a PSAR F satisfies WUN iff for any $p \in \mathcal{P}^n(X)$, if $p_i=p_j=p$ for any $i,j \in N$ then $F(p\ )=p$.

Anonymity (AN) : a PSAR F satisfies AN iff for any permutation σ of N, and any profile $p \in \mathcal{P}^n(X)$ $F(p_\sigma)=F(p)$ (where $p_\sigma=(p_{\sigma(1)},..,p_{\sigma(n)})$) .

Neutrality (NT) : a PSAR F satisfies NT iff for any permutation π of X, and any profile $p \in \mathcal{P}^n(X)$: $\pi(F(p))=F(\pi p)$, (where $\pi p(\{x\})=p(\{\pi(x)\})$, and $\pi(p_1,..,p_n)=(\pi p_1,..,\pi p_n)$).

Independence (IND) : a PSAR F satisfies IND iff for any $x \in X$ and any $p,q \in \mathcal{P}^n(X)$: $p_i(\{x\})=q_i(\{x\})$ for all $i \in N$ implies $[F(p)](\{x\})=[F(q)](\{x\})$.

Monotonicity (MON) : a PSAR F satisfies MON iff for any $x \in X$ and any $p,q \in \mathcal{P}^n(X)$: $p_i(\{x\}) \geq q_i(\{x\})$ for all $i \in N$ implies $[F(p)](\{x\}) \geq [F(q)](\{x\})$.

Strict Monotonicity (SMON) : a PSAR F satisfies SMON iff for any $x \in X$ and any $p,q \in \mathcal{P}^n(X)$: if for all $i \in N$, $p_i(\{x\}) \geq q_i(\{x\})$ and for some $j \in N$, $p_j(\{x\})>q_j(\{x\})$, then $[F(p)](\{x\})>[F(q)](\{x\})$.

Extended versions of IND,MON and SMON, denoted by **IND***, **MON*** and **SMON***, respectively, obtain by requiring that the last two conditions hold when replacing $\{x\}$ with any $Y \subseteq X$. IND* may be interpreted as a requirement against trivial opinion (agenda) manipulation. Indeed, IND* can also be given an equivalent formulation in terms of a requirement with an explicitly "strategic" flavour which has been used by several authors in the literature on surplus sharing methods (see e.g. Chun(1988)), namely :

No Advantageous Reallocation (NAR) : a PSAR F satisfies NAR iff for any $Y \subseteq X$, $i \in N$, $p'_i \in \mathcal{P}(X)$ and $p \in \mathcal{P}^n(X)$ s.t. $p_i(Y)=p'_i(Y)$, $[F(p)](Y)=[F(p_{-i},p'_i)](Y)$.

A prominent PSAR is the simple (arithmetic) mean M , also denoted in the voting literature as (uniformly) random dictatorship or **proportional lottery method** (PRLO), which chooses according to a lottery that assigns to every alternative the average of its individual choice probabilities, i.e. for any $p \in \mathcal{P}^n(X)$, and any $x \in X$:

$$(M(p))(\{x\})=\frac{1}{n}\sum_{1}^{n} p_i(\{x\}) .$$

Obviously enough, PRLO satisfies all the properties mentioned above. In fact, several alternative characterizations of PRLO with a finite X have been obtained by means of the properties listed above, starting with Intriligator(1973) who characterizes PRLO within the class of differentiable PSARs by 0-UN and a property (labelled "Strict and Equal Sensitivity to Individual Probabilities") which amounts to a combination of AN,IND and SMON. More recently, a generalized (i.e. weighted) version of PRLO - viewed as an aggregation method for probability judgments - has been characterized by 0-UN,IND (see e.g. Lehrer,Wagner(1981); Aczel,Ng,Wagner(1984) and Wagner(1989) provide several extensions of this characterization, while McConway(1981) offers a similar characterization of PRLO in a different framework allowing for infinite X and varying σ-algebras on X). Moreover, weighted PRLO has also been characterized by both WUN,MON and - within the class of continuous PSARs - WUN,IND (see Rubinstein,Fishburn(1986) as supplemented by the observations included in Barrett,Pattanaik(1987)). These results are summarized by the following proposition.

Proposition 1. Let X be a finite set s.t. $\#X \geq 3$ and $F:\mathcal{P}^n(X) \longrightarrow \mathcal{P}(X)$ a PSAR. Then

i) (Aczel,Ng,Wagner(1984)): F is PRLO iff a $\alpha \in [0,1]$, $\alpha \neq 1/n$ exists s.t. F satisfies α-UN,AN,IND.

ii) (Rubinstein,Fishburn(1986)): F is PRLO iff it satisfies WUN,AN,MON.

iii) (Rubinstein,Fishburn(1986)): if F is continuous then F is PRLO iff it satisfies WUN,AN,IND.

iv) F is PRLO iff it satisfies WUN,AN,NAR .

Remark 1. It should be noticed that MON implies IND, while IND plus 0-UN imply NT(see e.g. Lehrer,Wagner(1981)).Indeed, since AN,NT are the standard symmetry properties for a PSAR, 0-UN can be seen as the relevant Pareto efficiency criterion and IND* is a most natural translate for PSARs of Arrow's "independence of irrelevant alternatives" for preference-ordering aggregation rules, it could be claimed that PRLO is the legitimate solution of the voting paradox in a fully stochastic framework

(as a matter of fact, this is the interpretation that is suggested by Intriligator(1973) for his own result mentioned above). Similar claims are made by Nitzan(1975) in a setting with an infinite alternative space X and individual probabilistic choices representing Euclidean deterministic preferences, and by Clark(1992) who works with a finite model which allows the interpretation of probabilistic choices as the outcomes of random individual preference maximization .

A closer inspection of the relevant proofs shows that the cardinality of the range of the involved PSAR is inconsequential. Hence Proposition 1 can be slightly extended as follows.

Proposition 1bis . Let X be a finite set s.t. $\#X \geq 3$, $k \geq 2$ a positive integer, $\mathcal{P}_k(X)$ the set of probability measures on X assuming at most k distinct values, and F: $\mathcal{P}^n{}_k(X) \rightarrow \mathcal{P}(X)$ a restricted PSAR . Then the following statements are equivalent:

i) F is PRLO ;

ii) Some $\alpha \in [0,1]$, $\alpha \neq 1/n$ exists s.t. F satisfies α-UN, AN, IND;

iii) F satisfies WUN, AN, MON;

iv) F is continuous and satisfies WUN, AN, IND;

v) F satisfies WUN, AN, NAR.

As mentioned in the introduction, the results summarized by Proposition 1 suggest the following related issue : is PRLO strategy-proof as well? Of course, this issue is meaningless unless an explicit definition of "strategy-proofness" (or "nonmanipulability") for PSARs is provided. In fact, when the individual assessments of outcomes consist in (deterministic) preference relations and the social outcome is a lottery, a natural notion of strategy-proofness is available. Moreover, PRLO turns out to be the unique "nice" (i.e. symmetric and ex-post Pareto-efficient) method which is strategy-proof in that sense (see Barbera'(1978); see also Pattanaik,Peleg(1986) which - under the supplementary hypothesis that $\#X \geq 4$ - provides a characterization of PRLO in the same setting by combining ex-post Pareto efficiency, a choice-consistency requirement and a version of Arrow's independence of irrelevant alternatives, and Fishburn,Gehrlein(1977) for a characterization of PRLO in a world of two alternatives by means of UN and a "faithfulness" property requiring that the win probability of an alternative with average choice probability greater than 1/2 be greater than 1/2). However, in our PSAR case the attitude of the agents towards the outcomes is represented by probabilistic beliefs or choices as opposed to preference orderings. Hence, no obvious candidate definition of "strategy-proofness" is at hand. Some notion of preference for opinions or probabilistic choices has to be introduced.

We suggest the following general approach based upon dissimilarity coefficients.

Definition . A **dissimilarity coefficient** on a set Y is a function d: $Y \times Y \rightarrow [0,\infty]$ s.t. : i) for any $x,y \in Y$, $d(x,y)=d(y,x)$ and ii) for any $x \in Y$, $d(x,x)=0$.

Preferences on opinions (or probabilistic choices) can be defined in a natural manner as follows: i) take the true opinion (probabilistic choice) p_i of agent $i \in N$ as an "ideal point" for i in the space $\mathcal{P}(X)$ of possible opinions (probabilistic choices); then ii) define a suitable (parametric) dissimilarity coefficient d(p) on $\mathcal{P}(X)$, with $\mathcal{P}(X)$ itself as the set of parameters (d(p) may but need not be a metric). Finally, iii) take opinion (probabilistic choice) q to be preferred to opinion (probabilistic choice) r by i at p_i - to be written $(q,r) \in \succeq(d(p_i))$ - iff $(d(p_i))(q,p_i) \leq (d(p_i))(r,p_i)$.

We are now ready to introduce a suitable notion of strategy-proofness for PSARs .

Definition . Let F: $\mathcal{P}^n(X) \rightarrow \mathcal{P}(X)$ be a PSAR , and $d:\mathcal{P}^3(X) \rightarrow \mathcal{P}(X)$ a parametric dissimilarity coefficient on $\mathcal{P}(X)$. F is **strategy-proof w.r.t. d** (or **d-strategy-proof**) iff for any $i \in N$, and any **p**, **q** $\in \mathcal{P}^n(X)$:

$$(F(p_i, q_{-i}), F(q)) \in \succeq(d(p_i)) .$$

To be sure, the definition above provides an entire family of notions of strategy-proofness depending on the choice of d. It may be tempting to insist that d should be a fixed metric, in which case using the Euclidean distance δ^E is the most obvious choice. It is easily checked that PRLO is **not** strategy-proof w.r.t. δ^E, as the following simple example explicitly shows:

Example. Let $N=\{1,2,3,4\}$, $X=\{x,y,z\}$, $p_1(x)=p_1(z)=\frac{1}{2}$, $p_1(y)=0$, and $p_2=p_3=p_4=p^*$, with $p^*(x)=p^*(y)=0$, $p^*(z)=1$. Also, let $q \in \mathcal{P}(X)$ be s.t. $q(x)=\frac{3}{4}$, $q(y)=0$, $q(z)=\frac{1}{4}$. Then $\delta^E($ M(**p**), $p_1)=$ $\delta^E\left(\left(\frac{1}{8},0,\frac{7}{8}\right), p_1\right) = \left(\frac{9}{32}\right)^{1/2}$, whereas $\delta^E($ M($\mathbf{p}_{-1}$, q), $p_1))=\delta^E\left(\left(\frac{3}{16},0,\frac{13}{16}\right), p_1\right)= \left(\frac{25}{128}\right)^{1/2} < \left(\frac{9}{32}\right)^{1/2}$. It follows that F is δ^E- manipulable by i at **p** , i.e. F is not strategy-proof w.r.t. δ^E.

Let us then turn to an alternative choice of the (parameterized) dissimilarity coefficient d. Indeed, let us suppose that the support of an opinion (probabilistic choice) is what really matters for the typical agent. Of course, this amounts to assuming that any agent perceives her own opinion (probabilistic choice) as resting upon an essentially binary distinction between possible versus impossible events (acceptable versus not acceptable alternatives). In that case, the most natural way to assess the dissimilarity between two opinions (probabilistic choices) q,r from the perspective of a certain fixed opinion (probabilistic choice) p consists in measuring the difference between the probability masses that q and r assign to p's support. Therefore the following definition obtains:

Definition . Let $p,q,r \in \mathcal{P}(X)$. Then $(d^*(p))(q,r)= \mid q(\text{supp } p) - r(\text{supp } p) \mid$ (where $\text{supp } p =\{ x \in X: p(x)>0 \}$).

Remark 2 . It is easily seen that for any $p,q,r \in \mathcal{P}(X)$: i) $(d^*(p))(q,q)=0$, and ii) $(d^*(p))(q,r)=(d^*(p))(r,q)$, i.e. $d^*(p)$ is indeed a dissimilarity coefficient .

We are now ready to state the following result concerning PRL0's strategic properties in a fully stochastic framework.

Proposition 2. PRLO is d^*-strategy-proof .

Since PRLO satisfies MON*, the proof of Proposition 2 follows immediately from the following lemma.

Lemma . Any PSAR F which satisfies MON* is d^*-strategy-proof .

Proof. Let F satisfy MON*. Hence, for any $Y \subseteq X$, $i \in N$, $q_i \in \mathcal{P}(X)$ and $p \in \mathcal{P}^n(X)$, if $p_i(Y) \geq q_i(Y)$, then $(F(p))(Y) \geq (F(p_{-i},q_i))(Y)$. In particular, since $p_i(\text{supp } p_i)=1$, it follows that $(F(p))(\text{supp } p_i) \geq (F(p_{-i},q_i))(\text{supp } p_i)$. Thus, $\mid 1 - (F(p))(\text{supp } p_i) \mid \leq \mid 1 - (F(p_{-i},q_i))(\text{supp } p_i) \mid$. As a result, $(F(p),F(p_{-i},q_i)) \in \succeq (d^*(p_i))$. □

Corollary. PRLO is the unique PSAR which satisfies AN,UN,IND and is d^*-strategy-proof.

Remark 3. The foregoing Corollary amounts to a strong possibility result for opinion pooling and probabilistic social choice which is to be contrasted with both Arrow's and Gibbard-Satterthwaite's well-known impossibility theorems .

The encouraging positive result presented above might perhaps suggest a possibile extension of Proposition 2 to **coalitional strategy-proofness** as defined below :

Definition. Let F be a PSAR for (N,X) and d a (parameterized) dissimilarity coefficient on $\mathcal{P}(X)$. Then F is **coalitionally d-strategy-proof** iff for any $S \subseteq N$, $Y \subseteq X$, $p \in \mathcal{P}^n(X)$, $q^S \in \mathcal{P}^{\#S}(X)$, an $i \in S$ exists s.t.

$$(F(p), F(p^{N \setminus S}, q^S)) \in \succ (d(p_i)) ,$$

(where $\succ (d(p_i))$ is the asymmetric component of $\succeq (d(p_i))$).

Unfortunately, the following negative result obtains :

Proposition 3. PRLO is not coalitionally d^*-strategy-proof.

Proof. The proof of Proposition 3 consists in a simple counterexample. Let $N=\{1,2,3\}$, $X=\{x,y,w,z\}$, $p=\{p_1,p_2,p_3\} \in \mathcal{P}^3(X)$ where $p_1(x)=p_1(y)=0$, $p_1(w)=p_1(z)=1/2$, $p_2(x)=p_2(z)=0$, $p_2(y)=p_2(w)=1/2$, $p_3(x)=1$, $p_3(y)=p_3(w)=p_3(z)=0$, and $q \in \mathcal{P}(X)$ with $q(x)=q(y)=q(z)=0$, $q(w)=1$. Then,

$$(M(p))(\text{supp } p_1)= (M(p))(\text{supp } p_2)=1/2, \text{ while}$$
$$(M((q,q,p_3)))(\text{supp } p_1)=(M((q,q,p_3)))(\text{supp } p_2)= 2/3 .$$

Therefore, $(M(q,q,p_3), M(p)) \in \succeq (d^*(p_1)) \bigcap \succeq (d^*(p_2))$. □

Corollary 2. There is no coalitionally d^*-strategy proof PSAR which satisfies AN, WUN, IND .

Remark 4. Corollary 2 supplements some well-known negative results concerning coalitional strategy-proofness of probabilistic social choice methods under deterministic voting as presented in Barbera'(1979) (see also Dutta(1980)). It establishes that even in a fully stochastic framework with a mild-looking notion of strategy-proofness the requirement of robustness against **coalitional** - as opposed to individual - manipulation is too exacting for nicely simmetric and efficient aggregation methods.

Conclusions

The manipulability of probabilistic social aggregation rules (PSARs) has been explored to some extent. In view of the characterization results surveyed above, the arithmetic mean (or proportional lottery) is the only feasible "strategy-proof" candidate among nice PSARs. An entire family of possible "strategy-proofness" criteria has been proposed, relying on suitably defined dissimilarity coefficients. It has been shown that - if one insists upon the usual Euclidean metric - then no nice nonmanipulable PSAR exists. If, however, a different specification is chosen for the dissimilarity coefficients by assuming essentially **binary** opinions (or probabilistic choices) then the arithmetic mean (or proportional lottery) turns out to be individually - though not coalitionally - strategy -proof.

References

ACZEL J., T.G. NG, C.G. WAGNER (1984) : Aggregation Theorems for Allocation Problems . S.I.A.M. Journal of Algebraic and Discrete Methods 5, 1-8 .

ACZEL J., F.S. ROBERTS (1989) : On the Possible Merging Functions . Mathematical Social Sciences 17, 205-243 .

BARBERA' S. (1978) : Nice Decision Schemes , in *H.W. Gottinger, W.Leinfellner (eds.) : Decision Theory and Social Ethics.* Dordrecht: D. Reidel .

BARBERA' S. (1979) : A Note on Group Strategy-Proof Decision Schemes . Econometrica 47, 637-640.

BARRETT C.R., P.K. PATTANAIK (1987) : Aggregation of Probability Judgments. Econometrica 55, 1237-1241.

CHUN Y. (1988) : The Proportional Solution for Rights Problems. Mathematical Social Sciences 15, 231-246.

CLARK S.A. (1992) : The Representative Agent Model of Probabilistic Social Choice. Mathematical Social Sciences 23, 45-66.

DUTTA B. (1980) : Strategic Voting in a Probabilistic Framework. Econometrica 48, 447-456.

FISHBURN P.C., W.V. GEHRLEIN (1977) : Towards a Theory of Elections with Probabilistic Preferences. Econometrica 45, 1907-1924.

INTRILIGATOR M.D. (1973) : A Probabilistic Model of Social Choice. Review of Economic Studies 40, 553-560.

LEHRER K., C.G. WAGNER (1981) : *Rational Consensus in Science and Society.* Dordrecht: D. Reidel.

MARLEY A.A.J. (1991) : Aggregation Theorems and Multidimensional Stochastic Choice Models. Theory and Decision 30, 245-272.

McCONWAY K.J. (1981) : Marginalization and Linear Opinion Pools . Journal of the American Statistical Association 76, 410-414 .

NITZAN S. (1975) : Social Preference Ordering in a Probabilistic Voting Model. Public Choice 24, 93-100.

PATTANAIK P.K. , B. PELEG (1986) : Distribution of Power Under Stochastic Social Choice Rules. Econometrica 54, 909-921.

RUBINSTEIN A., P.C. FISHBURN (1986) : Algebraic Aggregation Theory. Journal of Economic Theory 38, 63-77.

WAGNER C.G. (1989) : Consensus for Belief Functions and Related Uncertainty Measures. Theory and Decision 26, 295-304.

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