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How many laypeople holding a popular opinion are needed to counter an expert opinion?

Jos Hornikx[a], Adam J. L. Harris[b] and Jordy Boekema[a]

[a]Centre for Language Studies, Communication and Information Studies, Radboud University Nijmegen, Nijmegen, The Netherlands; [b]Department of Experimental Psychology, University College London, London, UK

ABSTRACT
In everyday situations, people regularly receive information from large groups of (lay) people and from single experts. Although lay opinions and expert opinions have been studied extensively in isolation, the present study examined the relationship between the two by asking how many laypeople are needed to counter an expert opinion. A Bayesian formalisation allowed the prescription of this quantity. Participants were subsequently asked to assess how many laypeople are needed in different situations. The results demonstrate that people are sensitive to the relevant factors identified for determining how many lay opinions are required to counteract a single expert opinion. People's assessments were fairly good in line with Bayesian predictions.

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KEYWORDS Expert opinion; popular opinion; Bayesian argumentation

On 23 June 2016, the British electorate voted to leave the European Union – so-called "Brexit". This was despite the majority of political experts recommending that the country remain in the European Union, exemplified by 479 MPs declaring their support to remain in the European Union by 22 June, whilst only 158 supported Brexit (http://www.bbc.co.uk/news/uk-politics-eu-referendum-35616946). In contrast, the electorate voted to leave the European Union by 17,410,742 votes to 16,141,241 (http://www.bbc.co.uk/news/politics/eu_referendum/results). The next step in the process was a parliamentary vote. For rhetorical purposes, consider that a member of parliament (MP) had wanted to vote on the basis of what is in the best interests of the country. How should a public majority of 1.3 million be weighed against a majority of 321 MPs? Is the layperson majority large enough to outweigh the expert majority? In the current paper, we present a formal framework outlining how such a question can be answered and subsequently demonstrate

CONTACT Jos Hornikx j.hornikx@let.ru.nl

that people are sensitive to the relevant factors identified for determining how many lay opinions are required to counteract a single expert opinion.

Source-based appeals

The relationship between lay and expert opinions is surprisingly hidden in the literature, partly because the concepts of expertise and lay consensus are frequently considered separately. In argumentation research, for example, the influence of lay opinions comes under the heading of "appeals from popular opinion" (Godden, 2008; Walton, 1999; Wreen, 1993), whilst expert opinions are considered as "appeals to expert opinion" (Walton, 1997). In the scheme-based approach to argumentation, both are considered source-based arguments (Walton, Reed, & Macagno, 2008), and both, with a few exceptions (e.g., Wreen, 1993), are seen as fallacious argument forms (Godden, 2008; Van Eemeren, Garssen, & Meuffels, 2009; Walton et al., 2008). When the two arguments are discussed together, the differences between the two types of argument are stressed (Walton, 1999, p. 56–60). What, then, are the characteristics of these types of arguments?

The appeal to popular opinion – the "ad populum" argument – refers to the general opinion of a large group of people, which is used to support the truth or falsity of a hypothesis (Walton, 1999, p. 200):

Everybody (in a particular reference group, *G*) accepts A.
Therefore, *A* is true (or you should accept *A*).
Everybody (in a particular reference group, *G*) rejects A.
Therefore, *A* is false (or you should reject *A*).

In the scheme-based approach to argumentation, there is a unique description of each type of argument, accompanied by so-called critical questions (CQs) which help to determine whether a given argument of this type is presumptively valid. For the appeal to popular opinion, there are three CQs (Table 1; Walton, 1989).

The appeal to expert opinion or the appeal to authority (for which there are six question to evaluate it; see Table 1) refers to the opinion of a knowledgeable person (Walton, 1997; Walton et al., 2008, p. 14):

Source *E* is an expert in subject domain *S* containing proposition *A*
E asserts that proposition *A* (in domain *S*) is true (false)
A may plausibly be taken to be true (false).

As can be seen in Table 1, there is no overlap at all between the CQs associated with the appeal to popular opinion and those associated with the expert opinion, suggesting that the two argument types are seen as completely separate on the scheme-based approach. Finally, Walton (1999, p. 224; see also Walton et al., 2008) distinguishes a subtype of the appeal to popular opinion

Table 1. Critical questions for the evaluation of the appeal to popular opinion and the appeal to expert opinion.

Appeal to popular opinion (Walton, 1989, p. 89)	Appeal to expert opinion (Walton, 1997, p. 223)
Does a large majority of the cited reference group accept A as true?	How credible is E as an expert source?
Is there other relevant evidence available that would support the assumption that A is not true?	Is E an expert in the field that A is in?
What reason is there for thinking that the view of this large majority is likely to be right?	What did E assert that implies A?
	Is E personally reliable as a source?
	Is A consistent with what other experts assert?
	Is E's assertion based on evidence?

that combines the two: the "expert-opinion ad populum" argument. No CQs are provided for this type of argument, making it difficult to assess how this type of argument is precisely positioned between the other types of argument. Should one, for example, use the CQs for the appeal to expert opinion or popular opinion, or some (as yet unspecified) combination to evaluate the following argument?

Everybody in this group *G* accepts *A*.

G is a group of experts in a domain of knowledge.

Therefore, *A* is true.

Appealing to the opinion of large groups, or to the opinion of an expert, has attracted considerable research attention in social psychology (for a more formal treatment, see e.g., Ladha, 1992). Studies on persuasion have investigated how people's attitudes and decisions can be affected by a source's expertise (for reviews see Pornpitakpan, 2004; Wilson & Sherrell, 1993) and by appealing to majority opinions (e.g., Freling & Dacin, 2010; Maheswaran & Chaiken, 1991). Unfortunately, these studies have not addressed the question as to how the two types of sources relate to each other (for a rare study interested in public and expert opinion, see De Haan, Dijkstra, & Dijkstra, 2005).

Bayesian approach to source-based appeals

In epistemology, a broader perspective has been developed for the understanding of human testimony – whether it is for one testimony from an expert source, or for a larger number of relatively inexpert testimonies. Bovens and Hartmann (2003) present three dimensions that play a role in testimony: the reliability of the information source (the perceived correspondence between a source's testimony and the true state of the world), coherence between multiple sources (the degree to which their reports are consistent with one another) and the degree of (in)dependence between multiple sources. A simple conceptualisation of the appeal to expert opinion and popular opinion arguments is as two extremes on the same continuum. On the one extreme is a case with a small number of sources with high expertise (argument from expert opinion), and on the other extreme a case with a large number of sources with low expertise (argument from popular opinion).

A Bayesian conceptualisation enables qualitative and quantitative predictions of how convincing these (now quantitatively) different arguments should be (see also e.g., Bovens & Hartmann, 2003; Hahn, Harris, & Corner, 2009; Harris, Hahn, Madsen, & Hsu, 2016). Hahn et al. (2009), for example, demonstrate that an argument providing more evidence should be more convincing than one providing less (neither a novel nor surprising observation!) and that an argument from a reliable source should be more convincing than one from an unreliable source (again, neither novel nor surprising!). However, these elements (source reliability and amount of evidence) also interact with one another, and naïve participants were shown to be sensitive to this interaction in their evaluations of a message's persuasiveness. Our formalisation of the appeals to expert and popular opinion equates the opinion of a person with a piece of evidence. Consequently, one would predict the same effects as observed in Hahn et al., where the number of opinions substitutes for the number of pieces of evidence.[1] Note that, whereas the majority is what matters in the argumentation-scheme perspective to the appeal to popular opinion, only the number of group members is of importance in the Bayesian account (see Hahn & Hornikx, 2016, for a discussion of group size).

Conceptualising the appeals to expert and popular opinion as above allows us to answer the question of how to weigh the opinion of a large group of people (e.g., 1.3 million UK citizens) versus an expert's opinion (e.g., one specific MP). That is, taking one expert with a given level of expertise as a starting point, it can be computed, within the Bayesian framework, how many members in an argument from popular opinion of a certain low level of expertise are needed to counterbalance that expert.

Bayes' theorem as a normative standard for belief revision is shown below:

$$P(h \mid e) = \frac{P(h)P(e \mid h)}{P(h)P(e \mid h) + P(\neg h)P(e \mid \neg h)}$$

We set up our experiment such that it can be assumed that participants have no specific prior belief in the conclusion: $P(h) = P(\neg h) = .50$. If a first testimony is right in 60% of cases (accuracy = .60), $P(e|h)$ can be set at .60. In our predictions, we assume $P(e|h) + P(e|\neg h) = 1$. Although not prescribed

[1]There are more detailed Bayesian formalisations of the appeal to expert opinion (e.g., Harris et al., 2016) and of the appeal to popular opinion (Korb, 2003), but the present simplified conceptualisations of the two types of argument suffice for our current purposes.

mathematically, we see this as a natural interpretation of our experimental text. Following the first testimony, the posterior belief in the conclusion, $P(h|e)$, equals .60. With a second group member with the same $P(e|h)$, the new $P(h)$ now is the former $P(h|e)$ = .60. The updated $P(h|e)$ after two group members equals .69. When adding new independent group members with the same $P(e|h)$, $P(h|e)$ will increase to asymptote approximately 1 (cf. Hahn et al., 2009). Following this formalisation, as the accuracy level of a source increases, fewer members will be required to reach the same level of belief in the claim.

Consequently, the number of laypeople required to counteract a single expert will depend upon the expertise of the expert (more laypeople will be required the more expert the expert) and the expertise of the laypeople (fewer will be required the more expert they are). In the extreme, where laypeople are as accurate as experts, the opinion of a single layperson counteracts the opinion of an expert (further demonstrating why the two argument types might be most parsimoniously considered as on one continuum). Given that, intuitively (and, arguably, by definition), laypeople will be less accurate than experts, Figure 1 shows the effects of five different levels of lay accuracy and five levels of expert source accuracy on the number of lay reports required to counteract a single expert.

Figure 1 demonstrates an interaction between the two factors: with a decrease in lay accuracy, the impact of expert accuracy more strongly affects the predicted number of group members in a popular opinion. The present study's interest is in determining to what extent people's assessments follow these considerations:

RQ1 Do people assign a larger number of members in a popular opinion to counter an expert opinion when the expertise of the expert increases?

RQ2 Do people assign a smaller number of members in a popular opinion to counter an expert opinion when the expertise of the members increases?

RQ3 Do people's assessments of the number of members in a popular opinion reflect the Bayesian interaction between expert accuracy and member accuracy?

Finally, Figure 1 demonstrates that precise quantitative predictions can be obtained from the Bayesian formalisation (see also Harris, Hsu, & Madsen, 2012; Harris et al., 2016). Thus, our final research question is:

RQ4 Are people's assessments of the number of members in a popular opinion needed to counter an expert opinion quantitatively in line with Bayesian predictions?

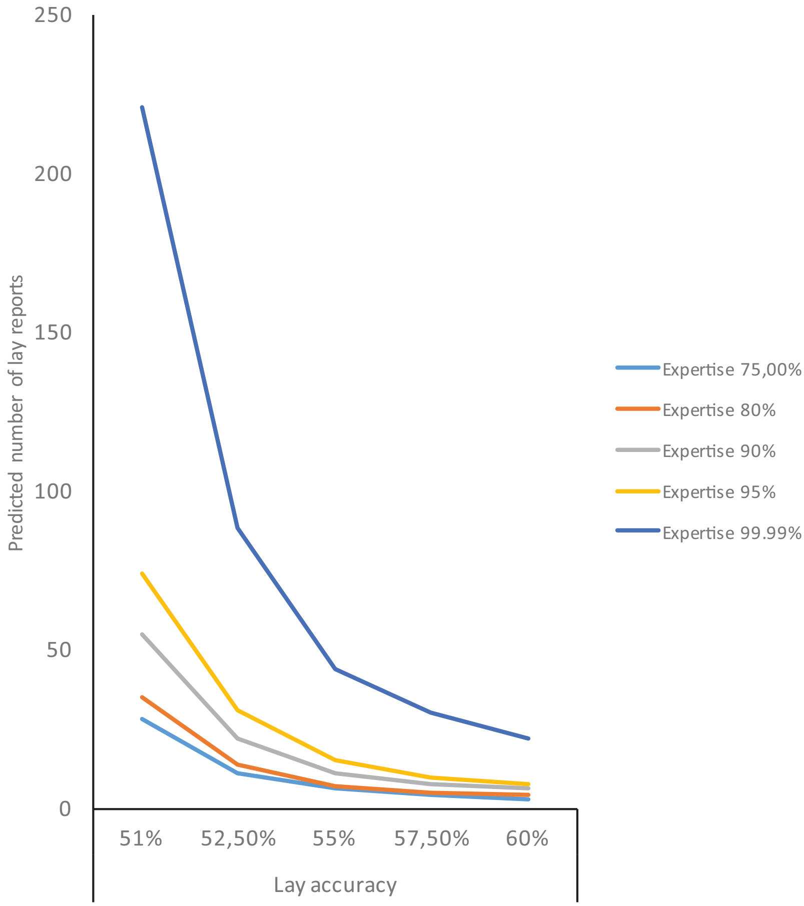

Figure 1. Predicted estimates of the number of lay reports required to counteract the expert reports across conditions.

Method

Participants

About 146 Dutch people (age: $M = 31.27$, $SD = 12.18$, range 17–70; 54% male) completed the study (4 participants from an original 150 were excluded having correctly guessed the study's purpose). Level of education ranged from lower vocational education (10%) to MA degree (19%), the largest category was BA graduates (37%).

Design

Participants received scenarios in which an appeal to expert opinion was countered by an appeal to public opinion. Five levels of expert expertise were

Table 2. Design of the study, and the laypeople's accuracy for each scenario in the five versions.

	Expert's accuracy				
Scenario	99.99% Transportation in city	95.00% Loitering	90.00% Wildlife crossing	80.00% Car-free zones	75.00% Housing for students
Version					
1	55%	51%	60%	52.5%	57.5%
2	60%	57.5%	52.5%	51%	55%
3	52.5%	55%	51%	57.5%	60%
4	51%	60%	57.5%	55%	52.5%
5	57.5%	52.5%	55%	60%	51%

crossed with five levels of layperson expertise using a Latin Square design (for implementation of this design in argumentation research, see Corner & Hahn, 2009; Corner, Hahn, & Oaksford, 2011). Consequently, each participant responded to five scenarios and each of the levels of expert expertise and layperson expertise, although the combinations of these were randomised across participants (see Table 2).

Expertise of the experts and laypeople was manipulated through informing participants of the percentage of cases (similar to the present one) in which the sources were correct (experts: 75%, 80%, 90%, 95% and 99.99%; laypeople: 51%, 52.5%, 55%, 57.5% and 60%). Five different scenarios were introduced, which always corresponded with the same expert expertise levels: Transportation in a mid-sized city (99.99%), housing for students (75%), loitering (95%), car-free zones in city centres (80%) and wildlife crossing on regional roads (90%). Participants always saw the scenarios in this order.

For each scenario, participants were asked to indicate (free numerical response) how many laypeople they thought were required to counter the opinion of the expert.

Materials and procedure

Participants were invited to take part in an online study, ostensibly concerning municipal plans, run through Qualtrics (www.qualtrics.com). Upon consenting to participate, they responded to the five scenarios. The scenarios had the form of a dialogue between Person A, Person B and Person C (inspired by previous materials in Bayesian argumentation research – e.g., Oaksford & Hahn, 2004). An example for the topic of car-free zones is:

> Person A: Have you heard about the plan to make Nieuwstraat in Apeldoorn[2] a car-free zone, because they expect it to raise the number of customers in the shopping street?

[2]The cities in the scenarios were within 100 km. of where the study was conducted (Nijmegen, The Netherlands).

Person B: Yes, but why do you ask me that question?

Person A: Because I do not know whether it is a good plan or not.

Person B: I think it is.

Person A: Why?

Person B: A professor in retail marketing at Utrecht University has indicated that this will help to increase the number of shop customers. And he is in a good position to know because he is right in 80 percent of the cases about consumer purchases.

(Person C hears the conversation between Person A and Person B, and now rejects Person B's statement.)

Person C: But I heard that road workers, who are working in the area, are telling that this zone will not help in increasing the number of customers in the shops.

Road workers are not knowledgeable when it comes to consumer purchases. On this topic each road worker is right in 52.5% of the cases. However, there is a large number of road workers who have this opinion. How large would the group of road workers have to be to outweigh the opinion of the professor in retail marketing?

After the five scenarios, participants provided demographic information and stated what they thought the goal of the study was.

Results

As a first test, we wanted to determine whether participants' estimates of the number of laypeople required to counteract the expert opinions were qualitatively in line with the Bayesian predictions. Figure 2 demonstrates that, whilst not perfect, the general pattern of results predicted in Figure 1 appears to be observed.

Analyses confirmed that participants were sensitive to the three predicted factors. In relation to RQ1, participants indeed assigned a larger number of members in a popular opinion when expert accuracy increased, $F(4, 705) = 260.6$, $p < .001$, $\text{eta}_p^2 = 0.60$. For RQ2, participants assigned a smaller number of members when lay expertise increased, $F(4, 705) = 315.1$, $p < .001$, $\text{eta}_p^2 = 0.64$. For RQ3, participants' assessments reflected the predicted interaction between expert accuracy and member accuracy, $F(16, 705) = 9.2$, $p < .001$, $\text{eta}_p^2 = 0.17$.[3]

In order to assess the quantitative fit of the data to the Bayesian predictions (RQ4), we correlated the mean responses with the Bayesian predictions (Figure 3) across the combinations of lay and expert accuracy. People's assessments of the number of members in a popular opinion needed to counter an

[3]For the reported inferential statistics, the dependent variable was transformed such that each participant's mean response = 0, and a factorial analysis of variance was performed on the resulting data (Howell, 1997, p. 452). A regular repeated measures ANOVA was inappropriate as a result of the Latin Squared design. Significance levels were the same when untransformed data were analysed.

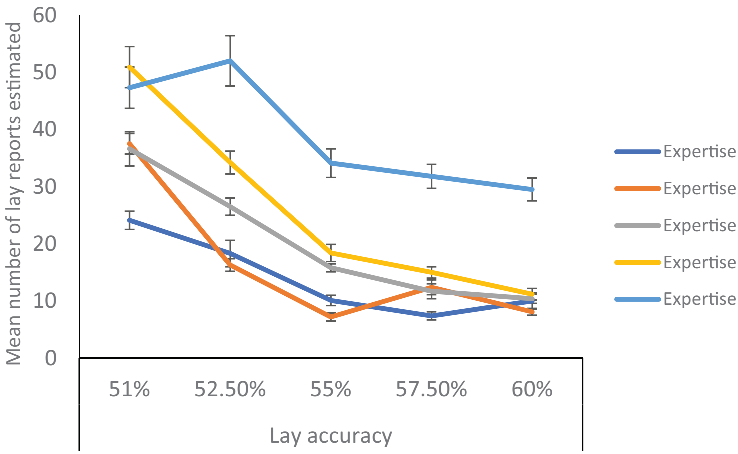

Figure 2. Mean estimates of the number of lay reports required to counteract the expert reports across conditions. Error bars are plus and minus 1 standard error.

expert opinion were approximately in line with Bayesian predictions, with 54% of variance in participants' responses explained by the Bayesian predictions, $F(1, 23) = 28.93$, $p < .001$, $R^2 = .54$, $\beta = .75$. Close inspection of Figure 3 suggests that participants were least successful in following a Bayesian account when the expert was said to have an extreme level of expertise (99.99%; arguably an unrealistic scenario). In those cases, relatively large

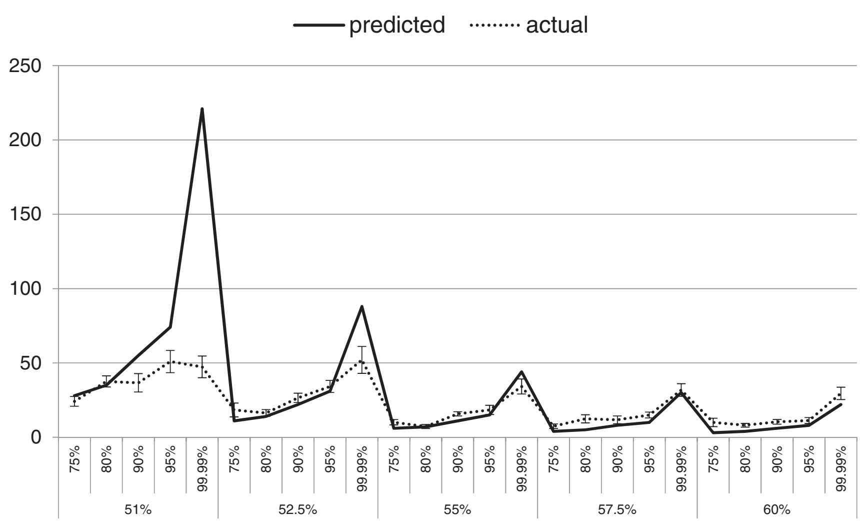

Figure 3. Predicted and actual estimates of the number of lay reports required to counteract the expert reports across conditions. Error bars represent 95% confidence intervals.

numbers of members are predicted, and participants rarely provided estimates greater than 50. If the scenarios with 99.99% of expert accuracy were discarded in the analysis, the fit between participants estimates and Bayesian predictions increased to explain 91% of the variance, $F(1, 18) = 191.61$, $p < .001$, $R^2 = .91$, $\beta = .96$.

Discussion

Against the background of previous, relatively independent, treatments of lay opinions and expert opinions, the present study examined an original question as to whether people are capable of assessing how many lay opinions are needed to counter an expert opinion. People were found to be fairly good at assessing how many lay opinions are needed. Their assessments were compared to predictions that followed a Bayesian formalisation of source-based arguments (cf. Hahn et al., 2009). In line with this formalisation, participants in the current study correctly assigned a larger number of members when expert accuracy increased, and a smaller number of members when lay expertise increased.

The present study employed several simplifying assumptions: the independence of the laypeople; the infallibility of testimonies from Persons B and C; rigidity in perceptions of the accuracy levels of the experts and the laypeople. The likelihood of some dependency in the laypeople's opinions suggests that the Bayesian estimates might require revision upwards, though effects of dependency are complex and, at times, unintuitive (e.g., Bovens & Hartmann, 2003; Ladha, 1992); the potential for some unreliability in the reports of Person's B and C could be modelled using Bayesian Networks (as in Hahn, Harris, & Corner, 2016); receipt of a large number of reports all stating the same fact might lead to a revision in one's estimate of the accuracy of the laypeople and the expert – so-called dynamic inference (e.g., Oaksford & Chater, 2013). Furthermore, whilst Harris et al. (2016) demonstrated that people were differentially sensitive to the trustworthiness/veracity of the expert and their expertise/sensitivity (see also, e.g. Shafto, Eaves, Navarro, & Perfors, 2012), the current study combined these elements into a single reliability measure. Consequently, there are a variety of avenues for future research to explore.

The present work adds to work on Bayesian argumentation (e.g., Bovens & Hartmann, 2003; Hahn & Oaksford, 2006, 2007), highlighting that a Bayesian perspective to argumentation can provide insights into how people reason with arguments. The present study explicitly related expert opinions with lay opinions. People were shown to be able to relate the two opinions to each other, which suggests that – in line with the Bayesian account of source-based arguments – the two types of arguments are more closely connected than suggested by the scheme-based approach. This study may stimulate research examining the connections and differences between various source-based arguments. The fit between Bayesian predictions and participants' assessment was extremely good with data excluding extreme expert accuracy, and fairly good with all five levels of expert accuracy. Systematic investigation of the assumptions underlying this work may provide better insights into how good people are in their assessments, where exactly they start to underperform, and what may explain this underperformance.

Disclosure statement

No potential conflict of interest was reported by the authors.

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