Arguments from expert opinion – An epistemological approach

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In times of populist mistrust towards experts, it is important and the aim of the paper to ascertain the rationality of arguments from expert opinion and to reconstruct their rational foundations as well as to determine their limits. The foundational approach chosen is probabilistic. However, there are at least three correct probabilistic reconstructions of such argumentations: statistical inferences, Bayesian updating, and interpretive arguments. To solve this competition problem, the paper proposes a recourse to the arguments' justification strengths achievable in the respective situation.

KEYWORDS: argument from expert opinion, Bayesian updating, epistemological approach to argumentation, interpretive arguments, probabilistic arguments, statistical arguments

1. INTRODUCTION: KNOWLEDGE AND COGNITION FROM EXPERT OPINION

Verifying procedures, i.e. introspection, observation and deduction, are rather limited in their reach. How can our relevant knowledge [1] be extended beyond them? Besides e.g. the collection of pieces of evidence, documents etc. available to others, there are above all three, argumentation-theoretically, interesting extensions.

(1) The first way to expand the set of our justified beliefs is the use of indirect and uncertain, therefore also defeasible and non-monotonic justification procedures such as inductive, probabilistic and practical justifications.

(2) A second way is the social transmission of justified beliefs through primary arguments, i.e. arguments that guide the addressee to carry out

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[1] 'Knowledge' (or 'cognition') is used here in the broad sense of: rationally justified (acceptable) belief, i.e. not in the narrower, technical sense of: certainly justified and not deviantly acquired true belief.

the aforementioned individual verification or uncertain justifications by specifying to him those facts which he must check in such a justification. (Lumer, 2005a, sect. 5 (= pp. 221-224); 1990, pp. 43-51.)
(3) The third way to expand our relevant knowledge are assertions by informed persons and the secondary arguments based on them. With this third way we rely on the fact that another subject has gained a certain knowledge, but without us tracing and reproducing his cognition – as with the primary arguments. *Secondary* (or *genesis of knowledge*) *arguments* substantiate their thesis by referring to a primary subject of knowledge and by describing (in more or less detail) that and how this subject recognized the thesis as acceptable and how this knowledge was then passed on to the moment of argumentation; and they can supplement these descriptions with assessments of the reliability of the steps taken (Lumer, 1990, pp. 246-260). Special cases of such secondary arguments are arguments from testimony, argument from expert opinion or proof by citing historical sources (Lumer, 1990, pp. 248-257).

The enormous evolutionary success of humans is essentially based on these three extensions of knowledge, in particular also the social transmission of knowledge (ways 2 and 3). For this also allows new insights to be gained through the division of labour, where the insights can then be socially disseminated and thus accumulated. This article deals with secondary cognitions based on expert opinions and arguments to expert opinion. Recently, the dissemination of social media and populism have plunged expert-based knowledge into crisis. On the one hand, the objectivity of knowledge in general, experts' advance in knowledge and their trustworthiness are being questioned. On the other hand, far too few requirements are placed on the sources of socially conveyed opinions and in particular on experts; and unjustified trust is credited to certain "experts". This article develops criteria for good arguments from expert opinion and acceptable secondary cognitions, and thus also criteria for when trust in experts is epistemically rational, i.e. when it leads to acceptable beliefs and when it does not.

2. WHAT ARE ARGUMENTS FROM EXPERT OPINION AND WHY DO WE NEED THEM?

Direct cognition based on expert opinion consists in:
1. A subject *s* directly perceives a statement of a person *e*, that *p*, where
2. *p* is from the field of knowledge *f*, and
3. the subject *s* justifiably believes that *e* is an expert in the field of knowledge *f*, and
4. *s* then (on the basis of 1, 2, 3) believes in *p* itself.

This is e.g. the situation of a judge or a member of a parliamentary commission who is directly informed by an expert. In the case of *arguments from expert opinion* (in the narrow sense), (at least) one further instance is involved: The arguer *a* reports to an addressee the statement *p* made by the expert *e* and adds to it (if necessary or appropriate) information about *e*'s expert status – basic form:

> '[P1] *e* asserts (at that and that occasion) that *p* is true.
> [P2] *e* is an expert in the field of *f*,
> [P3] containing the proposition *p*.
> [T] Therefore, *p* is (very likely) true.' (See e.g. Walton, Reed & Macagno, 2008, p. 310.)

In the simplest case, the arguer *a* has directly perceived the expert's statement; in more complicated cases, *a* himself has again only indirectly learned of the expert's statement. Cognition based on an argument from expert opinion always includes a *cognition* based on expert opinion; but a further cognitive step is added, i.e. the assessment of the reliability of the arguer's not directly verifiable statements (P1 and P2). (Premise P3 can usually be judged by the arguer on the basis of his analytical knowledge; its acceptance then does not presuppose trust in the arguer. It is therefore usually omitted.) In order to simplify the epistemological discussion, this additional step (assessment of the arguer's reliability) is occasionally disregarded in the following, i.e. only the cognition from expert opinion is dealt with.

Expert based cognition is, as already mentioned, a *secondary cognition* which is based on the (possibly only alleged) primary cognition of the expert (e.g. a scientific investigation or a mathematical proof) and does not consist of an reenactment of this primary cognition, i.e. it is not a primary cognition. The most important reasons for this renunciation of the primary recognition or for its impossibility are: The expert assertion deals (among other things) with the observation of an object, which (currently or always) is not (any longer) or only with difficulty accessible for the cognizing subject; the reproduction of the expert cognition would be too costly; or this primary cognition is too *esoteric* for the cognition subject: The cognition subject *s* is in the situation of a layman or novice towards the expert *e*. If the argument from expert opinion is adequately used, the *novice* understands the thesis (but even this can be a popularized version of the actual scientific thesis incomprehensible to the novice), but he cannot understand and reenact the expert's reasoning or really judge its validity (An attempt to convince by means of primary, esoteric reasoning would therefore be inadequate in such a situation (Lumer, 2005a, pp. 225-227, 231, 235-236).)

The situation of the novice is epistemologically particularly problematic: How can a novice – without being able to judge the validity of the expert's justifications – recognize the expert status of a person and in particular her degree of reliability? Without a justified assumption of the novice about the expert's degree of reliability, his belief in the expert's assertion would be epistemically irrational. I will come back to this problem in section 4.

3. WHO IS AN EXPERT?

In addition to cognitive experts who have special knowledge, there are practical experts (figure skaters, dancers, plumbers, violinists ...). '(Cognitive) expert' is defined here by five conditions:

> A person *e* is (at time *t* in a society *c*) a *(cognitive) expert* in an area *f*, iff
> *E1: Social embedding:* person *e* lives at time *t* in society *c*; and
> *E2: High reliability: e* has a significantly higher rate of true beliefs (relative to all her beliefs in *f*) in the area *f* than the vast majority of other people (at *t* in *c*); and
> *E3: Extensive knowledge: e* has a significantly greater number of true beliefs in the area *f* than the vast majority of other people (at *t* in *c*); and
> *E4: Justified belief:* the beliefs (according to conditions 1 and 2) of *e* in area *f* are for the very most part justified; and in a core area specific to *e* from *f* they are also primarily justified; and
> *E5: Mastery of justification procedures: e* masters methods and justification procedures (of time *t* in *c*) from area *f* in order to be able to form new primarily justified true beliefs.

What will be most important for our discussion of arguments from expert opinion is the reliability condition E2. (Conditions E3 and E5 are similar to Goldman's (2001, pp. 91-92).)

4. JUDGEMENTS ON THE EXPERT'S RELIABILITY

Within the framework of the epistemological approach in argumentation theory, the *social reliability* of a person and especially of experts with regard to their assertions (or in other words: the social reliability of the assertion made by the expert) is interpreted probabilistically.[2] (The reasons for this probabilistic approach are discussed in section 5). The social reliability of the expert with respect to his assertion (or of the assertion made by the expert) is then the

[2] For a qualitative or comparative approach see e.g.: Ennis, 1995, pp. 58-69.

conditional probability that this assertion is true given the assertion. To be more precise: An expert e is *(socially) reliable* with respect to an assertion p made by him to the degree x (= the assertion p made by the expert e is (socially) reliable to the degree) if the conditional probability that p is true given the assertion is x ($P(p|Ae,p)= x$, with Ae,p := e asserts p; time variables are omitted here and often in the following). This social reliability of the assertion can then be further broken down into i. epistemic or investigator reliability, i.e. the conditional probability that the result of the investigation achieved (and believed by e) is correct, and ii. veracity in asserting, i.e. that the expert actually says what he believes. The primary and direct justification of probabilistic reliability judgments about an expert's assertions (in a given field) is that they are founded on information about the relative frequency of true assertions made by that expert (in that field): what is the proportion of true assertions in the total number of assertions he has made (and which have become known to us)? (Let Re,f = the reliability of e in the area f; and $RF(Gx\ /\ Fx)$ = the relative frequency of Gs among the Fs, then $Re,f := RF(p_x\ /\ p_x \in f\ \&\ Ae,p_x)$.

Rational expert-based knowledge always uses assumptions about the reliability of the expert as an essential premise. For the expert-based knowledge to be rationally justified, this assumption of reliability must also be rationally justified. And the royal road to this justification is statistical information about the relative frequency of correct assertions by the expert, which in turn must be rationally justified; and for their justification the premises underlying the statistics that the expert's statement was true in that and that case must be justified – although the statements to be assessed themselves are expert statements again. How is such a justification for a novice possible?

There are some primary methods for establishing an expert’s reliability, which are accessible even to a novice: success statistics of previsions or instructions, dimensional assessment with some dimension accessible to the novice, dialectical superiority in debates and (negatively) interests and biases. Once one has acquired cognition about some expert’s reliability one can use direct or indirect judgements of these experts about their colleagues’ reliability as the basis for a secondary recognition of these colleagues’ reliability.

The agreement or disagreement of the expert's assertion with the statements of other experts is not treated here as an indication of the expert's reliability, but as additional indicators of the truth or falsehood of the thesis (section 9). Otherwise, the procedure would be circular, because the agreement with other experts who answer the question of whether p in the same way as the expert e in question is only a positive indication of the reliability of the expert e if the answer that p is true. But that is exactly the question that is to be answered first.

5. THREE TYPES OF ARGUMENTS FROM EXPERT OPINION

In argumentation theory, various normative reconstructions of arguments from expert opinion or criteria for good arguments from expert opinion have been developed (Ennis, 1995; Hahn, Oaksford & Harris, 2013; Wagemans, 2011; Walton, 1997; Walton, Reed & Macagno, 2008). Unfortunately, I cannot discuss them all here properly. I only want to argue briefly why non-probabilistic treatmens of arguments from expert opinion like Walton's are unsatisfactory and then explain the possible probablistic approaches.

I have discussed Walton's approach in more detail elsewhere (Lumer, 2011a, sect. 2.2 (= pp. 5-8); Lumer, 2016, in particular sect. 4 (= pp. 14-17)). Therefore, here I will only discuss the points most important in the current context.

The two main problems of Walton's scheme of argumentation from expert opinion are: 1. All quantitative questions are left out: the degree of reliability of the expert, the degree of plausibility of the thesis, the degree or frequency of truthfulness of the arguer. Thus, the conclusion of the argumentation says nothing about the plausibility of the thesis *p*; for, contrary to what the scheme suggests, its thesis cannot simply and without reservation be assumed to be true. The argumentation can therefore also not deal with all cases in which the available evidence points in different directions. It is astonishing in this context that Walton and his co-authors did not include the actual major premise, namely the premise indicating the degree of reliability of the expert, in the argumentation scheme at all (but only the qualitative premise: '*e* is an expert in the field *f*'). Thus, the most important basis for subsequently determining the degree of plausibility of the thesis *p* is missing. 2. Walton's theory provides no explanation or justification why arguments developed according to his argumentation scheme are good arguments, in particular why it is rational if one believes in the premises then to believe in the thesis as well. The critical questions (and the respective answers) do not resolve this problem.

The most straightforward approach that solves the two problems just mentioned is a probabilistic reconstruction of arguments from expert opinion as a probabilistic inference. The conclusion of such an inference is a probabilistic thesis: 'The probability of *p* is *x*' or '*p* is probable to degree *x*' ($Pp=x$). And this probability is computed from the probabilities of the premises (or the statistical frequencies given therein). This would solve the first problem, that of the degree of plausibility of the thesis and that of the treatment of premises of varying strength and of opposite evidence. In addition, such a probabilistic approach is based on probability theory and thus on a theory that is not only generally accepted, but also axiomatically founded, and whose practical application in decisions also leads to optimal results: The use of the probabilities (determined with the help of probability theory) in decisions, according to the rules of rational decision theory, leads in the long run to the best results for the decision maker, better than any other strategy in dealing with uncertain information. – In the following I will concentrate on the aspects of the conclusiveness of cognition and arguments from expert opinion; i.e. most pragmatic questions and the exact description of the form of these arguments as well as the criteria for their validity and situational adequacy are left aside here. For an answer to these questions, see a general theory of probabilistic argumentation: Lumer, 2011b.

How can cognition and arguments from expert opinion be reconstructed probabilistically? I see (at least) three possibilities for this:

1. Statistical inferences: The simplest form is: 'Expert e claims p, where p is in the field f. e's reliability in the field f is (statistically) x. (We have no better information regarding p.) So p is likely to degree x.'

2. Bayesian updating: In the simplest case Bayesian updating has this form: 'The prior probability of p is x ($P_0p=x$). e claims p, where p is in the field f. The conditional probability that if p is true (and is in the field f), e (based on an appropriate investigation) will claim that p is y. The conditional probability that, if p is not true (and is in field f), e will claim that p is, z. Therefore (according to Bayes' theorem) holds: The posterior probability of p (i.e. P_1p) is $(x \cdot y)/[x \cdot y+(1\text{-}x) \cdot z] = q$.'

3. Interpretive arguments: 'e asserts p, where p is in the field f. That e claims p can be explained with the following hypothetical interpretations i_1, ..., i_n (with more or less detailed descriptions of these hypothetical explanations; in these explanations it is explicitly assumed in each case whether p is true or not). These interpretations have prior probabilities of p_1, ..., p_n. (This is calculated in more detail.) In interpretations i_1, ..., i_m (with $m \leq n$), p is assumed to be true. The aposteriori probability of p is then: $P_1p = (p_1+…+p_m) / (p_1+…+p_n) = q$.'

All of these three ways of probabilistically reconstructing arguments from expert opinon are correct. In the following sections they are presented in more detail. The final section 10 deals with the question of when which of these forms of argumentation should be used.

6. COGNITION BASED ON EXPERT OPINION AS STATISTICAL INFERENCE

Statistical inference is the basic form of probabilistic cognition. It is based on the:

> *Foundation principle:* If the relative frequency of the *E*s among the *F*s is *x*, if in addition a certain object *y* has the property *F* and nothing else is known about *y*'s possible being *E*, then *y* is also *E* with a probability of *x*.

(*Formalization:* That the existing database contains no further information relevant for cognizing the proposition in question is here abbreviated as "NBI" (= no better information). Probabilities are actually always relative to a certain database *d*, which in particular can be the set of information of a certain person at a certain time. This can be expressed in the form: *Pp*,*d* - 'the probability of *p* on the database *d*'. This reference to the database is not mentioned in the following and also usually not elsewhere, but should be expressed in the formulation of the foundation principle. Then the foundation principle can be formalized as a general conditional probability as follows:

> *Foundation principle:* $P[Ey \mid RF(Ez/Fz){=}x \;\&\; Fy \;\&\; NBI],d = x$, for all E, F, d, x, y, z, if $P[RF(Ez/Fz){=}x \;\&\; Fy \;\&\; NBI],d > 0$. (Lumer, 2011b, p. 1146))

(This Foundation Principle is a reformulation of Hacking's Principle of Direct Probability (Hacking, 1965; 2001, p. 137).)

Cognitions from expert opinion conceived as statistical inference are a special application of the foundation principle. The relative frequency in this case is the share of the true assertions of the expert *e* in all his assertions in the field *f*. The predicate *Fz* from the above formulation is in this case the predicate: 'proposition p_x is from the field of knowledge *f*, and p_x has been asserted by *e*'. The predicate *Ez* is: 'proposition p_x is true'. The basic form of statistical argumention from expert opinion is then:

> *P1:* The reliability of *e* in the field *f* is *x*. (According to the above definition this means: The relative frequency of the true assertions of *e* among his assertions in the field *f* is *x*.)
> *P2:* *e* asserts that *p*.
> *P3:* *p* is from the field of knowledge *f*.
> (*P4:* the database contains no further relevant information about the possible truth of *p*.)
> (*P5:* foundation principle.)
> ∴ *T:* *p* has the probability *x*.

(*Formalisation:* That *p* is true is equivalent to *p* itself. Then the argument is:

> *P1:* $RF(p_y/Ae,p_y \;\&\; p_y{\in}f){=}x$. (= $Re,f{=}x$.)

P2: Ae,p.
P3: $p \in f$.
(*P4:* NBI.)
(*P5:* Foundation principle.)
$\therefore$ *T:* $P(Tp) = Pp = x$.)

These arguments are very simple, at least in the sense that they do not require great arithmetic skills.

Another extension of knowledge from expert opinon based on statistical inferences is the inclusion of the (frequently occurring) possibility that the addressee *s* does not yet know anything about the expert statement and is only informed by the arguer that the expert has claimed that *p*. In such a case, the possibility should also be considered that the arguer may be saying something untrue about this. This consideration is normally a step which the addressee has to take on his own, and which does not occur in the argument presented by the arguer. For the probabilities of the arguer and the addressee are now different.

In this case, the probability of the thesis of the argument from expert opinion must be calculated according to a more complicated formula (Jeffrey conditionalization (Talbott, <2001> 2016)):

Probability of the thesis of argument from expert opinion depending on the reliability of the expert and the arguer:
JC: $P_1p = P_1(Ae,p \ \& \ p \in f) \cdot P_0(p \mid Ae,p \ \& \ p \in f) + P_1\neg(Ae,p \ \& \ p \in f) \cdot P_0(p \mid \neg(Ae,p \ \& \ p \in f)) = x \cdot y + (1\text{-}x) \cdot z$.

In the following it is always assumed that it is certain that the thesis *p* is of the field *f* (thus: $P_0(p \in f)=1$) and that the addressee has no other relevant information at his disposal. Let us now consider the individual components of the formula JC! 1. $P_1(Ae,p \ \& \ p \in f) = x$: This is the probability that the expert has actually asserted *p*; this probability corresponds to the reliability of the arguer in reports on experts' statements. It can be determined by a statistical inference (how great is the relative frequency of corresponding correct reports of the arguer *a*?). 2. $P_0(p \mid Ae,p \ \& \ p \in f) = y$: This is the reliability of the expert *e* in the field of knowledge *f*, as it has already been statistically justified in the simpler argumentation. 3. $P_1\neg(Ae,p \ \& \ p \in f) = 1\text{-}x$: This is the complement to term 1; the value of this expression is therefore 1-*x*. 4. $P_0(p \mid \neg(Ae,p \ \& \ p \in f)) = z$: How can this conditional probability that *p* is true, although the expert did not claim it to be true, be determined in a justified way? One difficulty with this determination is that besides the probabilities of a true and a false assertion of the expert about *p*, one must also assume a probability that the expert *e* does not express himself at all about *p*. In the simplest case, this may be ruled out because *e had* to make a statement; he was asked with respect to *p* as an expert. Under these conditions, the expression in question is identical to a formula easier to be determined:

> *P6:* $P_0(p|\neg(Ae,p \,\&\, p{\in}f)) = P_0(p|\neg Ae,p) = P_0p\cdot(1\text{-}Re,f) \,/\, [P_0p\cdot(1\text{-}Re,f) + P_0\neg p\cdot Re,f] = k\cdot(1\text{-}y) \,/\, [k\cdot(1\text{-}y) + (1\text{-}k)\cdot y]$, where Re,f = (statistically determined) reliability of the expert *e* in the field *f* – which we had already considered several times above.

The right side of P6 contains only already known variables except for $P_0p=k$, the prior probability of the thesis *p*. JC and P6 combined then result in the following formula for the thesis' probability of statistical arguments from expert opinion with two reliability assumptions:

> *Simplified probability of the thesis of an expert argumentation depending on the expert and arguer reliability and the initial probability:*
> *JCS:* $P_1p = P_1(Ae,p \,\&\, p{\in}f) \cdot P_0(p \mid Ae,p \,\&\, p{\in}f) +$
> $+ P_1\neg(Ae,p \,\&\, p{\in}f) \cdot P_0p \cdot (1\text{-}Re,f)/[P_0p\cdot(1\text{-}Re,f) + P_0\neg p\cdot Re,f] =$
> $= x\cdot y + (1\text{-}x)\cdot k\cdot(1\text{-}y) \,/\, [k\cdot(1\text{-}y) + (1\text{-}k)\cdot y] =$
> $= xy + k\cdot(1\text{-}x\text{-}y\text{+}xy) \,/\, (k\text{-}2ky\text{+}y)$,
> with x = arguer's report reliability; y = expert's reliability; k = prior probability of the thesis *p*.

The prior probability may take very different values. In table 1 the posterior probabilities of *p* for different prior probabilities of *p* are calculated using the formula JCS on the basis of the assumptions that both the reliability of the arguer and that of the expert are each 0.9 ($x=P_1(Ae,p \mid Aa,(Ae,p))=0.9$; $y=Re,f=P_0(p \mid Ae,p \,\&\, p{\in}f)=0.9$).

Case	1	2	3	4	5	6
P_0p (=k)	0.01	0.30	0.333	0.50	0.85	0.99
P_1p	0.8101	0.8146	0.8153	0.8200	0.8486	0.9167

Table 1 – Posterior probabilities of a thesis depending on varying priors (with a fix arguer and expert reliability of 0.9) after a simplified statistical inference

1. The term "$x\cdot y$" in the formula JCS has the following effect: If both the reporting arguer and the expert are quite reliable, then the posterior probability of the thesis is also very high; and a very different prior probability of the thesis has very little influence on the posterior probability. Table 1 represents such a case: Both reliabilities are assumed to be 0.9; to the resulting base of 0.81 posterior probability

($x{\cdot}y$) extremely different prior probabilities of 0.01 to 0.99 add only comparatively little different additional posterior probability (range 0.1066 (=0.9167-0.8101)). This is different from Bayesian updating, where the prior probability has a much greater influence (see section 7).
2. With decreasing reliability of the arguer and expert, the posterior probability decreases and the influence of the prior probability increases. (For example, if both reliability values are 0.5, with a prior probability of 0.01 the (total) posterior probability is 0.2550, with a prior probability of 0.99 it is 0.7450 (range 0.4900).)

7. COGNITION FOM EXPERT OPINION AS BAYESIAN UPDATING

The Bayesian approach [3] to cognition from expert opinion is: to update one's prior probability of the thesis p (or hypothesis h) after receiving new relevant information i, following Bayes' theorem.

> *Bayes' theorem:* $P(h|i) = [P(h){\cdot}P(i|h)] / [P(h){\cdot}P(i|h) + P(\neg h){\cdot}P(i|\neg h)]$.

The conditional probability $P(h|i)$ is determined with the specifications on the right side of this formula. The assumed prior probability of the hypothesis h itself is one of these presupposed values: P_0h. If one now receives new information i, which (in the simplest and standard case) now has the probability 1 (P_1i=1), then one can very simply determine the updated posterior probability of h (P_1h) with the calculated conditional probability, for P_1i=1 it is identical with the conditional probability $P(h|i)$. ($P(i)=1 \Rightarrow P(h)=P(h|i)$.)

If one applies this procedure to arguments from expert opinion, the new information i (in the simplest case) is the expert statement Ae,p (together with the information that p is from the field f and that e is an expert in the field f), and the hypothesis to be updated is the thesis p claimed by the expert. So one obtains the following argument:

> *P1:* Expert e asserts p.
> *P2:* p is part of the field of knowledge f.
> *P3:* e is an expert in the field f.
> *P4:* The prior probability of p is x.
> *P5:* The probability that the expert e asserts p, where p is from the field f and e is an expert in the field f, under the condition that p is y.

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[3] Bayesian reconstructions of arguments from expert opinon have been advocated above all by Hahn and her co-authors: Hahn & Hornikx, 2016; Hahn, Oaksford & Harris, 2013. These essays also contain descriptions of further possibilities that go beyond the reconstructions developed here.

P6: The probability that the expert e asserts p, where p is from the field f and e is an expert in the field f, under the condition that not p is z.
(*P7:* Bayes' theorem.)
(*P8:* Nothing else is known about p or other relevant facts.)
$\therefore$ *T:* The posterior probability of p is: $x \cdot y \ / \ (x \cdot y + (1\text{-}x) \cdot z)$.

(*Formalization:*

P1: Ae,p.
P2: $p \in f$.
P3: Ee,f.
P4: $P_0 p = x$.
P5: $P_0(Ae,p \ \& \ p \in f \ \& \ Ee,f \mid p) = y$.
P6: $P_0(Ae,p \ \& \ p \in f \ \& \ Ee,f \mid \neg p) = z$.
($P_0 \neg p = 1\text{-}P_0 p = 1\text{-}x$.)
(*P7:* Bayes' theorem.)
(*P8:* NBI.)
$\therefore$ *T:* $P_1 p = x \cdot y \ / \ (x \cdot y + (1\text{-}x) \cdot z)$.)

Bayesian updating of the form just described presupposes many premises. The premises P1, P2 and P3 are still comparatively harmless and can even be certain, as presupposed in the argument form just outlined. However, the premises P4, P5 and P6 are problematic. With the premises P5 and P6 the question already arises when (and with which probability) the expert should have reason to pronounce his opinion about p, and this not only if p is true (P5), but also if p is not true (P6). In the simplest case, but unfortunately by far not always, one can perhaps assume again that the expert had to comment on p or not p, e.g. because he had a corresponding investigation order. Then the required conditional probabilities (if one can assume for certain that p is from the field f and that e is an expert in the field f) result, as already assumed above, from the expert's reliability: The conditional probability $P_0(Ae,p \ \& \ p \in f \ \& \ Ee,f \mid p)$ that he then claims p (because he has examined p and p falls within his field of expertise) corresponds to his degree of reliability; let's assume this reliability to be 0.8 ($P_0(Ae,p \ \& \ p \in f \ \& \ Ee,f \mid p) = 0.8$). And if he then, although p is not true, nevertheless claims that p, this corresponds to his "degree of *un*reliability" 0.2 ($P_0(Ae,p \ \& \ p \in f \ \& \ Ee,f \mid \neg p) = 0.2$). The last necessary and also problematic premise is the prior probability of the thesis p itself ($P_0 p$). If the cognizing subject does not yet have an opinion on this question, then she must, according to Bayesianism, estimate this probability. These prior probabilities have a considerable influence on the newly determined posterior probabilities, so that very problematic distortions can occur here. With the prior probabilisties of p already assumed above and an expert reliability of 0.8, the posterior probabilities indicated in table 2 result.

Case	1	2	3	4	5	6
P_0p	0.01	0.30	0.333	0.50	0.85	0.99
P_1p	0.0388	0.6300	0.6667	0.8000	0.9577	0.9975

Table 2 – Posterior probabilities of a thesis after expert statement (with a fix expert reliability of 0.8) depending on varying priors (descrete values), according to Bayesian updating

More generally, with an expert reliability of 0.8 we get, depending on various priors (x-axis) of p, the posteriors scheduled in figure 1.

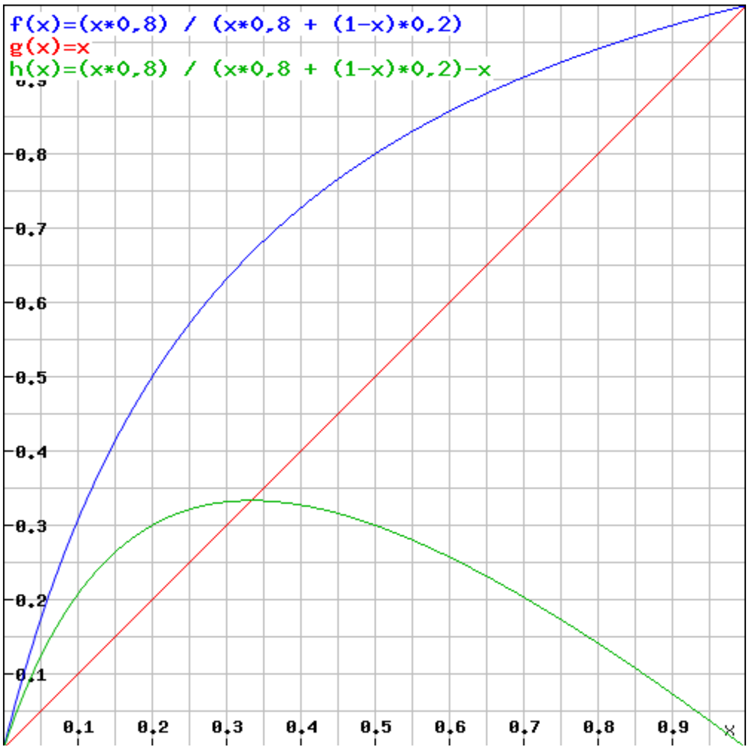

Figure 1 – Posterior probabilities of a thesis after expert statement (with a fix expert reliability of 0.8) depending on varying priors (continuum), according to Bayesian updating. (Diagonal = unchanged priors; left curve = posteriors; lower curve = the impact of the expert judgement (difference between priors and posteriors).)

These are interesting results. 1 The posterior probabilities of *p* vary very strongly, in the examples between 0.0388 and 0.9975, and are massively oriented to the priors. 2. If the cognizing subject is a priori "neutral" between *p* and $\neg p$, i.e. gives them both the same probability (case 4), then the posterior probability corresponds completely to the assumed expert reliability (0.8); hence, the expert reliability is used as a probability determinant. 3. In all cases, the probability of *p* is increased by the additional consideration of the expert statement – even if the reliability of the expert is lower than the prior probability (case 5). The posterior probability thus does not approach the degree of reliability of the expert statement, but is always increased by the expert statement (as long as this reliability is above 0.5). 4. The very low prior probability of 0.01 (case 1) is also increased by the new evidence of the expert statement, even more than tripled; the posterior probability, however, remains very low. This may be justified if the prior probability is strongly justified. But if instead it is based only on a very weak justification, e.g. an empirically uninformed estimate, this is inadequate; in this case, the cognizing subject should rationally give much more weight to the expert judgement. The Bayesian treatment of this case thus rather reflects a populist cognitive behavior: We all have equal rights as cognizants – and then we go with the crowd. This cognitive behaviour completely ignores – in an epistemically irrational way – the justifications and the very different strengths of justification, e.g. of an expert judgement or a scientific theory on the one hand and an uninformed or poorly informed lay estimation on the other.

In the above reconstruction of more complex cases of arguments from expert opinion as statistical inference, the reasoning had to take into account that the expert's assertion was only reported by the arguer so that the respective reliability of the arguer had to be considered too. This and similar split-ups are also possible in the Bayesian approach (for more details see footnote 3). However, they are very complex and require many premises.

8. COGNITION FROM EXPERT OPINION AS INTERPRETING COGNITION

Interpretive cognition or argument is a probabilistic version of an "inference to the best explanation".[4] It is used in various contexts: in criminology or whodunits to determine the perpetrator and the course of action, in archeology to reconstruct the history behind some relic, in

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[4] Detailed description and justification of the criteria for interpretive arguments: Lumer, 1990, pp. 223-246; detailed example of an application for text interpretation: Lumer, 1992; English description of the procedure: Lumer, 2010, sect. 6.

text interpretation to find out the intended meaning etc. In its application to cognition or argument from expert opinion, there is a fact known with certainty, viz. the expert's assertion that *p* or the arguer's report of such an assertion; perhaps some further relevant facts are known as well. 1. In a first step of the cognition procedure one constructs possible explanations of these facts, so-called *interpretations*, which, because not all relevant facts are known, have to include mere possible hypotheses. Among these hypotheses there are also some about the proposition in question, i.e. that *p* is true or that something incompatible with *p* is true and was part of the events leading to the expert's or the arguer's assertion. For instance, the straight interpretation says that the expert has checked whether *p*, has come to the conclusion that *p*, and has also expressed this truthfully; or an odd interpretation e.g. assumes that *p* in fact was not true but that the expert made a measurement error during the observation, which made it appear to him that *p*, etc. 2. Once having found all possible interpretations i_1, …, i_n – or at least the most relevant of them –, in a second step the prior probabilities P_0i_1, …, P_0i_n of these interpretations are determined: How probable is the combination of the mere hypotheses assumed in them? 3. In the third step, finally, the posterior probabilities of *p* is established: From the interpretations i_1, …, i_n, those according to which *p* is true are marked; let's call these interpretations i_1, …, i_m with $m \leq n$. The posterior probability of *p* is then given by the formula IP:

> *IP: Interpretation based probability:* $P_1p = (P_0i_1+\ldots+P_0i_m) / (P_0i_1+\ldots+P_0i_n)$.

Applying this procedure and formular to various examples the following observations can be made.

1. Interpretive cognition and argumentation come to the same result as the detailed Bayesian updating (described in section 7), if all probabilities are assumed to be equal. This is because in the end both calculatione are based on the same formular.
2. Also with interpretive arguments, an extreme dependence of the resulting posterior probability of *p* on the corresponding prior results. In contrast to Bayesian updating, however, these prior probabilities can also be ignored or assumed to be neutral values. And this should indeed be done if these prior probabilities are poorly justified, i.e. significantly worse than the expert's findings.
3. Interpretative arguments are based on the procedure that certain facts are explained in relative detail, where in these explanations also the circumstantial evidences must be taken into account. These explanations may then go into more or less detail on critical points in

the process which led to the explanandum. Thereby, the explanations, on the one hand, are relatively detailed but, on the other, flexible. The alternative interpretations are usually not created by permutation on the fulfillment or not of few key issues, because otherwise, i.e. taking into account also detailed variants, much too many and no longer manageable alternatives would result. Rather, main interpretations are considered, and where necessary subdivided into subinterpretations; however, some of these subinterpretations are not considered further, but eliminated as irrelevant because of impossibility or too low, only marginal probability.
4. The premises of the probability calculation in interpretive arguments are unconditional prior probabilities of possible interpretations ($P_0 i_j$). These prior probabilities are often much easier to determine than the conditional probabilities required for Bayesian updating.

9. COGNITION AND ARGUMENTATION FROM TWO OR MORE EXPERT OPINIONS

Today's difficulties with recognition on the basis of expert opinions arise to a large extent from the fact that not only the opinions of one, but of several experts to some question are known, which then often contradict each other. One can then no longer simply refer to *the* experts. How can a novice determine the probabilities of the theses in question in such situations using probabilistic methods? Goldman has discussed at length the proposal to decide in such cases according to the number of experts. Goldman rejected this proposal for two reasons. For one, the expert opinions could be very differently well founded. For another, the expert opinions are often not independent of each other; if one expert blindly follows another, the statement of the first does not provide additional evidence. (Goldman, 2001, pp. 97-103)

Of the three probabilistic methods for novices for cognition from expert opinions discussed here, statistical inference cannot be used to treat such complex cases. Because as a rule, there are no statistics that could provide information on the relative frequency of true theses among the theses put forward by conflicting experts. The other two methods, on the other hand, can in principle deal with such cases.

The basic procedure of Bayesian updating with several, in particular also contradictory expert opinions is the sequential updating of the degree of belief (Hahn, Oaksford & Harris, 2013, p. 24). The procedure described above is thus applied several times in succession. After applying the procedure to the first evidence, i.e. the first expert statement, one obtains a posterior probability of p, which now forms the prior probability of p in the second application of the procedure to the second expert statement. If the social reliability of the second expert is estimated to be above 0.5, his consenting statement increases the posterior probability of p and his contradicting statement lowers it. But even with this double application of Bayesian updating, the original prior probability of the cognizing subject is still very dominant. If, for example, the cognizing subject and the first expert are of the same opinion, then however a new independent, but contradictory expert with the same reliability is considered, the posterior probability of p is lowered, but not back to the initial level. The successive application of Bayesian updating also holds the danger that possible dependencies between the various expert opinions will be neglected.

Interpretive arguments, on the other hand, treat the multitude of expert statements and in particular contradictory expert opinions as an overall date: comprehensive hypothetical explanations, interpretations and prior probabilities are sought for the entire situation of (contradictory) expert statements. In these interpretations all connections between the individual expert utterances, influences by interests, by biases etc. can be then also dealt with and so a coherent explanation of the entire situation can be supplied. Determining the prior probabilities of these comprehensive interpretations is often difficult, but certainly easier overall, than successively determining increasingly complex conditional probabilities of the type $P_1(Ae_2,\neg p \mid p\&v\&t \,\&\, Ae_1,p)$. The resulting probabilities of both methods would have to be the same if the procedure was correct. But the way there via the interpretive argument is much clearer and simpler and thus less error-prone.

10. WHAT TYPE OF ARGUMENT FROM EXPERT OPINION SHOULD ONE USE?

If all these three types of probabilistic cognition from expert opinion are valid which one shall we use?

All three cognition procedures presuppose suitable premises; and these must be justified, according to the epistemological approach. Sometimes the appropriate premise is not known; then the procedure cannot be applied. This is particularly the case with statistical inferences when contradictory expert statements are present. In many other cases, especially with Bayesian updating or interpretive arguments, these premises are in principle also missing. But a frequent practice then is to use very weakly justified premises in such places: estimates – occasionally taking into account the known information, but often also quickly produced mere intuitions. If, in principle, several methods can be used that may lead to contradictory results, which one should be used? One aspect to be considered when answering this question is also the effort; well-founded Bayesian updating and interpretive reasoning are usually much more complex than statistical inferences. The effort must then be rationally weighed against the epistemic gain. With an unimportant question the epistemic advantage may be too small to justify the effort by an elaborate procedure. In important questions the higher expenditure might be justified. Such questions of effort are excluded in the following, and only the epistemic side is considered.

In the case of different methods of cognition and argumentation on the same question, whose epistemic prerequisites for application are all fulfilled, but which lead to contradictory answers, according to the epistemiological approach, the method that is more strongly justified is epistemically better. Elsewhere (Lumer, 2018) I have outlined a theory of justification strength with which this strength can be determined and which is to be used as a basis here.

According to this approach, the strength of a justification is determined multiplicatively from the strengths in six dimensions, namely:

D1: justification strength of the premises or the data used,

D2: truthfulness of the justification procedure (how often does the correct application lead to a true answer?),

D3: examination intensity and extensity,

D4: the yieldingness of the foundational material (e.g. (un)clean samples, (un)sharp photos),

D5: correctness, fault-freeness in the application of the justification procedure,

D6: metatheoretical certainty about the justification procedure.

Differences between the three probabilistic cognition methods based on expert statements essentially result from the dimensions D1 (justification strength of the premises) and D5 (correct application of the method).

All three cognition procedures require information about the reliability of the expert and, in the extended argumentation version, also about the arguer. In the basic form of statistical inferences based on expert opinion, this is usually the only really problematic premise. All other methods contain additional problematic premise. Therefore, the basic form of statistical reasoning on the basis of expert opinions, if it is applicable, always leads to stronger justifications than the other two methods. Also statistical inferences which are extended by the consideration of the step from the expert assertion to arguer’s claim, if they are applicable, lead to stronger justifications than the other two main forms of cognition from expert opinion, because the latter argumentations must make the same step and then contain again further problematic premises.

However, Bayesian updating and interpretive argumentation are applicable in many cases where simple statistical inference is no longer possible. In principle, both more complex methods (Bayesian updating and interpretive arguments) use the same premises except for one possible exception – but often in a hidden way. Then one or the other method may use the better justified premises, depending on the particular case.

Besides, the recourse to justification strength also implies a theoretical solution for cases in which the expert makes an unbelievable assertion. An assertion is only unbelievable if it contradicts the prior assumptions; in this case, the cognizing subject must in fact already have an at least weakly justified belief with respect to *p*, namely that *p* is wrong. If this belief is sufficiently strongly justified it can then be used to reject the "expert" and to reduce his credibility.

Correctness in the application (D5) is actually also an aspect that does not concern the procedure itself, but its application. But the procedures are more or less complicated and thus promote incorrect applications to a greater or lesser extent. Statistical inference also has the advantage over the other methods in this respect. However, there are differences between the latter, more complex procedures: If the knowledge subject already has a reasonably well-founded belief about *p*, then, if there are no further complications to consider, Bayesian updating is the simpler procedure. In more complex situations, especially when there are several and above all contradictory expert statements, the interpretive argumentation (especially with regard to detail) is often the clearer procedure, whose premise probabilities are also easier to determine. Likewise, the posterior probabilities of the interpretations and thus also of the thesis are easier to calculate and intuitively easier to estimate than the Bayesian posteriors, because the former are proportional to the interpretations' prior probabilities.

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