

The epistemological status and cognitive limits of technology assessment

1. Relevance of cognitive problems in TA

In the literature on TA, there has been a tendency in recent years for the relevance of cognitive problems to be increasingly devalued in favor of discussion of communication problems in the TA process or implementation problems (cf. some of the articles in Petermann 1991). Of the possible explanations, the following (with the exception of the first point) should all apply to some extent:

- (a) Success: The cognitive problems are largely solved. It would then be logical to address the other (non-cognitive) problems in order to optimize TA.
- (b) Resignation: The cognitive problems are recognized as unsolvable. The only hope that remains is to compensate by making special efforts in other areas.
- (c) Insensitivity: The realization that the success-determining aspects of TA do not lie in the area of cognitive problems, but in communication.
- (d) Systems theory: If the relevance of problems is only seen at the level of second-order observation (Luhmann 1984, 1990), then talking about cognitive problems seems almost old European.

The fact that communication is of fundamental importance in technology development is as true as it is trivial: no matter how good the TA results are, they will remain ineffective if they are not communicated in a suitable forum. However, the counter-question must also be allowed as to whether all TA results that are communicated in a suitable forum have a fruitful effect there, regardless of the cognitive quality of what is communicated.

The thesis that dealing with the cognitive problems of TA is not only not anachronistic, but even urgently required, is supported by an argument that cannot be ignored for reasons of action theory. The methodological primacy of the cognitive side follows from the fact that reliable TA results must first be available before any thought can be given to communicating and implementing these results. No matter how good the policy of implementing TA results is, sooner or later it will disavow itself if the implemented results prove to be nonsensical,

inappropriate or otherwise counterproductive in relation to the expectations of TA.

Furthermore, the role responsibility of TA requires that it fulfills its task of informing the decision-maker about the risk remaining in its own statements, namely about the reliability of its statements. This task alone requires a cognitive and scientific-theoretical effort, namely a reflexive focus on the validity of the results produced.

If one also considers that the critical function of TA vis-à-vis particular interests can only be maintained through scientific-theoretical efforts, this is a further argument for reflecting on the validity problems of TA statements. Disregarding the cognitive side of TA would therefore not be conducive to its own business in several respects. The dependence of TA on the cognitive quality of its results should thus be sufficiently proven.

2. Fields of investigation and methodological approach

Dealing with cognitive statements of TA implies a renunciation of the assessment of evaluative statements: It is only about the cognitive function of TA. Methodologically, cognition precedes evaluation: Before a fact can be assessed under previously justified criteria, it must be recognized, i.e., a descriptive sentence containing this fact must be available.

In the analysis, TA statements are differentiated according to their decision- and action-theoretical status:

- Statements about means-ends relationships, degrees or possibilities of achieving the purposes through new technology (problem-induced TA).
- Statements about all classes of consequences of the introduction (or the decision to introduce) (production, use, disposal) of a technology (technology-induced TA).
- Statements about current or future contexts of technology implementation and use: Need for use or problem-solving, future actual use, acceptance, etc. (any TA).

Particular problems of knowledge arise, for example, in the areas of:

- quantified knowledge,
- assessment of risks,
- determination of causal relationships and chains,
- long chains of effects.

The omnipresent problem of forecasting TA statements is different in each of these areas. I will deal with some basic problems, such as the *ex ante* assessment of their reliability, in Sec. 3 and 4.

3. Epistemological status of TA

Central concepts of epistemology are truth, falsifiability and justification. The epistemological status of TA is discussed below along these concepts.

The concept of truth in constructive philosophy of science (Lorenzen 1987; Hartmann 1990; Grunwald 1989) as a situation-invariant justification of a statement places the verifiability of the results of actions at the beginning of justification chains. It may come as a surprise that this concept of truth is mentioned in connection with TA, since TA statements are always statements about future circumstances that cannot be conclusively assessed for truth and are therefore justifiable but not capable of truth. Insofar as we are dealing with predictions of action contexts, this objection can be accepted immediately. When predicting the consequences of actions (including the consequences of technology), however, a differentiation is appropriate.

A distinction should be made between the situation-invariant (and thus necessarily) occurring and the situation-dependent (contingent) consequences of an action. Necessary are, for example, secondary consequences of technical action that can be deduced from the design plan of a machine, since the use of the corresponding machine necessarily leads to these secondary consequences. They are inherent to the technology and can therefore be derived analytically from the design principles of the technology in question. The occurrence of contingent secondary consequences, on the other hand, depends on the circumstances at the time the corresponding actions are carried out. The distinction between “situation-variant or situation-invariant” reconstructs the common ontological distinctions between direct and indirect consequences or consequences and effects from the perspective of action theory.

Since statements about contingent secondary consequences always depend on prognostic and therefore non-truthful statements about future situations, statements of this kind are not truthful. In contrast, analytical knowledge of consequences is certainly capable of truth (Janich 1994). This is because if this knowledge can be derived from the design plan of a technology, it can be conclusively tested for truth by making a decision about it in the laboratory.

Since the contingent consequences or secondary consequences are usually of decisive importance in TA practice, the question arises as to the relevance of the concept of truth in an epistemological assessment of TA. Trivially, the reliable determination of analytical side-effects is the methodological and logical prerequisite for the discussion of contingent side-effects. The importance of analytical consequence statements is therefore evident.

On the other hand, the question of the advantage of truth-predicated statements leads to the concept of reliability. In constructive philosophy of science, labeling a statement as true allows it to be judged as reliable relative to a pre-discursive agreement (Grunwald 1989). However, if the (usually more relevant) contingent TA statements are not capable of being true, their reliability cannot be guaranteed. Worse still, it is not even possible to reliably determine the degree of reliability of statements and thus the risk involved in decisions based on them. This is because such a determination would itself be a forecast that would have to face the question of reliability. This consideration obviously leads to an infinite regress.

Now, in the tradition of critical rationalism, one could use the criterion of falsifiability and attempt to operationalize the reliability of TA statements by means of the concept of the degree of reliability, based on the classification of TA statements proposed in Sec. 2.

Statements about means-ends relations, degrees or possibilities of achieving the purposes through new technology are falsifiable: It may turn out empirically that a technology in which great hopes were placed does not lead to the planned purpose realization after all, or not to the full extent. Reflecting on such failures is the engine of learning through the improvement of means-ends relations and their application conditions.

Statements about current or future contexts of technology implementation, such as the need for use or problem-solving, acceptance, etc., on the other hand, can only be falsified if self-influencing forecasts can be ruled out. If actions are carried out on the basis of predictions in such a way that the prediction actually occurs or does not occur, empirical and methodologically independent falsification would not be possible.

Finally, situation-variant statements about all classes of consequences of the introduction of a technology are, since they depend on context predictions, even more subject to falsification. In part, they are purely hypothetical in nature: Whenever it is a matter of weighing up alternatives, which is only possible on the basis of predicted degrees of purpose achievement, secondary consequences, etc.,

the statements about alternatives that are not chosen can never be verified (cf. Weyer 1994).

Even if some of the TA statements are falsifiable, there is a pragmatic reason why this criterion cannot be used in TA. This is because the problem situation in TA is completely different from that in the natural sciences, from which the principle of falsifiability is adopted. TA is not concerned with the repeatability of experiments under variable parameter conditions to test the validity of hypotheses, but with generally singular cases of the realization of technologies. There is no interest here in falsifying hypotheses, nor are time or resources usually made available for this. Rather, the aim of TA is to contribute in a comprehensive sense to the success of technical development and the achievement of its purposes in each individual case.

If truth and degree of reliability are largely omitted as categories in the operational assessment of the reliability of TA statements, the question arises as to how TA can constructively deal with the dilemma that prognostic statements should be decision-oriented about technology whose reliability can neither be reliably assessed *ex ante* nor even guaranteed.

According to the thesis, the concept of justification functions as a pragmatic substitute for the guarantee of reliability in complex decision-making situations in pluralistic societies. It is the justification of TA statements that is decision-oriented, not the reliability of the statement. If reliability were the decisive attribute of prognostic TA statements, the only remaining option would be to wait for them to materialize or not. The fact that the reliability of forecasts cannot be guaranteed is compensated for discursively and pragmatically by justifications: The quality of a justification determines the degree to which a future-oriented argumentation can be accepted in technology discourses.

The justification of a TA statement turns out to be a decisive epistemological touchstone of TA because it determines the claim to validity in technology discourses. Non-violent conflict resolution in modern plurality requires as a formal criterion the critical comparison of the scope of the validity claim of competing justifications. At this point, we are thus referred to trans-subjective justification as the epistemological core of the TA problem (on procedural justification and justification procedures, cf. Gethmann 1979, 1982).

If we continue to ask, with a reconstructive intention, about the purposes of substantiating predictions, it is clear that neither a guarantee nor an increase in accuracy can be decisive arguments (although an empirical study would presumably show that substantiated predictions are in most cases more accurate than unsubstantiated ones). Because fortune-tellers can make astonishingly good

predictions in individual cases, a substantiated prediction is by no means more accurate per se than an unsubstantiated one.

The significance of the justification lies rather in the fact that it lends trans-subjectivity to the prediction. A fortune teller's prediction can only be believed or rejected: It cannot be understood trans-subjectively with reasons and is not capable of discourse. Only scientific justifications of TA predictions make it possible to make rational decisions in modern pluralistic societies by justifying the decision-oriented predictions and thus making them comprehensible to everyone. In this way, they are able to compensate for the impossibility of guaranteeing reliability by fulfilling the universal claim to validity that must be directed at decision-oriented TA statements. The justifications in TA must therefore also be taken into account from this perspective.

The epistemological status of TA could thus be classified according to different types of justification from a pragmatic perspective. These could include, for example:

- true sentences as situation-invariant justified sentences (analytical sequences),
- deductive-nomological predictions based on knowledge of the law,
- other forms of TA statements (Delphi forecasts, etc.).

However, no further details can be provided in this article.

4. Cognitive limits of TA

Cognitive limits of TA as limits to its justifiability will be explained below using quantitative results and deductive-nomological prognoses (for more details see Grunwald 1994a, 1994b).

Quantification is a way of acting that assigns numerical values to certain quantities of a subject area – without the access of quantifying action, everything is initially qualitative. Its purpose is to establish intersubjectively comprehensible and reproducible comparability. A necessary prerequisite for quantification in TA would therefore be that procedures and quantification rules can be defined that guarantee the intersubjective and situation-invariant reproducibility of the assignment of numerical values.

Such a prescriptive theory of measurement exists for the quantitative natural sciences (Lorenzen 1987 and the literature cited there). The success of quantitative methods in the natural sciences is based on the fact that they can actually

be applied in a “value-neutral” way. In the social and cultural sciences, on the other hand, no such strict decoupling of ethics and politics is possible (Janich 1979). For example, the assignment of a monetary measure to a commodity is not independent of political and ethical questions, as no universal procedure for determining this value can be specified. Rather, the significance of quantitative measures for culturally determined values lies precisely in their dependence on situations, actions and decisions.

If it is only about the descriptive recording of variables and not about forecasts, this restriction is not yet a cognitive limit. The absence of situation-invariant quantification norms then merely relativizes the statements with regard to situation variance. Situation-invariant statements – and this applies to all cultural studies – are, however, only insufficiently suitable for justifying forecasts, because the future situations for which forecasts are made can be different and, as a rule, are also different due to the unpredictability of human actions.

Renouncing quantification does not mean renouncing objectivity, as is often claimed (Shrader-Frechette 1982). The distinctions subjective/objective and qualitative/quantitative are linguistically pragmatically independent of each other. Objectivity is constituted as the result of reasoning discourses. This can be achieved for both quantitative and qualitative statements.

The question of the conditions for the possibility of proving laws of progression as a prerequisite for deductive-nomological predictions leads to the following: For a law of progression to be recognized as proven, the corresponding progression must be reproducible. However, reproducibility can only be verified if it is possible to reproduce the initial situation, i.e., a finite system of rules must be specified, the observance of which results in the production of the initial situation. If the same effect occurs again and again in the produced initial situation, the law of progression is considered to be true. The following therefore applies: The validity of progression laws requires the reproducibility of the initial situation as a necessary condition and the reproducibility of the same effect as a sufficient condition.

Due to people's ability to learn, the necessary condition for the proof of laws of progression is not fulfilled in the case of social technological consequences. Therefore, one should not speak of laws of progression in connection with social developments and should not make any corresponding forecasts. As with questions of quantifiability, the situation-independence that would be necessary to establish laws of progression is not given here either. The cognitive limit is that predictions in the social sphere are inevitably situation-dependent, namely in relation to the concrete and changing meaning and knowledge of people.

5. The theory-practice dilemma of TA and its resolution

The cognitive limits of TA as the limits of the justifiability of its results are simultaneously the limits of its rationality. Because they are uncomfortable, such problematizations of scientific theory often remain without consequences – in TA no differently than in the specialist sciences. Johannes Weyer (1994) constructs a theory-practice dilemma at this point: However, “expert opinions are delivered to the various clients that do what is described as impossible in theoretical reflections, namely: anticipating the future and participating in its planned design” (Weyer 1994, p. 7).

In fact, the theory says that the anticipation of the future cannot succeed, i.e., that no matter how good the justification, it must not be confused with a guarantee of reliability. However, according to G.W.F. Hegel, one cannot rationally demand what cannot succeed. It is therefore one of the aims of this article to support the gradual reorientation of TA away from a focus on anticipation and toward a focus on justification and planning. TA cannot be about making “correct forecasts,” as this term cannot be operationalized: There is no other way to determine whether a forecast is correct than to wait and see. However, this is generally pointless because the technology-related decision has to be made *ex ante*.

Furthermore, the widespread misunderstanding that the task of TA is to forecast the development of technology must be dispelled. Weyer (1994, p. 11), for example, asks “what TA can be useful for if not for the reasonably reliable prediction of future developments in technology.” However, this would be both an excessive demand and a failure of purpose. TA as decision advice is not intended to anticipate the future, but rather to substantiate the hypothetical consequences of individual decisions. TA is never generally about the development of “the” technology.

As discussed, taking the impossibility of anticipating the future seriously requires a shift from the question of reliability to the question of justification. Justifications enable the trans-subjective recognition of TA statements as a common basis for decision-making, action and planning. In this way, one of the main functions of TA comes into view, namely to exercise a conflict-regulating function in technology discourses. As a discourse moderator, TA is dependent on critically examining the validity of the arguments put forward and thus the justifications. It must therefore be all the more careful to attach particular weight to the justifications for its own statements. In this way, TA is placed at the center

of a social technology control and risk minimization strategy in questions of technology.

In this way, the theory-practice dilemma proves to be an apparent dilemma: It is resolved in pragmatic reflection by the fact that the planned shaping of the future is by no means dependent on its anticipation, as the above quote from Weyer suggests. Rather, planned shaping of the future is possible through collective reference to trans-subjectively set purposes and the respective available trans-subjective knowledge of action and prognosis. However, trans-subjectivity can only be produced discursively in justifications.

Literature

- Gethmann, Carl Friedrich (1979): *Protologik: Untersuchungen zur formalen Pragmatik von Begründungsdiskursen*. 1st ed., Frankfurt am Main: Suhrkamp.
- Gethmann, Carl Friedrich (1982): *Proto-Ethik. Zur formalen Pragmatik von Rechtfertigungsdiskursen*. In: Stachowiak, Herbert; Ellwein, Thomas; Herrmann, Theo; Stapf, Kurt (eds.): *Bedürfnisse, Werte und Normen im Wandel*, Vol. 1. München, Paderborn: Schöningh, pp. 113–143.
- Grunwald, Armin (1994a): *Prognostizierbarkeit von Technikfolgen der Raumfahrt*. In: Grunwald, Armin, Sax, Hartmut (eds.): *Technikbeurteilung in der Raumfahrt: Anforderungen, Methoden, Wirkungen*. Berlin: Edition Sigma, pp. 74–87.
- Grunwald, Armin (1994b): *Wissenschaftstheoretische Anmerkungen zur Technikfolgenabschätzung: Die Prognose- und Quantifizierungsproblematik*. In: *Journal for General Philosophy of Science* 25 (1), pp. 51–70. <https://doi.org/10.1007/BF00769276>
- Grunwald, Armin (1998): *Das prädiskursive Einverständnis. Wissenschaftlicher Wahrheitsbegriff und prozedurale Rechtfertigung*. In: *Journal for General Philosophy of Science* 29 (2), pp. 205–223. <https://doi.org/10.1023/A:1008275423019>
- Grunwald, Armin; Sax, Hartmut (1994): *Technikbeurteilung in der Raumfahrt: Anforderungen, Methoden, Wirkungen*. Berlin: Edition Sigma.
- Hartmann, Dirk (1990): *Konstruktive Fragelogik: vom Elementarsatz zur Logik von Frage und Antwort*. Mannheim: BI-Wissenschaftsverlag.
- Janich, Peter (1979): *Möglichkeiten und Grenzen quantitativer Methoden*. In: Mittelstraß, Jürgen (ed.): *Methodenprobleme der Wissenschaften vom gesellschaftlichen Handeln*. Frankfurt am Main: Suhrkamp, pp. 370–383.
- Janich, Peter (1994): *Beruht Technikfolgenabschätzung (TA) auf einem falschen Verständnis von Naturwissenschaft und Technik?* In: Grunwald, Armin, Sax, Hartmut (eds.): *Technikbeurteilung in der Raumfahrt. Anforderungen, Methoden, Wirkungen*. Berlin: Edition Sigma, pp. 160–172.
- Lorenzen, Paul (1987): *Lehrbuch der konstruktiven Wissenschaftstheorie*. Mannheim: Bibliographisches Institut.

- Luhmann, Niklas (1984): *Soziale Systeme: Grundriss einer allgemeinen Theorie*. 1st ed., Frankfurt am Main, Alexandria, VA: Suhrkamp, Alexander Street Press.
- Petermann, Thomas (1991): *Technikfolgen-Abschätzung als Technikforschung und Politikberatung*. Frankfurt am Main, New York: Campus.
- Shrader-Frechette, Kristin (1982): Das Quantifizierungsproblem bei der Technikbewertung. In: Rapp, Friedrich; Durbin, Paul T. (eds.): *Technikphilosophie in der Diskussion*. Wiesbaden: Vieweg+Teubner, pp. 123–138. https://doi.org/10.1007/978-3-322-89413-7_10
- Weyer, Johannes (1994): Wissenschaftstheoretische Implikationen des Praktisch-Werdens der sozialwissenschaftlichen Technikfolgenabschätzung. In: Weyer, Johannes (ed.): *Theorie und Praktiken der Technikfolgenabschätzung*. Wien: Profil Verlag, pp. 7–14.