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Artificial Intelligence as an Emerging Technology in the Pharmaceutical Industry: What are the Legal Challenges?

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This article explores the possibilities and challenges of implementing emerging technologies in the form of Artificial Intelligence in the Pharmaceutical Industry under the current European legal framework governing medicinal products and medical devices. This includes among other things the question, to which degree an AI-programmer or the pharmaceutical manufacturer using such AI can be held liable for damages caused by the decisions of an autonomously acting AI-system.

I. Introduction

Emerging technologies can be described as fast growing new technologies that have a prominent impact but also uncertain possible outcomes and uses.[1] Artificial Intelligence ('AI') has become an emerging technology with steadily growing impact on the Pharmaceutical Industry. For example, AI is already used in drug discovery to identify ligands of target proteins (see below under I.2).

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1 Daniele Rotolo et al 'What is an emerging technology' (2015) 44 Research Policy, 1827.

2 Annex 1, Commission staff working document Liability for emerging digital technologies accompanying the document Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions Artificial intelligence for Europe { SWD/2018/137 final}.

3 Hongming Chen et al, 'The rise of deep learning in drug discovery' (2018) 23 Drug Discovery Today 1241, 1242.

4 Jürgen Schmidhuber, 'Deep learning in neural networks': An overview' (2015) 61 Neural Networks; Thomas Hoeren and Maurice Niehoff 'Artificial Intelligence in Medical Diagnoses and the Right to Explanation' (2018) EDPL 308, 310.

1. Artificial Intelligence – Characteristics and Terminology

The term Artificial Intelligence (AI) is commonly used to refer to a range of technologies such as software, algorithms, processes, and robots that - contrary to machines only acting on human command - are able to acquire analytical capabilities and to perform tasks (often on the basis of 'machine learning' and 'big data' techniques).

Technically, the characteristics of AI can be described in broad terms as code 'that can reason, gather knowledge, plan intelligently, learn, communicate, perceive, and manipulate objects.'[2] The code (usually software) executes the assigned function by the use of algorithms which are processes or sets of rules to be followed in calculations or other problem-solving operations. 'Machine Learning' is a special field of AI where a machine is trained to identify patterns and develop solutions based on existing databases and algorithms. 'Deep Learning' is a subset of machine learning, using layered ('deep') hierarchic structures of algorithms in the form of artificial neural networks.[3]

A deep learning-AI-system learns contexts without any human intervention. The system is trained using big data components, ie large amounts of data. Based on the training data the system recognises correlations, structures, new patterns and questions the initial results and improves itself.[4]

As of now there exists no unified and legally binding definition of Artificial Intelligence (AI) for the European legal framework. However, a resolution of

the European Parliament on Civil Law Rules on Robotics (2015/2103(INL))[5] contains several recommendations to the commission to create special legislation on 'smart robots' including a definition of cyber physical systems, autonomous systems, smart autonomous robots and their subcategories by taking into consideration the following characteristics of a 'smart robot':

- the acquisition of autonomy through sensors and/or by exchanging data with its environment (inter-connectivity) and the trading and analysing of those data;
- self-learning from experience and by interaction (optional criterion);
- at least a minor physical support;
- the adaptation of its behaviour and actions to the environment;
- absence of life in the biological sense;[6]

The above definition of a 'smart robot' shares many characteristics - minus the requirement of a '*minor physical support*' – with the above-mentioned description of an AI by the Commission Staff working staff document.[7] The European Commission's Communication on AI also addresses most of these characteristics:[8]

> 'Artificial intelligence (AI) refers to systems that display intelligent behaviour by *analysing their environment* and taking actions – with some degree of *autonomy* – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (eg voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (eg advanced robots, autonomous cars, drones or Internet of Things applications).'

The above description was also used as a basic definition of AI in the 'Draft Ethics guidelines for trustworthy AI' (currently under revision) by the High-Level Expert Group on Artificial Intelligence (AI HLEG), a European Commission-backed working group made up of representatives from independent experts representing academia, industry, and civil society to develop EU policies.[9]

Key characteristics of a possible upcoming definition of AI within the European legal framework therefore will likely revolve around systems that artificially develop 'autonomy' by 'self-learning from experience or by interaction' and by 'adaptation of [their] behaviour and actions to the environment'.

The following sections provide an overview of how AI is already used in the Pharmaceutical Industry and which future applications of AI are currently being discussed.

2. AI in the Pharmaceutical Industry

Emerging technologies are already being used by the Pharmaceutical Industry in many different areas, ranging from the early stages of drug discovery to the diagnosis of patients in real-time:

Drug discovery is one of the most pivotal and time-consuming tasks in the pharmaceutical industry. Traditionally the search for new active pharmaceutical ingredient (API) employed high-throughput screening of thousands or millions of actual substances stored in a substance library. In recent years, big pharmaceutical companies, often in collaboration with institutes or firms specialized in Computer Science, have begun to use AI to shorten this process by computing the most likely candidates for a new active pharmaceutical ingredient (API),[10] eg by predictions

5 European Parliament resolution of 16th February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) (2018) OJ C 252/239.

6 European Parliament resolution of 16th February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) (2018) OJ C 252/239, 243.

7 Annex 1, Commission Staff working document 'Liability for emerging digital technologies accompanying the document Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions Artificial intelligence for Europe' {SWD/2018/137 final},< https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A52018SC0137> accessed 23 February 2019.

8 Commission 'Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions - Artificial Intelligence for Europe' (25 April 2018) <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0237&from=EN>accessed 23 February 2019.

9 Cf 'A definition of Artificial Intelligence: main capabilities and scientific disciplines' 18 December 2018, <https://ec.europa.eu/digital-single-market/en/news/definition-artificial-intelligence-main-capabilities-and-scientific-disciplines> accessed 23 February 2019, and 'Draft Ethics guidelines for trustworthy AI' from 18 December 2018, <https://ec.europa.eu/digital-single-market/en/news/draft-ethics-guidelines-trustworthy-ai> accessed 23 February 2019.

10 For example the Accelerating Therapies for Opportunities in Medicine (ATOM) partnership: Mullin, 'Pharma partnership applies deep learning to very big data' (2017) 95 Chemical & Engineering News.

of the Quantitative structure-activity / structure-property relationship (QSAR/QSPR). For example, AI is already used to predict the binding potential of molecules to (drug) targets, eg to identify ligands of target proteins and to make predictions about the toxicology of a substance.[11] Other firms use AI to repurpose already existing compounds by analysing their properties and predicting possible new indications ('Repurposing of known components').[12]

While – when looking beyond the early stages of drug discovery – AI is not yet used to completely substitute clinical trials, there are already efforts to organise such trials more efficiently with the help of AI. For example, AI can help to optimise recruitment for clinical trials by analysing eligibility and expected drop-out quotes of patients. On the market, AI is already promoted as a tool to screen and match patients with fitting eligibility criteria to corresponding open clinical trials by analysing questionnaires of the patients.

Beside the increasing use of AI for the various stages of drug development, pharmaceutical companies also employ this emerging technology in the field of diagnostics. Recently, a big pharmaceutical company has announced its plans to analyse voice samples obtained from clinical trials by AI to non-invasively predict Alzheimer's and neurodegenerative diseases before the emergence of clinical symptoms. Another example is the collaboration between a pharmaceutical company and a technology company that plans to analyse electro-cardiac data provided by smartwatches ('real-world-data') in real time via AI to detect anomalies.

3. Current Discussions about the Future Use of AI in the Pharmaceutical Industry

Currently the future use of AI is discussed in connection with the full or partial substitution of preclinical studies and clinical trials.

One major topic of discussion is, whether AI can substitute Phase I and II of clinical trials, so that the results of the AI would only have to be confirmed by a traditional Phase III study. Phase I and II studies involve risks for human life and health. For example, during the Tegenero-Phase I study, six test subjects suffered life-threatening conditions after the first application of the drug. Such risks could be avoided or minimised if the safety of the new drug is assessed by using an AI instead of human subjects by extrapolating potential health risks from the toxicology data of the new drug.

Going even further, it is also being discussed if AI can substitute control by placebo or standard-of-care treatments in Phase IIII studies.[13] For example, using placebos in trials may become problematic under ethical aspects if AI can correctly predict the outcome of administering placebos to test subjects on the basis of existing data. In addition, when only a small number of test subjects are available, eg for Orphan Drugs, A.I. may be used to extrapolate the existing data of clinical trials to generate a more broad and reliable database.

Especially with regard to statutory healthcare systems, drug research must not only take into account the safety, efficacy and tolerability of a new drug, but also its 'economic efficiency'. AI could be used to extrapolate already existing Real-World-Data to speed up lengthy Health-Technology-Assessments and Cost-Benefit-Evaluations of pharmaceuticals, as these assessments often require long phases of monitoring the drug under everyday life conditions.

II. Implementation of Emerging Technologies under the European Legal Framework

The current European legal framework provides no specific subset of rules for the use of AI in the pharmaceutical sector yet. The above mentioned recommendations by the European Parliament, including topics such as the creation of a special European Authority to register autonomous systems, ethical coding of autonomous systems and accompanying liability and insurance schemes are still in early development.

This leads to the question, to what extent the aforementioned emerging technologies can already be used to develop and manufacture medicinal products

11 Daniel Siegismund et al, 'Developing Deep Learning Applications for Life Science and Pharma Industry', (2018) Drug Res 68, 305.

12 Cf Chen et al, 'IBM Watson: How Cognitive Computing Can Be Applied to Big Data Challenges in Life Sciences Research' (2016), 38 Clinical Therapeutics, 688, 697.

13 Cf Burkhard Sträter, 'Datenverabeitung und Künstliche Intelligenz' (2018) Pharm Ind 80, Nr 10, 1323, 1325.

under the existing rules currently applicable to the research, development and manufacture of such goods.

1. The Legal Framework: Regulation of Medicinal Products, Medical Devices and Emerging Technologies under the European Law

To contribute to answering this question, our article will highlight selected aspects of the question whether the current European legal framework allows the use of AI for the research and development of medicinal products. Before examining the use of AI in the pharma sector, we have to examine how AI as a technology is regulated in the medical field, for example, if it generally must be qualified as a medical device. Therefore, we will examine whether AI-systems used for research, development and manufacture of medicinal products fall within the scope of the Medical Devices Directive 93/42/EEC 'MDD'[14] and the Regulation (EU) 2017/745[15] concerning medical devices 'MDR', which will be applicable in May 2022.

In a next step, we will examine if and to what extent the current European legal framework allows the use of emerging technologies, particularly AI, during the research, development and manufacture of medicinal products. This will entail an exemplary look at specific provisions of Directive 2001/83/EC (Community code relating to medicinal products for human use),[16] Regulation (EC) No 726/2004[17] on centralised authorisation procedure for medicinal products for human use, Directive 2001/20/EC (Clinical Trials Directive)[18] and an outlook on the changes that Regulation (EU) No 536/2014 (Clinical Trials Regulation)[19] might entail when possibly becoming applicable later this year, dependent on the functionality of the European Database. We excluded other legal aspects like patentability and data protection from the discussion in this article.[20]

2. AI as a Medical Device?

According to Article 1 (2) (a) MDD a 'medical device' means 'any instrument, apparatus, appliance, software, material or other article' intended by the manufacturer to be 'used for human beings' for a medical purpose. The delimitation of medicinal products at the end of Article 1 (2) MDD implies a direct effect of the medical device 'in or on the human body'. Thus, AI-systems directly supporting therapeutic measures, eg giving specific therapeutic advice or assisting in surgery, can be classified as medical devices. However, this is less certain for AI that provides no immediate therapeutic or diagnostic utility and is rather employed in more abstract preliminary stages of healthcare, eg the development of new active substances or formulations. As a result, whether an AI-system can be qualified as a medical device will have to be determined on a case-by-case assessment.

3. Preclinical Phase: The Search for Active Substances and Preclinical Trials using AI

Regardless of whether an emerging technology can be classified as a medical device or not, the question remains if, or to what extent, these new technologies can be used for pharmaceutical research and development of pharmaceuticals under the current Euro-

14 Council Directive 93/42/EEC of 14 June 1993 concerning medical devices [1993] OJ L 169/1.

15 Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC (2017) OJ L 117/1.

16 Directive 2001/83/EC of the European Parliament and of the Council of 6 November 2001 on the Community code relating to medicinal products for human use (2001), OJ L 311/67.

17 Regulation (EC) No 726/2004 of the European Parliament and of the Council of 31 March 2004 laying down Community procedures for the authorisation and supervision of medicinal products for human and veterinary use and establishing a European Medicines Agency (2004) OJ L 136/1.

18 Directive 2001/20/EC of the European Parliament and of the Council of 4 April 2001 on the approximation of the laws, regulations and administrative provisions of the Member States relating to the implementation of good clinical practice in the conduct of clinical trials on medicinal products for human use (2001) OJ L 121/34.

19 Regulation (EU) No 536/2014 of the European Parliament and of the Council of 16 April 2014 on clinical trials on medicinal products for human use, and repealing Directive 2001/20/EC (2014) OJL 158/1.

20 The implications of AI for the General Data Protection Regulation –Regulation (EU) 2016/679 (EU GDPR) are explored by Thomas Hoeren, Maurice Niehoff 'Artificial Intelligence in Medical Diagnoses and the Right to Explanation' (2018) EDPL, 308; Pierce 'Machine Learning for Diagnoses and treatment: Gymnastics for the GDPR' (2018) EDPL, 333.

pean legal framework. The first step in this process is the search for a new active pharmaceutical ingredient (API) which is then tested in preclinical trials.

a. Searching for New Substances/Formulations

As mentioned in the introduction (cf above I.3), AI is already used to speed up the search for new APIs and formulations by predicting the optimal structure and binding properties of molecules for further drug research. From a regulatory and legal point of view this use of AI does not raise any legal concerns, as long as Good Manufacturing Practice ('GMP') requirements are fulfilled (with regard to GMP, see also below II.5).

b. AI in Preclinical Studies

With regard to preclinical studies, there are still limitations for the use of AI under the current regulatory framework. According to Article 8 (3) of Directive 2001/83/EC, which is also applicable to centralised authorisation procedures pursuant to Article 6 (1) of Regulation (EC) 726/2004, the application for authorisation of a medicinal product 'shall be accompanied by the following particulars and documents, submitted in accordance with Annex I...': This comprises inter alia 'toxicological and pharmacological tests' (second indent of Article 8 (3i)). The nature of the toxicological tests is further specified in Annex I. For one, the acute toxicity test 'must be carried out in two or more mammalian species of known strain unless a single species can be justified.'[21] Thus, the wording of the Annex requires actual testing in live animals and does not allow for a complete substitution of this test by use of AI which computes the toxicity of the relevant substance. However, the wording does not restrain the use of AI to *supplement* the test in mammalians. For example, AI could extrapolate the data from the test conducted with mammalians and thus could possibly help to reduce the number of animals needed for testing.

Adhering to the requirements of the Annex I is not expressed by Article 8 (3) of Directive 2001/83/EC as a 'must' but as a 'shall'. This wording as an exercise of discretion theoretically allows for some leeway to override the requirements of Annex I if a balancing of interests leads to the conclusion that submission of test results according to Annex I cannot be justified. Eg, under the assumption that AI-toxicology tests provide the same safety for later human use of pharmaceuticals as traditional test with mammalians, the use of the latter could be questionable under animal protection aspects. In this case the term 'shall' in Article 8 (3) of Directive 2001/83/EC could be interpreted to use AI instead of mammalians to ascertain the toxicity. At least, with regard to the balancing of interests, AI-extrapolation of data gained from animal tests could help to reduce the number of animals needed for testing. In this case 'shall' could be interpreted to mean that toxicology tests as set out in Annex 1 can be submitted with a smaller sample size of animals tested when supplementing AI-data is provided. However, in practice – and without reliable proof of equivalence/superiority of AI toxicity testing in comparison to testing mammalians as set out in Annex I - it seems unlikely that the competent authorities will accept test results that were not generated in accordance with Annex I. As long as there is no reliable scientific evidence for the use of AI in toxicology testing, such AI testing will likely not be acceptable under the Annex. Also, the acceptance of AI for such testing will likely require an update of the Annex or the scientific guidelines by the scientific guidelines European Medicines Agency's Committee for Medicinal Products for Human Use.

As Annex I does not contain comparable requirements with regards to other aspect of the preclinical phase, eg pharmacological results, it stands to reason that submission of such data on the basis of AI is not prohibited under the Directive *per se*.

As a consequence, in the preclinical phase of drug development AI is already being used for a wide range of tasks, including the search for API's. However, in some cases, like toxicity tests, the European legal framework makes explicit mention of testing 'in vivo', so that a substitute of such tests is in practice not advisable yet.

4. AI as a Substitute for Clinical Trials (Scientific Evidence of AI Results)?

The above-mentioned considerations about the substitutability of drug testing using AI come into even

21 Annex I of Directive 2001/83/EC, Annex I Part 3: Toxicological and Pharmacological Tests, II. Performance of tests, Single Dose Test.

sharper focus with regard to 'clinical trials' which also 'shall' be provided by the applicant for marketing authorisation pursuant to Article 8 (3) of Directive 2001/83/EC.

According to Article 2(a) of Directive 2001/20/EC a 'clinical trial' is 'any investigation in *human subjects* intended to discover or verify the clinical, pharmacological and/or other pharmacodynamic effects of one or more investigational medicinal product(s)...'. The explicit requirement to investigate 'in human subjects' does not allow for a (complete) substitution of the investigation methods with AI. Again, as mentioned above with regard to preclinical trials, the wording of Article 8 (3) of Directive 2001/83/EC ('shall') does not prohibit supplementing clinical trial data with data extrapolated from AI *per se*. The use of AI for such purposes is especially apparent with regard to orphan drugs, where the patient population often is very small and only patients with special mutations etc. are amenable to the specific treatments. The use of AI might also help to accelerate and optimise the marketing authorisation procedures. It is already being discussed, if AI can substitute control by placebo or standard-of-care treatments in phase IIII studies or at least determine the standard for 'best supportive care'.[22] Furthermore, looking beyond the authorisation of a medicinal product, it becomes questionable to treat patients of phase IV studies with ineffective placebos, when comparable data could be extrapolated by AI.

Eventually, AI may provide a new class of evidence to prove efficacy and safety of medicinal products. The quality of evidence gained by AI – and the recognition of AI based/supported data by the authorities - will depend on the validity of the data used for the initial computations and the accountability of the AI-system. For example, AI could use real-world-data eg data from smartwatches with health-monitoring-applications or anonymised healthcare-data from the statutory health insurance systems. Whether real-world-data can be sufficiently processed to provide the same validity as data gathered from clinical trials is already subject of an ongoing discussion, in particular with regard to cost-benefit-evaluations for the statutory health insurance system[23]. Ideally, AI could use such data to extrapolate the cost-benefit-ratio of new drugs which have not been put on the market yet and thus could speed up health technology assessment procedures considerably.

With regard to the upcoming Regulation (EU) 536/2014 it is interesting to note that – at least with regard to the English language version of the Regulation – the terminology for clinical trials has changed slightly: Article 2 Nr 2 introduces a new definition of 'clinical trial' which simply uses the term 'subject' instead of 'human subject'. The term 'clinical trial' itself is now defined as a subset of the general term 'clinical study'[24] which is described as an 'investigation *in relation to* human subjects'. This differs slightly from the wording 'investigation *in* human subjects' employed by Directive 2001/20/EC for clinical trials. Currently it is rather clear that the wording of the Regulation aims at '[human] subjects'. However, the interpretation of the Regulation could become muddled in the future if the concept of an 'e-person' – as considered by the above-mentioned recommendations of the EU Parliament on robotics – is introduced and AIs could become legal subjects[25].

However, under the legal 'status quo' a complete substitution of clinical trials by AI is not practical yet.

5. Manufacturing: GMP for AI

AI used for pharmaceuticals can fall within the scope Annex 11 of the EU GMP Guidelines, as it applies to computerised systems which are defined as a set of software and hardware components which together fulfil certain functionalities. The Annex states that applications should be validated and the IT infrastructure should be qualified. Furthermore, where a computerised system replaces a manual operation, there should be no resultant decrease in *product quality, process control or quality assurance* and there should be no increase in the overall risk of the process.

The possibility to effectively validate and qualify AI-systems varies strongly with regard to the func-

22 Cf Burkhard Sträter, 'Datenverabeitung und Künstliche Intelligenz' (2018) Pharm Ind 80, Nr 10, 1323, 1325.

23 Thomas Gerst 'Real World Data? Nutzlos für die Datenbewertung?', (2016) Dtsch Artzebl; 113(13) A-62.

24 Cf Recital 4 of the Regulation (EU) 536/2014.

25 Recommendation 59 f, European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) (2018) OJ C 252/239, 250.

tion the AI is supposed to serve. On the one hand, where the AI performs tasks with discrete output values, eg image-recognition tasks, pre-prepared datasets can be used to test if the AI interprets the images correctly. On the other hand, where the AI is used to search for a new API, results cannot be compared with existing datasets for already existing APIs.

6. Liability for Damages caused by AI

Besides regulatory challenges, the use of AI in the pharmaceutical industry has also to address the question of liability when using AI, eg health-related damages caused by pharmaceuticals where safety and tolerability were computed incorrectly by the AI. A common problem when assigning liability for the use of emerging technologies is increased interconnectivity between different production stages: it gets increasingly difficult to pinpoint a specific subject for claiming damages when it remains unclear whether the cause for the damages can be traced back to deficient raw materials, construction errors, software malfunctions or simply misuse by the operator of the emerging technology. For the sake of clarity, this article will not address the manifold possibilities to attribute liability by contractual stipulations. Instead it will focus on some exemplary aspects of extra-contractual liability of the AI-programmer and of the pharmaceutical manufacturer using this AI, although more complex situations are easily imaginable (eg service provider of AI acting as a link between programmer and manufacturer).

a. Extra-contractual Liability for Damages caused by AI under the Current Legal Framework

Extra-contractual strict liability under Council Directive 85/374/EEC (Product Liability Directive – PLD) only applies to movables. Thus, if the AI is only used as software code and not embedded in a tangible system, the Directive will not apply.[26]

Hence, extra-contractual liability depends on the applicability of the law of torts, which are not yet based on unified European legal framework. Especially specifics regarding the causality and foreseeability of the damage differ between the Member States. These aspects are highly relevant as it can be questioned if damages are attributable to and foreseeable by the programmer of an AI that later makes autonomous decisions.[27]

b. New Concepts for an Extra-contractual Liability for Damages caused by AI

The EU Parliament has addressed this problem by calling on the Commission to explore, whether AI should be subject to a fault-based liability, strict liability, an obligatory insurance system or a completely new system of addressing liability.[28] Strict liability systems could eliminate many of the problems associated with ascertaining causality and foreseeability under the laws of tort. However, strict liability can weaken the incentive to actively minimise risks, as efforts to avoid foreseeable damages do not exonerate from the liability per se under such liability schemes; also strict liability can act as a barrier of entry for innovation, as small enterprises with limited assets may want to eschew the liability risks.[29] Other ideas of the European Parliament attributed liability to an 'e-person' could be misused to shield creators and users of AI from claims for damages[30]. Parts of the 'transparency' problems associated with a liability under the law of torts can be addressed by establishing a 'black box', which records data on every transaction carried out by the machine, including the logic that contributed to its decisions, and that ensures that each computation of the AI is doc-

26 Cf No 4.1 of Commission Staff Working Document on the free flow of data and emerging issues of the European data economy accompanying the document Communication Building a European data economy {COM(2017) 9 final} <https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=COM%3A2017%3A9%3AFIN> accessed 23 February 2019.

27 Yavar Bathaee, The artificial intelligence black box and the failure of intent and causation, Harvard Journal of Law & Technology (2019) Volume 31, 890, 982 f.

28 Recommendations 49 ff, European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) (2018) OJ C 252/239, 249.

29 Yavar Bathaee, The artificial intelligence black box and the failure of intent and causation, Harvard Journal of Law & Technology (2019) Volume 31, 890, 928 f.

30 Recommendations 59, European Parliament resolution of 16th February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) (2018) OJ C 252/239, 250: 'creating a specific legal status for robots in the long run, so that at least the most sophisticated autonomous robots could be established as having the status of electronic persons responsible for making good any damage they may cause, and possibly applying electronic personality to cases where robots make autonomous decisions or otherwise interact with third parties independently'.

umented and processed in a way that can be understood by humans.[31] One possible approach by the Commission which can be used to assess tort-based liability under the current law, is to tie the liability of the degree of instructions given by a person to the AI:

> 'Considers that, in principle, once the parties bearing the ultimate responsibility have been identified, their liability should be proportional to the actual level of instructions given to the robot and of its degree of autonomy, so that the greater a robot's learning capability or autonomy, and the longer a robot's training, the greater the responsibility of its trainer should be; ...'[32]

This implies that liability originally lies with the programmer giving instructions in form of the initial code of the AI which will then be changed by self-improvement of the autonomous system. Later, liability might shift from the programmer to a trainer, eg a pharmaceutical company feeding the AI with faulty data and thus leading the AI to wrong assumptions about medical correlations that ultimately lead to the damage of a person treated with an AI-developed drug.

The central question of the aforementioned approach is to assess the proportional effect of the instructions given by the parties (plural!) that have ultimate responsibility with regard to the damage. It is apparent that instructions given during the initial coding by a programmer without any pharmaceutical expertise cannot easily be compared to instructions given to the AI by an end-user in the pharmaceutical industry without any programming expertise. Therefore, liability for each discipline engaged in the creation and use of AI must be held accountable by its specific standards of care. The Annex of the recommendations of the European Parliament already sets out a charter with various sets of principles that should be adhered to by engineers, users and other parties engaged with autonomous systems.[33] For example, the charter comprises of principles like 'autonomy' (engineers should remain accountable for the social, environmental and human health impacts that robotics may impose on present and future generations) and 'reversibility' ('The ability to undo the last action or a sequence of actions allows users to undo undesired actions and get back to the 'good' stage of their work [ie training of the AI]').

III. Conclusion and Looking Ahead

Emerging technologies can already be used in a variety of aspects during the development and the preclinical phases. However, a full substitution of toxicity tests as set out in Annex I of Directive 2001/83/EC by AI computations is not feasible yet due to regulatory and practical considerations. The same is true for the full substitution of clinical trials in human subjects by AI. However, this could change, if the future regulatory framework or supplementing scientific guidelines establish AI as a new grade of evidence equal to the traditional methods of testing efficacy and safety of medicinal products. This will heavily depend on clear rules for and accountability of the AI-creators and/or users, the transparency and reversibility of the decision-making process of the AI and the quality of the data used for the AI.

There is no unified European legal framework to address specific aspects of extra-contractual liability with regard to emerging technologies, especially with regard to multi-causal damages. With regard to AI not embedded in tangible systems, the PLD will not apply and extra-contractual liability is limited to the law of torts until legislative efforts for a specific set of rules for robotics/AI have been established in the European Union. It remains to be seen if in the meantime criteria to assign liability – as discussed by the European Parliament in its recommendation for Civil Law Rules on Robotics – will be implemented into the current legal system via case-law.

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31 Recommendation 12, European Parliament resolution of 16th February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) (2018) OJ C 252/239, 244.

32 Recommendation 56, ibid 249.

33 Recommendation 56, ibid 253ff.