Augmented Human Technology Emergence & Regulation

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Abstract – **In five years 40% of enterprises are expected to be augmenting workers physically and cognitively. Despite benefits for improved efficiency, emerging Augmented Human (AH) is a concern for the dignity and safety of people. This means addressing new challenges for businesses following regulation troubled by technological change in national enhancement. These observations are introduced to this paper as emerging technology, AH, and regulation topics. Thereafter, a literature review presents the findings of emerging AH technology, ethical managerial issues, and regulatory implications. Research gaps are then discussed around the Collingridge dilemma and uncertainties assessing regulatory AH impact. The paper concludes AH advantageous, diverse, and tentatively regulatable with appeal for new laws. Future work is suggested for engineering solutions that enhance the very nexus between AH and socio-economic regulation for public trust.**

Index Terms – Augmentation; Emerging; Human; Regulation; Technology.

I. Introduction

A. Background

Businesses need to adapt ever more quickly to latest digital solutions to rival competitors [1]. This is not just because market growth and commercial advantage in information technology (IT) represent major benefits for company survival [2]. It is the result of new software regularly fluxed by rapid changes in further technological innovation [1]. To remain profitable, enterprises may continuously assess their technology management to optimise success [3]. For many enterprises looking at future investments, this requires identifying early development potential called Emerging Technology (ET). Lately, emerging Augmented Human (AH) technology has been promising efficiencies for business by boosting workforce capability. However, former debates about whether regulators should assimilate enhanced workers bring challenges to the technology.

B. Context

Identifying ET [4] can be a dubious task. Unlike complexity theory, emergent characteristics are often examined qualitatively [5]. A reoccurring problem with this approach is that no consensus may be reached on what constitutes ET. It can result in various meanings with gaps in identification lifecycle processes [6]. For precision, five 'existing' ET attributes have been discovered [7]. More recently, these properties have been continued with 'future' social characteristics [8]. In evaluating each attribute, 'uncertainty and ambiguity', and 'prominent impact', are found to have limited operationalisation as candidate constructs for new innovations [9]. Thus, an uncertain but impactful ET for business is particularly troublesome for managers [1]. That is, inextant social-ethical effects in ET may gamble new digital venture capital.

If ever there was an ET with propensity to benefit business it would be AH, remarked the defining debate for this century [10]. Researchers now ponder whether AH horizons are already here with cyborg communities [11]. Except this paper is about enterprises enhancing human workers. Utility derived for that use case is where human beings are integrated with emerging IT [12]. AH's transformational impact on business is presently a major ET appraised trend [13]. Before it reaches plateau productivity, AH technology timespans vary between five and over ten years. Its future suggests a counterpoise on technological unemployment odds [14]. So, the trend proposes new jobs creation for people sharpened by machines within industrial change [15].

Need for technology regulation is a contested topic. But the gravity of its inclusion hinges on risk ET bears on national control [16]. While forecasting techniques exist to develop socio-political futures [17], exacting regulative measures to inform design is problematic. Seemingly, this is owing to irreconcilable policymaking and ET holding uncertain legal traction. Existing regulation may consequently struggle with new technologies without juridical footprint [18]. This poser has drawn commentators to question regulatory aptness for ET in jurisprudence. There has been a call for better techniques to ascertain regulatory policy for ET management as a stimulus for roadmapping adaption processes [19]. However, a perennial discussion about regulation revolves around its duality to promote or prohibit innovation [20]. This brings perspectives on AH regulation and whether the technology might be impacted by it [21].

C. Motivation

Emerging AH is loaded with sundry thought on its purpose for the human condition. We can learn about its place in society from discussions in scientific, ethical, and legal literature. This paper conducts a literature review from these sources based on research questions:

1) What is emerging AH technology and how is it used in workplaces?

2) What key social and ethical issues do enterprises face with AH technology?

3) What regulatory implications are there for AH technology in companies?

Afterwards, a discussion of resulting gaps from the study is presented in terms of regulatory implications, before concluding with proposals for future work.

II. Literature Review

A. *What is emerging AH technology and how is it used in workplaces*?

Although the concept dates to the Renaissance [22], sources say AH is twenty-first century ET [13] [23] [24]. Benefits include enhanced: learning, performance, careers, motivation, stress reduction, and medical support [25] [26]. Next decade, consumerised personal augmentation is predicted for companies to seize for their workforces [27]. IT facilitating AH can be summarised as follows:

1) Terms: Across literature, 'Augmented Human' has variable but similar terminology, definitions, and synonyms as per Table I.

TABLE I
DEFINITIONS OF AUGMENTED HUMAN

Term	Definition
[28] Augmented Human	*'[T]echnologies that enhance human productivity or capability, or that somehow add to the human body or mind.'*
[29] Human Augmentation	*'[T]echnologies that improve human productivity or capability, or that somehow surpass restauration* [sic] *and add features to the human body…'*
[30] Human 2.0	*'[F]ield of human augmentation…focuses on creating cognitive and physical improvements as an integral part of the human body.'*
[31] Human augmentics	*'[T]echnologies for expanding the capabilities, and characteristics of humans.' '…to enhance the quality of life.'*
[32] Assistive Augmentation	*'[A]ssistive technology, user interfaces and interactions that seamlessly integrate with a user's mind, body, and behaviour…providing enhanced physical, sensorial and cognitive abilities.'*

According to [25], 'Human Augmentation' and 'Human 2.0' have the same definition as AH. Similar terms to AH are 'Assistive Augmentation' which counts sensory enhancement, and 'Human Augmentics' in its improvement of capability and life characteristics rather than production.

2) Fields: AH is shaped by certain disciplinary areas commonly overlapped with 'Human Enhancement' (HE), as seen in Table II.

TABLE II
FIELDS OF AH & HE

AH fields	HE fields
[22] *'[S]pans several technical fields and methodological approaches including Experimental Psychology, Human-Computer Interaction, Psychophysiology, and Artificial Intelligence'* [33] *'Augmented Reality/Virtual Reality, Artificial Intelligence, Robotics Cyborgs, Human Interface'*	[34] *'HE is a multidisciplinary field, which covers neuroscience, robotics, nanotechnologies, biotechnology and synthetic biology which can give rise to provisional (pharmaceutical drugs) or permanent modifications of human performances (genetic enhancement)'*

In the table, HE [28] cuts across *inter alia* biological sciences and technology, whereas AH tends to be concentrated on only commoditised technology and systems. This aligns with the conclusion in [28] that AH may cover less fields than HE. AH closely relates HE [28], can encompass HE [29], or can be HE [23]. However, the division may not necessarily be partitioned as such. In reference [29], AH includes HE determined by its purpose and durability. Furthermore, the fields of discipline of AH in [22] should not be regarded equally widespread or conclusive. Commentary highlights an emerging AH trend towards immersive technology for workspaces and AH may also embrace cloud technology [31].

3) Taxonomy: Across literature human characteristics can be sorted into categories for augmentation showing in Table III.

TABLE III
TAXONOMIES OF AH

AH taxonomy
[27] *Physical and cognitive*
[28] *Action, cognition, and senses*
[35] *Perception, physiology, and cognition*
[33] *Body, cognition, perception, and presence*
[36] *Sense, intellect, space/time, and motion*

Foremost, AH can be reduced to 'physical' and 'cognitive' classes that use host technology, sometimes the same sort, on or in a person's body. In contrast categories for HE involves: transient or permanent, incremental or radical, medical or technological, and disability or ability aiding technologies [37]. In 'physical', a tangible augment may extend across child classes: senses, appendages and biology, the brain, or genetics. Literature may provide separate high-level classes for physical subcategories recursively, such as 'sense' [28] [36], and from this, 'perception' [33], despite its parent relation with 'physiology' [35]. The entire body can be actioned [28] in terms of motion [36] or 'space/time' [36] to map telepresence [33] remotely or virtually beyond the limits of real places and schedules. On the cognitive side, technology serves to exploit the intangible capacity of human thinking holistically in order to learn better through improved experiences [27]. The term 'cognition' [28] [33] [35], 'cognitive' [30], or analogously, 'intellect' [36] closely couples with 'perception' as a popular AH class.

4) Technology: By year 2025 40% of enterprises will be architecting humans [38]. Use cases for technology are shown in Table IV and V.

TABLE IV
PHYSICAL WORKPLACE AUGMENTATION

Technology	Use case
[25] Exoskeletons	Paralysis support, military, and construction work
[13] [25] Embedded chips	Radio-frequency identification for office and machine access nanomeds reporting
[24] Head-mounted devices	MR/AR/VR[a] devices for enhanced legal work, and medical training
[13] [24] Biotech	Artificial blood to boost physical performance

[a]Mixed Reality/Augmented Reality/Virtual Reality

TABLE V
COGNITIVE WORKPLACE AUGMENTATION

Technology	Use case
[13] [25] Emotion AI	Human resources aptitude reports, and hazard management
[13] [39] Immersive workspaces	'Smart spaces' to emulate physical conference and training rooms
[13] [40] Augmented Intelligence	Assisting financers in recommending products via MR/AR/VR and voice experiences
[24] [25] Smart drugs	Workforce nootropics, image and performance enhancing drugs in sport

Certain technologies can augment both physical and cognitive human qualities by a mixture of techniques, even materials extracted from the body or grown [41]. There is obscurity in future methods like brain uploading, envisaged [24], or implausible [42], and whether AH is expensive [15] or not [26]. Sectors picking up current AH technology include rehabilitation, medical, and defence. The AH healthcare market is expected to bring circa 23% global growth by the year 2025 at just under £9 billion [43].

B. What key social and ethical issues do enterprises face with AH technology?

1) Purpose: AH relates to a long-standing paradigm debated prolifically in bioconservative and transhumanist theory. Affirmed in [26] and [32], it regards two human intervention types, viz: users with a medical case of reduced capabilities that may be restored, or users possessing no therapeutic cause for its application to extend super abilities. Fig. 1 depicts this along a continuum.

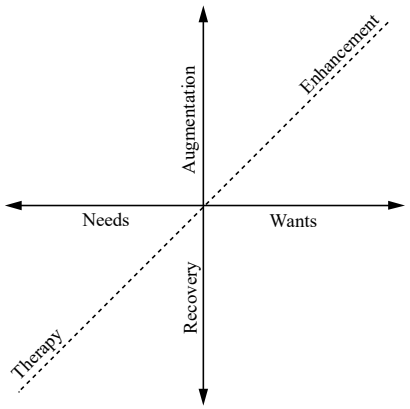

Fig. 1 Spectrum of AH – adapted from [32]

Dividing augmentation by intent may be inconsistent where there are identical effects on two people for whom either therapeutic or enhancement applies [24]. Conversely, demarcating at an arbitrary point is considered an economic necessity in society's limited resources [44]. Hence, academics will tend to agree there is no consensus. Research in [45] claims such a grey area obfuscates policy development, particularly in regard to commodity misuse.

2) Social influence: Members of the public hold negative views about mostly invasive enhancive technologies [46]. A study shows public disapproval increases proportionately to ideas raising enhancement levels [47]. In a European deliberative meeting organised by citizens, players advocated for restorative technologies over those providing abilities beyond norms [48]. Despite academic human normalcy paradoxes, user disinterest in enhancers is vocal about ethical and social implications possessing beyond human capabilities [47]. These range from concerns about tampering, suitability, and power misuse. This is an issue for managing workplace AH where incorporation success is said to depend on user acceptance and their social work network [26].

3) Humanness: In a survey conducted on emergent HE impacts, nearly 70% of respondents thought it likely that perceptions for what makes people human would change [24]. This might polarise masses based on whether or not they are fully human with labour markets seeing inequality between the two [43]. Likewise, [49] claims these divisions may disrupt performance appraisal fairness. As reference [24] shows, respondents view HE likely to affect human freedom. The report posits that companies may impose mandatory workers' enhancement to stay competitive. It also shares the view in [26] that unhuman work conditions could be vindicated for resilient users at the risk of their wellbeing. These are 'extreme' workers that have their capacity for work extended via technology [50].

4) Safety: The safety of AH workers has potential to be compromised. AH requires 'enormously enhanced' cybersecurity [25], warranting complex firewalls and protocols to protect assets and information from theft [49]. Also, malfunctioning systems and vulnerabilities pose a risk of danger [24]. Both risks lean on the cognition side, viewed in

[28] as more susceptible to privacy infringement. The reference says that the pervasiveness of emerging augmented cognition-ware infringes privacy such that a user is possibly rendered more susceptible. This research claims cognitive augmentation is most ethically laden, but sees sensory life-like immersive manipulation an issue too. Physical risks in errors are reported in [26], which reckons new technology dangers itself with imprecise risk-assessments.

C. *What regulatory implications are there for AH technology in companies?*

1) Frameworks: Studies in [26] maintain 'top-down' government regulation would serve employee interest rather than hybrid or bottom-up kinds. However, it should be borne in mind that regulation need not be characterised as prohibit or permit. It may also include subsidisation, deprivation, and choice [51]. Further structures can be delimited where AH regulation is mandatory and encouraged [26]. In reference [52] it is conceived that five approaches could be exercised for regulating augmenting product use in the European Union (EU) as: total ban, laissez-faire, pro-enhancement, restrictive, or a case-by-case. In a regulatory principles review for augmentation, [53] informs us that a legal framework could either govern all or isolated markets. The latter correlates with a preference for segmented data-oriented regulation over one size fits all policy [54].

2) Jurisdictions: We can learn about state regulatory scope by observing risks if it were devolved to local organisations. This is self-regulation thought perchance in [26] to dither harm risks, induce undignified bylaws, exploit workers, and levy dubious contracts. A precaution instead is to paramount nationalised protection such that human dignity should be balanced with safeguarding personal autonomy [55]. To exemplify, [56] avers state regulation should cover safety, age, and use in workplaces. Literature [52] concludes that AH technology be inadmissible if it has an intent to bodily disfigurement, impairs human will, desire, or rationality, and violates dignity, causing social inequity. In source [28] privacy, safety, and equality are utmost important. Devices that propel a body, or assist mobility for disabled people, are areas for regulation too [57], plus those which are hackable [58]. A 'no harm' rule is offered in [53], but the work also notes informed consent and best interests among codes. On the other hand, it is reported that AH device regulation should be dispensed with favouring a universal 'do no harm' ethos [59].

3) Rights: A range of fundamental rights *de lege ferenda* could materialise where current regulation is insufficient to account for emergent issues associated with deploying AH as per Table VI.

TABLE VI
AUGMENTED HUMAN RIGHTS

New envisioned rights
[60] [61] '*Right to cognitive liberty'*
[60] '*Right to mental privacy'*
[60] '*Right to mental integrity'*
[60] '*Right to psychological continuity'*
[61] '*Right to mental self-determination'*
[53] *Freedom of consent to augmentation*

An extended view on this issue [29] [55] is that a new human inducement legal concept would help facilitate regulative discourse on ET, and that humanity and legal personhood should be defined. Although theorist [62] says enhanced users remain human with access to the European Convention of Human Rights (ECHR). They also postulate the ECHR will affect different AH devices on: life, bodily integrity, inhuman or degrading treatment, privacy, torture, thought, expression, and fair trial. Moreover, [62] maintains that individual or state will be accountable for criminal acts in relation to enhancer use. In certain cases, even diminished responsibility could be claimable by an augmented defendant. From other research, AH intellectual property is considered. It is thought in [41] that the European Patent Convention and Biotechnology Directive usually allows AH patenting involving body parts that do not deleteriously affect human dignity. This is different to property rights, which [57] holds should not be used to control people in end-user license agreements.

III. DISCUSSION AND GAPS

Literature reviewed workplace AH, social-ethical management issues, and regulatory implications thereof. Together, they tell how emergent AH technology may undermine regulative agendas predisposed to a European legislature. Contrariwise, emerging digital innovations can be influenced by regulation. For example, regulation - social, ethical, or administrative - can dissuade or promote production with funding prospects for non-therapeutic enhancement studies [24] [20]. Yet, how IT engineering deals with regulatory impressions in AH is not so evidently profuse. Rather, the scientific AH response to regulation is uncertain. In many ways, gaps in this discussion come from unregulatable social and economic impacts rooted in sudden digital change [9]. Thus, legislators are said to act incrementally behind exponential changes in new technology [63] known as the 'pacing problem' [64]. Fig. 2 illustrates this principle.

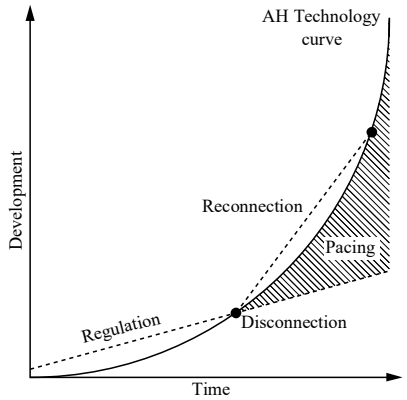

Fig. 2 AH technology pacing – adapted from [65] [66, p. 31]

As AH is qualitatively 'new', a lacuna between existing public policy [67] and its novelty may provoke a regulative 'disconnection' [68]. Disconnection may be such that it is

severed by new sociological norms in consumerism rather than ET per se [18]. For instance, researchers expect ET enhancements to become socially accepted as 'normal' [24]. This opinion is likened to [69] where it was proverbed that a human and their mobile phone would be indistinguishable to a Martian. It led to a decision that searching and removing mobile phones is impermissible without warrant. The ruling has been thought to brace a cyborg law fringe as a bodily data integration metaphor, which [57] warns would become invasive. Some businesses are convinced that biological boundaries are changing to meet modern business needs this way [25]. Still, in reality, most people today do not believe themselves to be biomechatronic organism from synthesis, as recognised at law [70]. This demonstrates that regulatory disconnections from AH could be allegorical in societal use or by data as a technical by-product concerning third-party doctrines [70].

It follows that reconnecting ET with regulation is a Collingridge dilemma - a double bind where if AH returns no regulatory mean, then its technological entrenchment may obscure reason for regulation [64]. Reversed consequences - no compliancy needs for AH and inflexible for regulation later - is seldom meditated within the selected literature. What we know is that experts believe regulation promotes or curtails science [29]. To wit, many participants at an IT and biotechnology TELOS conference were opposed to laws thought to diminish and burden scientific innovation [71]. Scholars too advise against national rules that could limit innovation while petitioning for policies that stimulate ethical practices [24] [59]. With reference to [18], it is professed that technical standards can discriminate against innovation by stopping future invention *usque ad coelum*. Yet, there are positives for experimentation. Based on [72], human rights can contribute to ET without placing hindrances to digital innovation. Specifically, it is recognised that public policy may be implicitly supporting better cognition in AH rather than reducing it [29]. Overall, it is also believed principally regulation accelerates innovation [73].

IV. Research Suggestions

From our discussion, technological influence on AH from regulation warrants legal forecasting [74]. However, we find regulators lagging in a pace driven gap by the technology [75]. Therefore, it is clear that hitherto AH has no national direction, at least, insofar as the EU. Research from 2012 shows there was no European normative framework regulating consumer augmentation markets [45] [76]. Last year's situation remains that no regulatory policy exists for enhancing technologies [24]. In previous administrations, councils have been set up to debate global legal affairs about enhancement [77]. Except observations are still absent from international states on AH measures to take in quantitative or empirical terms. This paper proposes transnational research on horizon scanning regulations altering topographical AH scalability.

Regulation may cover broader terms than literature reviewed by and large on state actors in this paper. For example, regulation can comprise alternative social and economic control mechanisms which capture soft laws [78]. Notionally, its future is a dependency network constrained individually by infrastructural, market, norms, and legal parameters acting in sum to determine behavioural rules [79]. Where immersive AH devices are connecting, this theory predicts that code as law will increase in cyberspace. Self-regulation of this form may likely question extents to which AH engineering would be affected by its own algorithmic governance, and consequently human will [80]. It is suggested that research on regulative sources with technical sway, present or future, would be critical to implementing right infrastructural designs for workplace management.

Given ethical ramifications underlying commercialised AH, it is submitted that enterprises should forecast regulatory shift on this technology. Looking at how regulation attempts to overcome uncertainty [81] may inspire such research [82]. For instance, it is advised that regulating new technologies should be executed proactively [83]. Others petition for responsive regulation driven by data, competition, and sandbox testing [84]. While this literature review shows 'special' regulation [85] required for AH devices concerning social uncertainties, it also suggests legislative status quo may suffice. Striking a balance here could resort to nuancing laws based on regulatory precedents [83]. However, this paper suggests research where technologists and regulators, or a union of their products, are closely coupled resembling the symbiotic machine human relation. Purposely, it would investigate IT pacing solutions for AH, including 'regulation by design' [86], 'precautionary principles' [87], 'regtech' [88], and 'techno-regulation' [89].

V. Conclusion & Future Work

A. Conclusion

This literature review gave a three-dimensional report on managing emerging AH for enterprises exploring workplace technology, social ethics, and regulatory implications. In conclusion:

1) AH is a multifarious term divided by physical and cognitive enhancements shaped by niche emerging markets, offering competitive benefits for enterprises to improve worker experience and efficiency.

2) While AH has commercial merits, negative public concern raises several ethical questions contested on its purpose for the human condition, how it affects workers humanness, and their safety.

3) National regulation that balances human dignity with safeguarding personal autonomy and information without harm or inequality is widely considered paramount for AH, but rights need not be enhanced too.

B. Future work

Mapping AH digital infrastructure affected by laws in an industrial adoption process is limited by its unregulated state as ET calculated to outpace public policy. Future work on methods testing and patching the technology in response to regulative movement is beneficial. But digital regulation also has social

significance when impacting part human IT. Following the conclusion respectfully, areas for this future work are:

1) Refining AH definition, plotting future AH business technologies, evaluating technological determinism, and sourcing research from more intercontinental literature.

2) Exploring collaborative methods which tie AH developers and regulators in design, patent, and marketing processes that can be publicly trusted for the human condition, while offering fair employment.

3) Proposing regulative monitoring tools, centralised and peer-to-peer, interfaced or written, in AH software that maps synchronically to system tier constraints on devices, less human interference.

The above points envision managing emergent AH with Achilles and Tortoise dispelled from the regulation vis-à-vis technology bond. By enabling contemporaneous synergies between them, AH might tune parallel to measures and tenders of socioeconomic change.

REFERENCES

[1] M. Zaki, "Digital transformation: harnessing digital technologies for the next generation of services," *Journal of Services Marketing,* vol. 33, no. 4, pp. 429-435, 2019.

[2] B. Dehning and T. Stratopoulos, "Determinants of a sustainable competitive advantage due to an IT-enabled strategy," *Journal of Strategic Information Systems,* vol. 12, no. 1, pp. 1-14, 2002.

[3] E. Unsal and D. Cetindamar , "Technology Management Capability: Definition and Its Measurement," *European International Journal of Science and Technology, ,* vol. 4, no. 2, pp. 181-186, 2015.

[4] H. A. Smith and J. D. McKeen, "IT Managemnt Forum - Emerging Technologies Management," [Online]. Available: https://smith.queensu.ca/_templates/documents/it-forum/emerging-technologies.pdf. [Accessed 9th November 2019].

[5] S. E. Cozzens, S. Gatchair, J. Kang, K. -S. Kim, H. J. Lee, G. Ordóñez and A. Porter , "Emerging technologies: quantitative identification and measurement.," *Technology Analysis & Strategic Managemen,* vol. 22, no. 3, p. 361–376., 2010.

[6] C. M. Christense, "Exploring the limits of the technology S-curve," *Production and Operations Management,* vol. 1, no. 4, p. 339, 1992b.

[7] R. Daniele, D. Hicks and B. Martin, "What is an emerging technology?," *Research Policy,* vol. 44, no. 10, p. 1827–1843, 2015.

[8] O. Litvinski, "Emerging Technology: Toward a Conceptual Definition," *International Journal of Trade, Economics and Finance,* vol. 9, no. 6, pp. 256-260, 2018.

[9] M. Halaweh, "Emerging Technology: What is it," *Journal of Technology Management and Innovation,* vol. 8, no. 3, pp. 112-113, 2013.

[10] P. Lin and F. Allhoff, "Against Unrestricted Human Enhancement," *Journal of Evolution and Technology,* vol. 18, no. 1, pp. 35-41, 2008.

[11] B. Dharmapalan and A. M. Thomas , "Your Friend Could Be A Cyborg!," *Science Reporter ,* vol. 54, no. 12, pp. 14-19, 2017.

[12] A. Albertin and R. de Moura, "The Benefits of Information Technology in Business Performance," in *Americas Conference on Information Systems (AMCIS).*, USA, pp. 871-872, 2004.

[13] K. Panetta, "5 Trends Appear on the Gartner Hype Cycle for Emerging Technologies, 2019," 12 August 2019. [Online]. Available: https://www.gartner.com/smarterwithgartner/5-trends-appear-on-the-gartner-hype-cycle-for-emerging-technologies-2019/. [Accessed 12 November 2019].

[14] C. B. Frey and M. Osborne, The Future of Employment, Oxford, p.3 : Oxford Martin Programme on Technology and Employment, 2013.

[15] L. Young, "A Spectrum of Human Augmentation," Strategic Business Insights, April 2017. [Online]. Available: http://www.strategicbusinessinsights.com/about/featured/2017/2017-04-spectrum-human-augmentation.shtml. [Accessed 04 12 2019].

[16] R. Brownsword and K. Yeung, Regulating Technologies: Legal Futures, Regulatory Frames and Technological Fixes, p. 5: Bloomsbury Publishing, 2008.

[17] D. Norburn, Blackwell Encyclopaedic Dictionary of Strategic Management, New York: Blackwell, 2005.

[18] L. B. Moses, "How to Think About Law, Regulation and Technology: Problems with 'Technology' as a Regulatory Target," *Law, Innovation and Technology 1-20; UNSW Law Research Paper No. 2014-30.,* vol. 5, no. 1, pp. 1-19, 2013.

[19] A. J. Groen and S. T. Walsh, "Introduction to the Field of Emerging Technology Management," *Creativity & Innovation Management,* vol. 22, no. 1, pp. 1-5, 2013.

[20] The Organisation for Economic Co-operation and Development (OECD), Regulatory reform and innovation, Paris: STI: Science. Technology. Industry, 1996c.

[21] W. D. Eggers and M. Turley , "The future of regulation: principles for regulating emerging technologies," Deloitte Center for Government Insights, 2018.

[22] B. Alicea, " An integrative introduction to human augmentation science," arXiv preprint arXiv:1804.10521, 2018.

[23] P. Brey , "Human enhancement and personal identity," in *New waves in philosophy of technology*, Springer, 2009, p. 169–185.

[24] S. R. Jensen, S. Nagel, P. Brey, T. Ditzel, R. Rodrigues, S. Broadhead, D. Wright, M. de Araujo and A. Resseguier, "D3.1 State-of-the-art Review WP3 – Human Enhancement," SIENNA, 2018.

[25] MYOB, " The Augmented Human," MYOB The Future of Business series special report , 2016.

[26] Academy of Medical Sciences, the British Academy, the Royal Academy of Engineering, and the Royal Society , "Human enhancement and the future of work," The Academy of Medical Sciences, London, 2012.

[27] K. Panetta, "Gartner Top 10 Strategic Technology Trends for 2020," Gartner Inc., 21 October 2019. [Online]. Available: https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2020/. [Accessed 23 November 2019].

[28] R. Raisamo, I. Rakkolainen, P. Majaranta, K. Salminen, J. Rantala and A. Farooq, "Human augmentation: Past, present and future," *International Journal of Human-Computer Studies,* vol. 131, pp. 131-143, 2019.

[29] A. Nordberg , "Defining Human Enhancement Towards a Foundational Conceptual Tool for Enhancement Law," *Journal of Law, Information & Science,* vol. 25, no. 3, pp. 1-29, 2017.

[30] Gartner, Inc, "Gartner Glossary," 2019. [Online]. Available: https://www.gartner.com/en/information-technology/glossary/human-augmentation. [Accessed 16 November 2019].

[31] R. V. Kenyon and J. Leigh, "Human Augmentics: Augmenting human evolution," in *Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Boston, MA, 2011.

[32] J. Huber, R. Shilkrot, P. Maes and S. Nanayakkara, Assistive Augmentation, New York: Springer, Singapore, 2018.

[33] J. Kyokuhon, A. T. Yagi and Y. Ishiguro, "Human Augmentation I - University of Tokyo Graduate School of Information Sciences," 1 October 2018. [Online]. Available: https://humanaugmentationblog.files.wordpress.com/2018/10/habook_i.pdf. [Accessed 20 November 2019].

[34] D. Ruggiu, "Implementing a responsible, research and innovation framework for human enhancement according to human rights: the right to bodily integrity and the rise of 'enhanced societies'," *Law, Innovation and Technology,* vol. 10, no. 1, pp. 82-121, 2018.

[35] A. Schmidt, S. Schneegass, K. Kunze, J. Rekimoto and W. Woo, "Workshop on Amplification and Augmentation of Human Perception," in *CHI EA '17 Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, Denver, Colorado, USA, 2017.

[36] T. Susumu, Telexistence, Singapore: World Scientific Publishing Co. Pte. Ltd 2nd Edition, 2014.

[37] Working Group on Bioethics and Biotechnology , "Human Enhancement - A disucssion Document," Conference of European Churches - Church & Society Commission, 2010.

[38] M. J. Miller, "Gartner's Top 10 Strategic Technology Trends for 2020," PC Mag, 23 10 2019. [Online]. Available: https://www.pcmag.com/article/371466/gartners-top-10-strategic-technology-trends-for-2020. [Accessed 17 12 2019].

[39] K. Costello, "Gartner Top Technologies and Trends Driving the Digital Workplace," Gartner Inc, 18 March 2019. [Online]. Available: https://www.gartner.com/smarterwithgartner/top-10-technologies-driving-the-digital-workplace/. [Accessed 24 11 2019].

[40] A. Sabhikhi and M. Sanchez, "10 Questions About Augmented Intelligence - Executive Guide to AI," CognitiveScale, 2017.

[41] M. Schellekens and P. Vantsiouri, "Patentability of human enhancements," *Law, Innovation and Technology,* vol. 5, no. 2, pp. 190-213, 2013.

[42] R. A. Jones, "Against Transhumanism - The delusion of technological transcendence," 2016. [Online]. Available: http://www.softmachines.org/. [Accessed 15 12 2019].

[43] Futures Centre , "Augmented humans," 5 June 2019. [Online]. Available: https://www.thefuturescentre.org/trend-card/augmented-humans. [Accessed 29 11 2019].

[44] J. Tomkins, "Better People or Enhanced Humans?," Sunnyside Books , 2013.

[45] T. Boer and R. Fischer, "Human Enhancement - Scientific, Ethical and Theological Aspects from a European Perspective," Church and Society Commission of the Conference of European Churches, Strasbourg, France , 2012.

[46] C. Funk, B. Kennedy and E. Sciupac, "U.S. Public Way of Biomedical Technologies to 'Enhance' Human Abilities," Pew Research Center, 2016.

[47] D. Whitman , "U.S. Public Opinion and Interest on Human Enhancements Technology," AARP Research, Washington, DC, 2018.

[48] D. M. Bruce and P. Walker , "Democs Games on Human Enhancement played to end June 2012 within the ETHENTECH Project, submitted to the European Commission," KTH Royal Institute of Technology, Division of Philosophy, Stockholm, 2012.

[49] A. S. Chauhan, "Will augmented humanity transform the workplace?," Livemint , 28 September 2018. [Online]. Available: https://www.livemint.com/AI/wT080RhR1knlwrdru4ALUI/Will-augmented-humanity-transform-the-workplace.html. [Accessed 28 November 2019].

[50] B. Bloomfield and K. Dale, "Fit for work? Redefining 'Normal' and 'Extreme' through human enhancement technologies," *Organization,* vol. 22, no. 4, pp. 552-569, 2015.

[51] I. G. Cohen, "What (if anything) is Wrong With Human Enhancement? What (if anything) is Right with It?," *Tulsa Law Review,* vol. 49, no. 3 , pp. 645-687, 2014.

[52] C. Coenen, M. Schuijff, M. Smits , P. Klaassen, L. Hennen, M. Rader and G. Wolbring, "Human Enhancement Study," European Parliament – Science and Technology Options Assessment (STOA), 2009.

[53] R. Brownsword, "Five Principles for the Regulation of Human Enhancement," *Asian Bioethics Review,* vol. 4, no. 4, pp. 344-354, 2012.

[54] W. D. Eggers and M. Turley , "The Future of Regulation - Principles for regulating emerging technologies," 11 June 2018. [Online]. Available: https://www2.deloitte.com/content/dam/insights/us/articles/4538_Future-of-regulation/DI_Future-of-regulation.pdf. [Accessed 01 12 2019].

[55] A. Nordberg, "Patentability of Human Enhancement: from ethical dilemmas to legal (un)certainty," in *Intellectual Property Perspectives on the Regulation of New Technologies*, Cheltenham, UK, Edward Elgar Publishing, 2018, pp. 54-92.

[56] L. Zonneveld , H. Dijstelbloem and D. Ringoir, Reshaping the Human Condition - Exploring HumanEnhancement, The Hague : Rathenau Institute, in collaboration with the British Embassy, Science and Innovation Network, and the Parliamentary Office of Science and Technology, 2008.

[57] G. Ramachandran, "Against the Right to Bodily Integrity: Of Cyborgs and Human Rights," *Denver University Law Review ,* vol. 87, no. 1, pp. 1-57, 2009.

[58] W. . A. Kaal and E. P. Vermeule, "How to Regulate Disruptive Innovation—From Facts to Data," *Jurimetrics: The Journal Of Law, Science & Technology,* vol. 57, no. 2, pp. 170-190, 2017.

[59] R. Johnson, G. Gillett and J. Snelling, "Regulation of cognitive enhancement devices: commentary," *Journal of Law and the Biosciences,* vol. 1, no. 3, p. 328–333, 2014.

[60] M. Ienca and R. Andorno , "Towards new human rights in the age of neuroscience and neurotechnology," *Life Sciences, Society and Policy,* vol. 13, no. 5, pp. 1-27, 2017.

[61] C. Bublitz, "My Mind Is Mine!? Cognitive Liberty as a Legal Concept," in *Cognitive Enhancement, Elisabeth Hildt & Andreas Francke (eds.)*, Springer, 2013, pp. 233-264.

[62] H. A. Harrison Dinniss and J. K. Kleffner, "Soldier 2.0: Military Human Enhancement and International Law," *International Law Studies,* vol. 92, no. 432, pp. 431-482., 2016.

[63] L. Downes , The Laws of Disruption: Harnessing the New Forces that Govern Life and Business in the Digital Age, New York: Basic Books, 2009.

[64] R. Leenes, "Of Horses and Other Animals of Cyberspace," Technology and Regulation, 2019.

[65] A. Thierer, "The Pacing Problem, the Collingridge Dilemma & Technological Determinism," The Technology Liberation Front , 16 8 2018. [Online]. Available: https://techliberation.com/2018/08/16/the-pacing-problem-the-collingridge-dilemma-technological-determinism/. [Accessed 14 12 2019].

[66] T. L. Friedman, Thank You for Being Late: An Optimist's Guide to Thriving in the Age of Accelerations, Penguin UK, 2016.

[67] J. Bersin, B. Pelster, J. Schwartz and B. van der Vyver, "Deloitte Global Human Capital Trends - Rewriting the Rules of Digital Age," Deloitte University Press, 2017.

[68] R. Brownsword, Rights, Regulation, and the Technological Revolution, Oxford: Oxford University Press, 2008.

[69] *Riley v. California,* No. 13-132, 573 U.S. ___ (2014), (slip op., at 9).

[70] B. Wittes and J. Chong, "Our Cyborg Future: Law and Policy Implications," The Brookings Institution, Washington, DC, 2014.

[71] J. Weckert and R. Lucas, Professionalism in the Information and Communication Technology Industry, Canberra, Australia: The Australian National University, 2013.

[72] D. Ruggiu, Human Rights and Emerging Technologies: Analysis and Perspectives in Europe, Singapore: Pan Stanford Publishing Pte. Ltd, 2018.

[73] F. Allhoff and P. Lin, "Nanoethics and human enhancement: a critical evaluation of recent arguments," *Nanotechnology Perceptions,* vol. 2, no. 1, p. 47–52, 2016.

[74] G. Laurie, S. H. Harmon and F. Arzuaga, "Foresighting Futures: Law, New Technologies, and the Challenges of Regulating for Uncertainty," *Law, Innovation and Technology,* vol. 4, no. 1, pp. 1-33, 2012.

[75] G. E. Marchant, "The Growing Gap Between Emerging Technologies and the Law," in *Marchant, Gary E., Allenby, Braden R., Herkert, Joseph R. (Eds.), The Growing Gap Between Emerging Technologies and Legal-Ethical Oversight: The Pacing Problem* , Tempe Arizona, Springer Science & Business Media, 2011, pp. 19-33.

[76] M. Garasic, "Human Enhancement in the EU," *Australian and New Zealand Journal of European Studies,* vol. 4, no. 1, pp. 31-41, 2012.

[77] L. R. Kass, "Biotechnology and Our Human Future: Some General Reflections," in *Seon D. Sutton (Ed.) Biotechnology: Our Future as Human Beings and Citizens*, New York , State University of New York, Albany, 2009, pp. 9-23.

[78] R. Baldwin, M. Cave and M. Lodge, Understanding Regulation: Theory, Strategy and Practice, Oxford : Oxford University Press, 2012 .

[79] L. Lessig, Code - version 2.0, Cambridge MA: Basic Books, 2006.

[80] J. Black, "Decentring Regulation: Understanding the Role of Regulation and Self-Regulation in 'Post-Regulatory' World," *Current Legal Problems ,* vol. 54 , no. 1, p. 103–146, 2001.

[81] M. van Asselt, E. I. Vos and T. Fox, "Regulating technologies and the Uncertainty paradox," in *M. Goodwin, B.J. Koops, R. Leenes (Eds.), Dimensions of Technology Regulation*, Nijmegen, Wolf Legal Publishers, 2010, pp. 259-284.

[82] Commission Staff Working Document , "Better Regulation Guidelines," Euopean Commission , Brussels , 2017.

[83] K. Ludlow, D. Bowman, J. Gatof and M. Bennett, "Regulating Emerging and Future Technologies in the Present," *NanoEthics,* vol. 9, no. 2, pp. 151-163, 2015.

[84] M. . D. Fenwick, W. A. Kaal and E. P. Vermeulen, "Regulation Tomorrow: What Happens When Technology Is Faster than the Law?," *American University Business Law Review,* vol. 6, no. 3, pp. 561-594, 2017.

[85] B. M. Lyria, "Recurring Dilemmas: The Law's Race to Keep Up With Technological Change," *University of Illinois Journal of Law, Technology & Policy ,* p. 239–285, 2007.

[86] K. Yeung, "Towards an Understanding of Regulation by Design," in *R. Brownsword & K. Yeung (Eds.), Regulating Technology*, Portland, Oregon, Hart Publishing, 2008, pp. 79-94.

[87] H. Miller and K. Engemann, "The precautionary principle and unintended consequences," *Kybernetes,* vol. 48, no. 2, pp. 265-286, 2019.

[88] J. Mulder, "RegTech: Tackling Regulation with Innovation," in *Janos Barberis Douglas W. Arner Ross P. Buckley (eds), The RegTech Book*, West Sussex, John Wiley & Sons, 2019, pp. 26-29.

[89] E. Bayamlıoğlu and R. Leenes, "The 'rule of law' implications of data-driven decision-making: a techno-regulatory perspective," *Law, Innovation and Technology,* vol. 10, no. 2, pp. 295-313, 2018.