HIDDEN INVENTORS

How divergent thinking can foster inventiveness in Europe

ThinkYoung

Partner

ERICSSON

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EXECUTIVE SUMMARY

The European Union is at a critical juncture. While simultaneously embracing digital transformation and working to maintain global competitiveness, the EU also needs to continue accelerating the transition to carbon neutrality. The ability to create an environment that fosters inventiveness to both drive incremental technological progress and scientific breakthroughs will be paramount to achieving these goals.

To better enable this, ThinkYoung and Ericsson are taking an in-depth look at the state of inventiveness in Europe and what we can do to nurture it.

After analysing characteristics that are common among inventors, we built and executed a survey to test our society's level of "inventiveness." With these results, we are able to better understand how to encourage invention through mentoring, fostering of digital skills, and a strong IPR framework—including for patents.

In our report, we stress the importance of ensuring teachers playfully engage young children and underline the need for extracurricular activities that allow teenagers to partake in creative problem-solving and novel challenges. We also highlight the importance of internship programmes at innovative firms and inspiring mentors for students. Most importantly, our report emphasises the importance of economic rewards and protections for inventors through a strong and effective patent system.

FOREWORD FROM IVAN ŠTEFANEC

"It had long come to my attention that people of accomplishment rarely sat back and let things happen to them. They went out and happened to things."

- Leonardo da Vinci.

It is a pleasure to have the opportunity to write a few words to introduce this important topic and honour European innovators.

The 20th century in Europe was one of inventions. Behind each of these are always clever and enthusiastic scientists and researchers with a vision for a better and safer world. Everyone likes to shine a spotlight on the triumphs, but there are no successful inventions without an enormous amount of work, and the trial and error inherent in experimentation. All those who bring inventions into our lives deserve our recognition.

This year, Europe is facing an unprecedented crisis. The need for resilience, sustainability, a green transition and many other challenges call for profound changes and inventions. Inventiveness is even more important during periods of crisis and is the only path to overcoming present challenges.

Our responsibility as legislators is to protect and boost the potential of inventors to develop themselves in the best possible way. It can be done by creating financial support through various funds like Horizon Europe, by shaping legislation so it does not harm innovation and protecting and rewarding inventions via patents.

Intellectual property plays a vital role in the development of new technologies, boosting European competitiveness.

We also need to anticipate deep societal changes. Research tells us that 65% of children born today will work in jobs that don't even exist yet. Educational strategy must be a priority: to motivate kids to choose STEM careers and help teachers prepare the next generation for these changes.

The future will also bring new business models. As a result, our education systems need to be innovative to adapt to the challenges and needs of employers. Lifelong learning will become an essential part of future life and digitalisation a cornerstone for growth.

By promoting inventors and inventiveness, we can drive European competitiveness at a global level and secure millions of jobs for our citizens This report by ThinkYoung and Ericsson emphasises the value of internship programs and inspirational mentorship to foster inventiveness in Europe. The report also highlights the need to provide financial incentives and protections to inventors through effective patent regimes. It is a valuable tool that helps us better grasp the realities of invention in Europe today and how to foster it.

Dear ThinkYoung team, I wish you many successes on your significant path to prepare and promote young talents for our future. To young innovators, I wish a lot of endurance, enthusiasm, success and enough energy. You are the real engineers of our future. The spotlight should be on you!

Ivan Štefanec

Member of the European Parliament,

European People's Party, Hidden Inventors Ambassador

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WHY INVENTION MATTERS FOR EUROPE

Grab a smartphone and look it over. Inside these ingeniously built machines is a marvel of modern computing originally developed by British inventor Sophie Wilson back in the early 1980s.

Aiming to make integrated computing work more efficiently, Wilson devised the very first ARM-based processor. Thanks to its efficient design, ARM chipsets cut the energy needed for computations—something ideal for gadgets with small batteries.

For its merits, 95% of today's mobile devices use ARM chips.[1] The impact of ARM chips is likely to intensify as Artificial Intelligence (AI) and the Internet of Things (IoT) become commonplace. Without technological advancements that enable data centres and devices to perform increasingly heavier tasks while using less energy, and therefore reduced emissions, we risk stunting innovation. ARM-based processors play a vital role in pushing the envelope—data centres powered by ARM architecture boast up to 3.5x more performance than systems using conventional processors.[2] European inventors are not only making our devices more efficient—they are also unlocking more sustainable manufacturing. For years, processors have required electronics-grade silicon, a costly material that also generates substantial emissions during production. Looking to reduce costs and benefit our planet, Portuguese inventors Elvira Fortunato and Rodrigo Martins worked to help fix that.

With their revolutionary paper-based microchip that uses coated paper sheets and thin layers of eco-friendly semiconductor materials, Fortunato and Martins have enabled a new generation of sustainable devices.[3] [4]

Invention is a specific type of creativity tied to engineering and design,[5] [6] which is often made possible thanks to patenting.[7] Indeed, any modern home, office, or factory contains many products that would not have gone to market

1 Arm, 'Sustainability through Intelligence', 1 March 2021, https://www.arm.com/-/media/Files/pdf/policies/arm-sustainability-through-intelligence.pdf?revision=9d1466c3-8cb6-4640-9311-c74c9af02481.
2 Arm
3 Advanced Science News, 'Microchips Made of Paper: Elvira Fortunato and Rodrigo Martins Named European Inventor Award 2016 Finalists', Advanced Science News (blog), 13 May 2016, https://www.advancedsciencenews.com/microchips-made-of-paper/.
4 The scale of the invention was recognised when Elvira won the Horizon Impact Award 2020, directed at impactful EU-funded projects.
5 Min Tang, 'China's Young Inventors: A Systemic View of the Individual and Environmental Factors' (PhD Thesis, Citeseer, 2010).
6 A narrow definition of the word invention would categorise it as exclusively belonging to engineering and technology. However, since designing involves manipulating existing objects and recombining them into a novel thing, it is considered by many as a crucial form of invention.
7 Tang, 'China's Young Inventors'.

without patent protection. Developers simply need safeguards to justify the investments required to research and commercialise new technologies.[8]

Yet, as the stories above illustrate, the trait that most differentiates inventors from other creative minds is the desire to solve contemporary problems in the physical world.[9] Creating an environment that allows inventors to solve problems helps to address challenges and seize the opportunities of the digital transformation[10] and green transition.[11]

Since about 1750, atmospheric greenhouse gas concentration and the global average temperature have soared.[12] Inventors now play a critical role in helping move society forward in the fight against climate change.

To this end, Daniel Töbelmann and Tobias Wendler examined the effects of environment-related inventions on carbon dioxide emissions in the EU-27 countries between 1992 and 2014.[13] Using environmental patent applications as an indicator of inventiveness, they found a wealth of environmentally-oriented inventions contributed to reductions in carbon dioxide emissions.[14] [15]

The EU will also need to support the development and adoption of new technologies to enable economic growth and continued competitiveness.[16]

8 Adam B. Jaffe and Josh Lerner, Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It (Princeton University Press, 2011), https://doi.org/10.1515/9781400837342.
9 Sheila J. Henderson, 'Product Inventors and Creativity: The Finer Dimensions of Enjoyment', Creativity Research Journal 16, no. 2–3 (2004): 293–312; Tang, 'China's Young Inventors'; Rolf A. Faste, 'The Role of Visualization in Creative Behavior.', Journal of Engineering Education 63, no. 2 (1972): 124–27.
10 The influence of the industrial and digital revolutions has been noticeable in almost every aspect of our civilisation. They have shaped industry, moulded our shopping and entertainment, as well as our work habits.x Will the coming AI revolution deliver similar, sweeping transformations? Spyros Makridakis, a worldwide leading scholar on forecasting, analysed analogous inventions of the industrial, digital and AI revolutions. His findings show that the AI revolution will have far-reaching effects in the next twenty years, affecting critical aspects of our society in a more dramatic way than the digital and industrial revolutions.
11 As part of the European Green Deal, on 11 December 2020, the European Council adopted a binding EU climate goal. The new target comprises a net domestic reduction of at least 55% in greenhouse gas emissions by 2030 compared to 1990. The goal was set to meet the target of a climate-neutral EU by 2050 under the objectives of the Paris Agreement. In July 2021, the European Commission unveiled thirteen policies intended to address climate change. The cornerstone of the EU's overall plan is to expand the Emissions Trading Scheme to incorporate emissions from the car industry and buildings' heating to speed up decarbonisation. The Commission will also increase its renewable energy goals to constitute 40 per cent of its energy sources by 2030.
12 Daniel Töbelmann and Tobias Wendler, 'The Impact of Environmental Innovation on Carbon Dioxide Emissions', Journal of Cleaner Production 244 (2020): 118787; Egbert Boeker and Rienk Van Grondelle, Environmental Physics: Sustainable Energy and Climate Change (John Wiley & Sons, 2011).
13 Töbelmann and Wendler, 'The Impact of Environmental Innovation on Carbon Dioxide Emissions'.
14 Töbelmann and Wendler.
15 However, despite solid increases in emission efficiency, Töbelmann and Wendler could not observe a robust drop in absolute emissions levels. They thus concluded that the necessary reduction in CO2 intensity to stay within the absolute limits for emissions is a long way from obtained by technological developments alone. Warning against over-reliance on technology, they claimed that we must see inventions as a complementary instrument in a fundamental transformation towards a green economy.
16 European Commission, '2021 Strategic Foresight Report - The EU's Capacity and Freedom to Act - Communication from the Commission to the European Parliament and the Council' (European Commission, 8 September 2021), https://ec.europa.eu/info/sites/default/files/foresight_report_com750_en.pdf.

Economic studies also show that research and development (R&D) investment fosters new inventions, promoting economic growth.[17] For instance, Fraumeni and Okubo found that returns from R&D accounted for 10 percent of growth in real GDP in the United States between 1961 and 2000.[18]

With an emphasis on OECD countries between 1970 and 2004, Falk discovered that the effect of business R&D spending appears to benefit GDP per capita in the long run.[19] In addition, Bulent Guloglu and R. Baris Tekin found evidence to suggest that more R&D expenditure leads to more inventions, therefore generating more economic growth.[20]

The link between invention and growth was also explored by economists Iftekhar Hasan and Christopher Tucci, who concluded that inventive activity seems to promote economic growth.[21] By analysing a sample of 58 countries from 1980 to 2003, they showed that countries hosting companies with higher quality patents experience a boost in GDP.[22]

As the world looks to emerge from the pandemic with more resilient and sustainable societies, there has never been a more critical time to encourage and protect inventiveness.

As a result, ThinkYoung and Ericsson have set out to understand the state of inventiveness in Europe today and what we can do to help support it. The following pages outline our key findings and recommendations for creating an environment in which invention thrives.

The report first examines our survey results on the state of inventiveness in the EU today by looking at the capacity for divergent thinking. We then analyse characteristics common among inventors, and finally discuss how to encourage invention through cognitive empowerment, mentoring and patent protection.

17 Bulent Guloglu and R. Baris Tekin, 'A Panel Causality Analysis of the Relationship among Research and Development, Innovation, and Economic Growth in High-Income OECD Countries', Eurasian Economic Review 2, no. 1 (2012): 32–47.
18 Barbara M. Fraumeni and Sumiye Okubo, 'R&D in the National Income and Product Accounts: A First Look at Its Effect on GDP' (Bureau of Economic Analysis, 2002).
19 Martin Falk, 'R&D Spending in the High-Tech Sector and Economic Growth', Research in Economics 61, no. 3 (1 September 2007): 140–47, https://doi.org/10.1016/j.rie.2007.05.002.
20 Guloglu and Tekin, 'A Panel Causality Analysis of the Relationship among Research and Development, Innovation, and Economic Growth in High-Income OECD Countries'.
21 Iftekhar Hasan and Christopher L. Tucci, 'The Innovation–Economic Growth Nexus: Global Evidence', Research Policy 39, no. 10 (2010): 1264–76.
22 As they argued, an essential limitation of their research was the equation of patents with invention, as patents can merely function as an approximate measure of the underlying concept (we should bear in mind, for example, that not all inventions are patentable). An added constraint their findings exhibited was one of possible reverse causation. In other words, how can we know if more patents lead to economic growth rather than more economic growth leading to more patents? However, Hasan and Tucci's analysis suggest that, while we cannot entirely exclude the possibility of growth being conducive to more and better patents, most of the evidence leads to concluding that higher-quality patenting tends to precede economic growth.

THE STATE OF INVENTIVENESS AMONG YOUNG EUROPEANS TODAY

Most psychologists view invention as a specific form of creativity.[23] As a result, psychological research on invention often draws from creativity studies.[24] A classical understanding of creativity among psychologists refers to the concept of "divergent thinking",[25] which alludes to exploring new ways of thinking when tackling a problem.

The notion of divergent thinking is appealing for a variety of reasons. First, it is a palpable illustration of reasoning that leads to innovative ideas.[26] Second, it contrasts with convergent thinking, which leads to traditional and "correct" ideas, instead of unique approaches.[27] While divergent thinking does not always lead to actual creative accomplishments, divergent thinking tests are reliable and reasonably valid measuring tools for creative potential.[28]

A common way to measure creativity as divergent thinking is counting the number of ideas someone generates when given a specific problem (fluency).[29] Another approach is to assess the originality of responses by computing levels of uniqueness (originality). This can be attained, for example, by dividing the number of ideas mentioned and the total number of participants taking part in a divergent thinking exercise.[30]

This section explores our survey results for the current state of inventiveness in the EU by examining the capacity for divergent thinking. The results allow us to draw some initial conclusions on inventiveness across age groups, gender, countries and level of education.

The findings particularly show a link between age and inventiveness, and suggest inventiveness is not evenly spread across populations, but rather, is often concentrated among a few highly creative individuals.

This survey was conducted between 21 October and 18 November, 2021, with a total of 1,504 respondents aged 18 to 40 from Belgium, France, Germany, Italy, Poland and Sweden. The survey design followed a quota sampling method, based on age and data collected through online panels.

To measure divergent thinking, we asked participants to list as many alternate uses for street billboards that they could imagine (Note: other than for advertising purposes). After a brief introductory text, the survey asked participants a main question and two probing items.

To incentivise participation, the 10 best responses each received an Amazon voucher of 50 EUR (or equivalent). Images of blank billboards were displayed on the questionnaire to better illustrate the purpose of the exercise.

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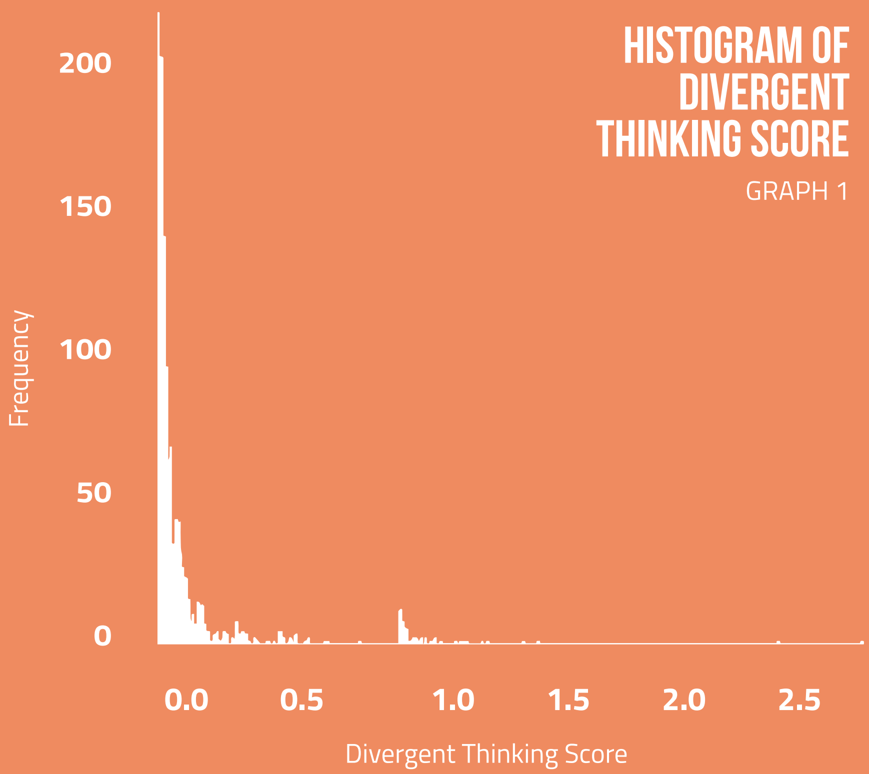
23 Merton C. Flemings, 'Invention: Enhancing Inventiveness for Quality of Life, Competitiveness, and Sustainability (Report of the Committee for the Study of Invention, Sponsored by the Lemelson-MIT Program and the National Science Foundation)' (Cambridge, MA: MIT, 2004); Harald A. Mieg, 'A Two-Path Process Model of Invention: Conclusions from Six Years of Research with Independent Inventors', 2020.
24 Mieg, 'A Two-Path Process Model of Invention'; Michael D. Mumford, 'Where Have We Been, Where Are We Going? Taking Stock in Creativity Research', Creativity Research Journal 15, no. 2–3 (2003): 107–20; Robert W. Weisberg, Creativity: Understanding Innovation in Problem Solving, Science, Invention, and the Arts (John Wiley & Sons, 2006).
25 Joy Paul Guilford, 'The Structure of Intellect.', Psychological Bulletin 53, no. 4 (1956): 267.
26 Mark A. Runco and Selcuk Acar, 'Divergent Thinking as an Indicator of Creative Potential', Creativity Research Journal 24, no. 1 (2012): 66–75.
27 Runco and Acar.
28 Runco and Acar.
29 Laura A. King, Lori McKee Walker, and Sheri J. Broyles, 'Creativity and the Five-Factor Model', Journal of Research in Personality 30, no. 2 (1996): 189–203; Robert R. McCrae, 'Creativity, Divergent Thinking, and Openness to Experience', Journal of Personality and Social Psychology 52, no. 6 (1987): 1258–65, https://doi.org/10.1037/0022-3514.52.6.1258; Mieg, 'A Two-Path Process Model of Invention'.
30 Mark A. Runco, Jody J. Illies, and Roni Reiter-Ralmon, 'Explicit Instructions to Be Creative and Original: A Comparison of Strategies and Criteria as Targets with Three Types of Divergent Thinking Tests', The International Journal of Creativity & Problem Solving 15, no. 1 (2005): 5–15.

A LONG-TAILED DISTRIBUTION OF DIVERGENT THINKING SCORES

Each participant was assigned a divergent thinking score computed as a function of the originality and fluency of their responses, based on the formula presented in Annex 3.

The Graph 1 summarises the distribution of the scores in the sample.



HISTOGRAM OF DIVERGENT THINKING SCORE

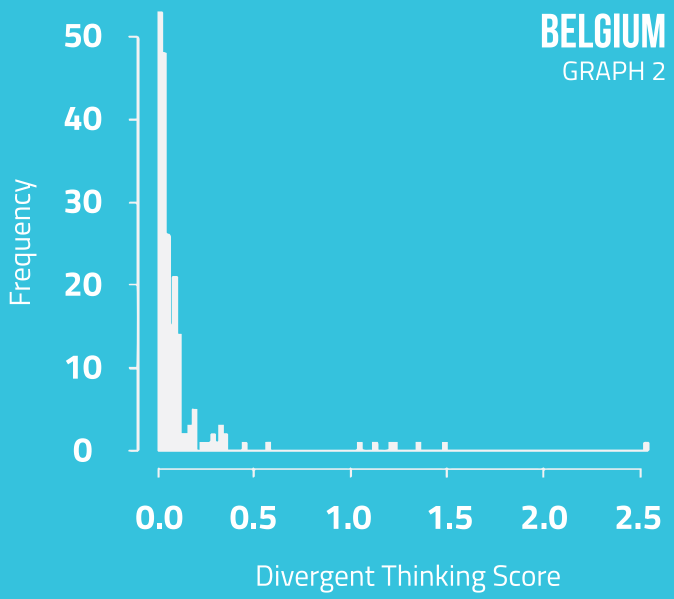
GRAPH 1

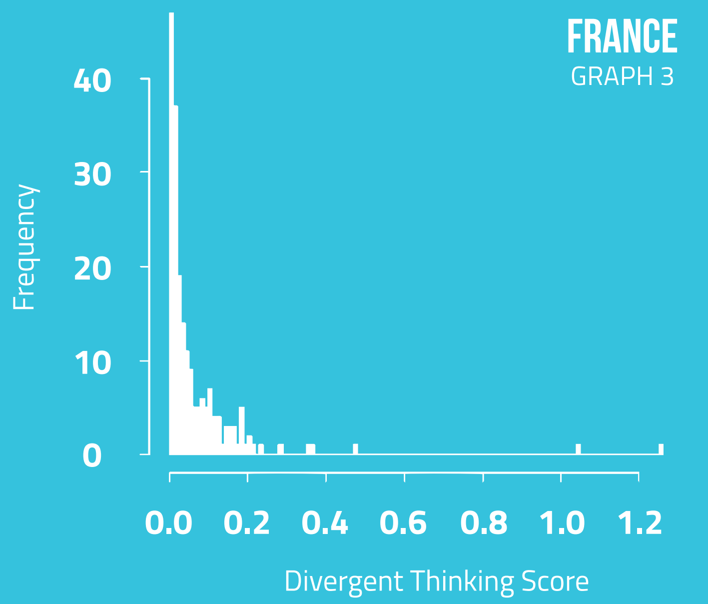
The result is right long-tailed. This is a well-known feature of certain frequency distributions–where high-frequency values are followed by low-frequency examples—gradually diminishing asymptotically in frequency.[31] This kind of distribution demonstrates that most respondents share relatively similar, mediocre levels of divergent thinking—while a few outliers score well above average.

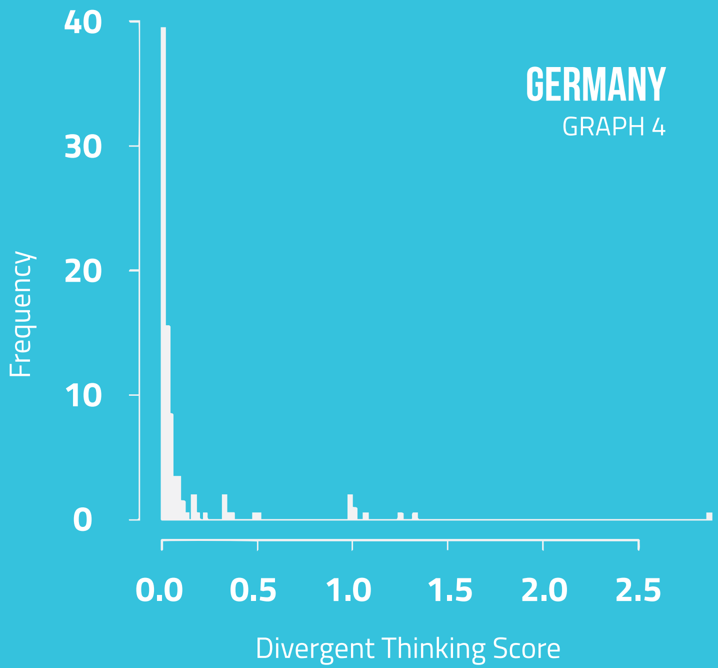
As seen in the histograms below, a similar distribution shape holds for all countries, genders and education levels. In all instances, we perceive the same pattern—most scoring unimpressively, while a few individuals stand out.

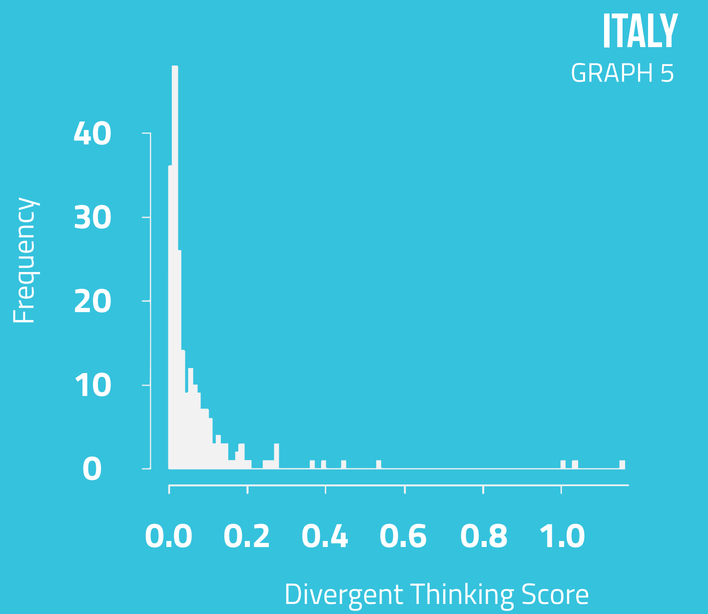
31 Examining the summary statistics for all cases (displayed in the annex) corroborates the "heavy-tailedness" of the distribution, with a mean far above the median. In other words, we observe that the average divergent thinking score is far above the divergent score of the average respondent. The high and skewness measurement (4.578) and Kurtosis value (28.051) are indicative of a long-tailed distribution with moderate skewness to the right.

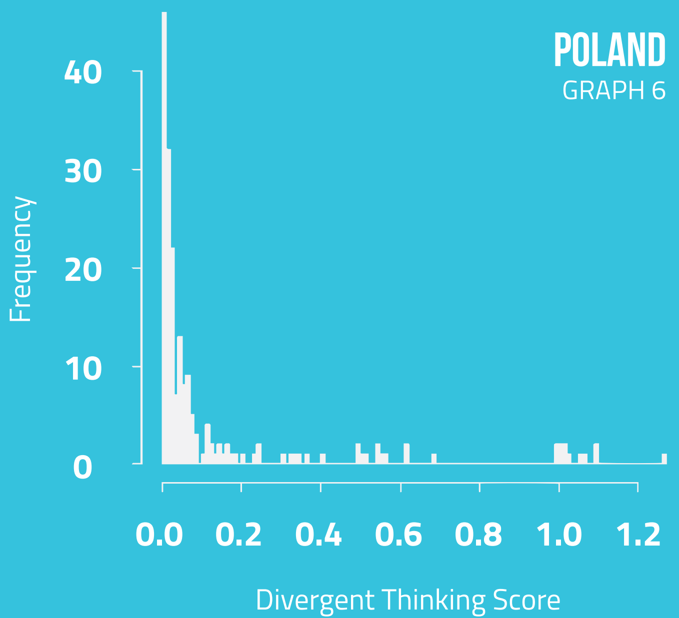
COUNTRY-SPECIFIC HISTOGRAMS OF DIVERGENT THINKING SCORES

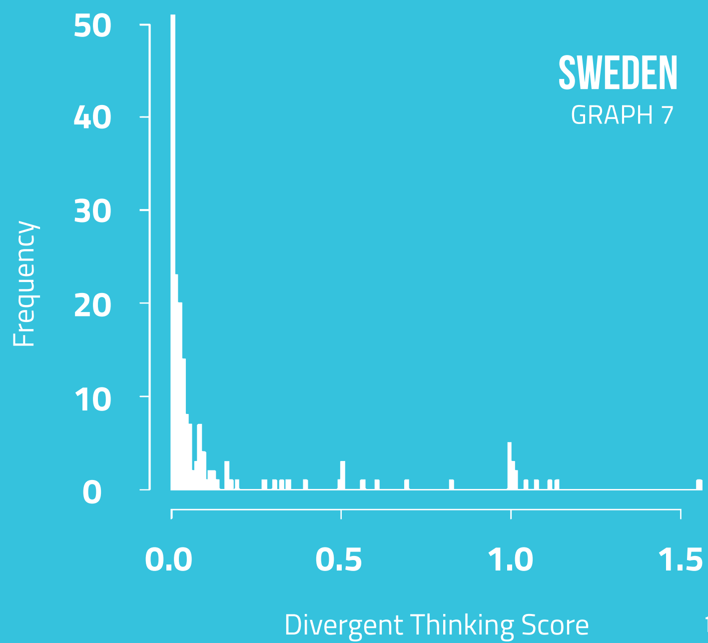






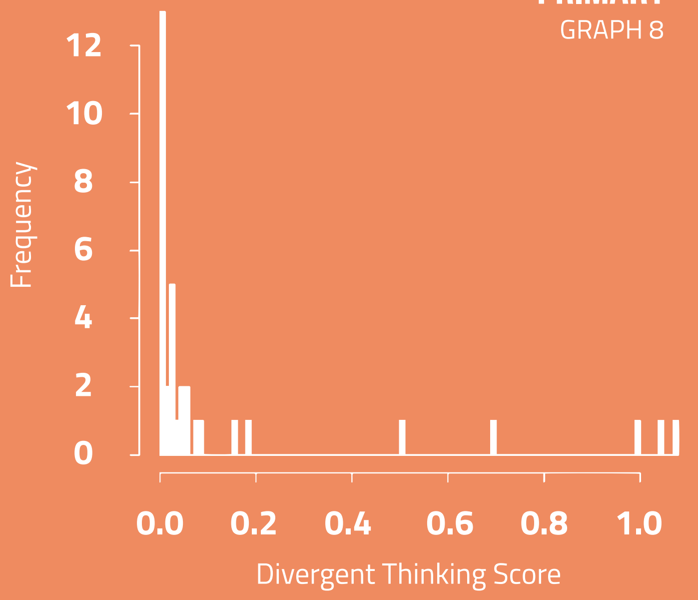




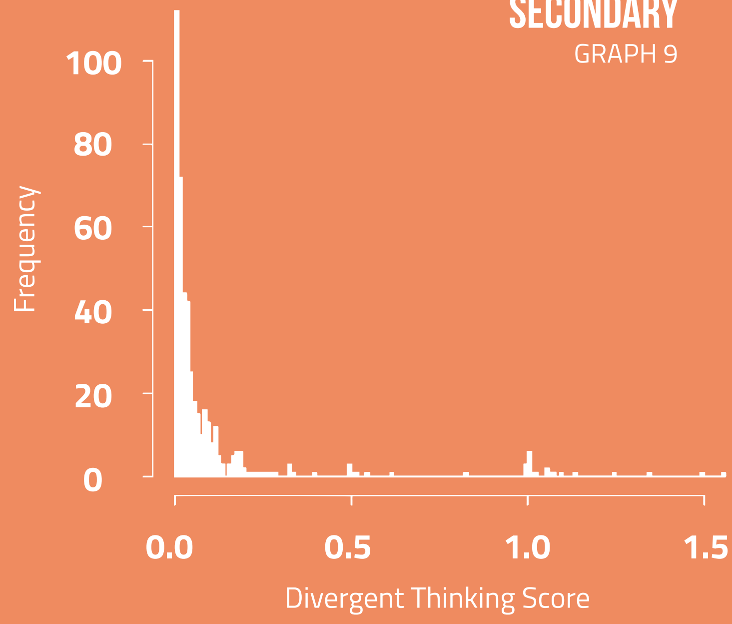


EDUCATION-SPECIFIC HISTOGRAMS OF DIVERGENT THINKING SCORES

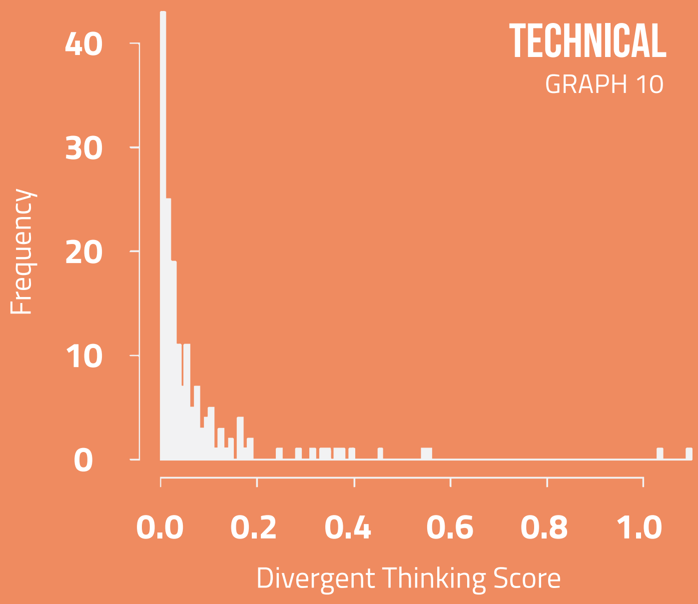
PRIMARY
GRAPH 8



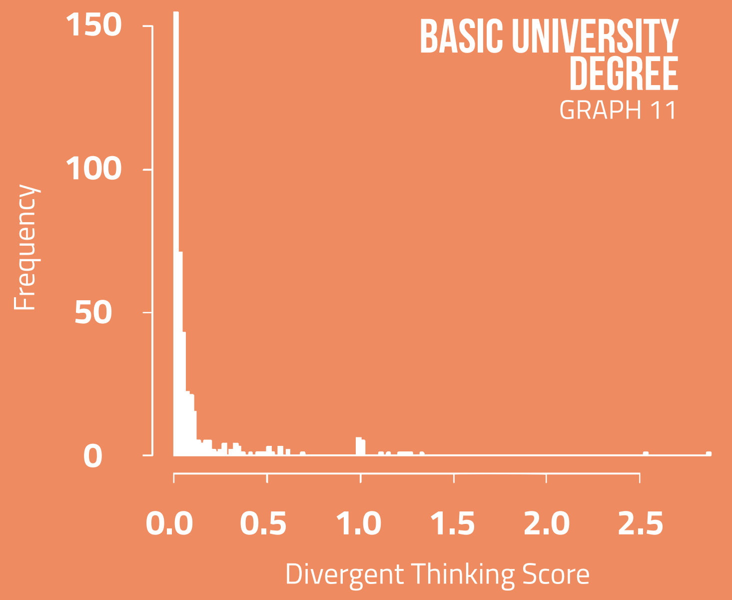
SECONDARY
GRAPH 9



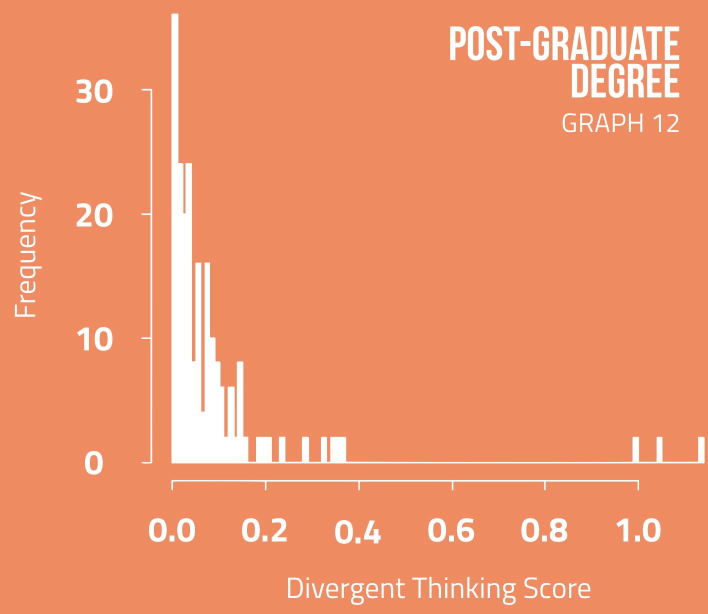
TECHNICAL
GRAPH 10



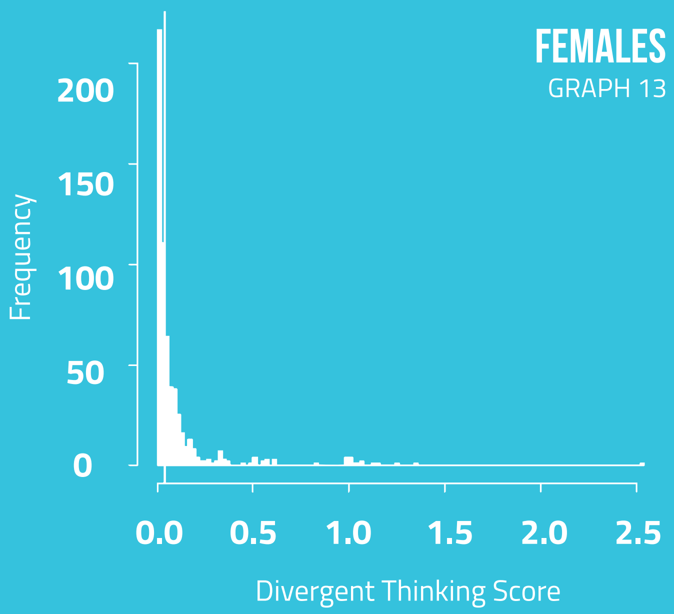
BASIC UNIVERSITY DEGREE
GRAPH 11

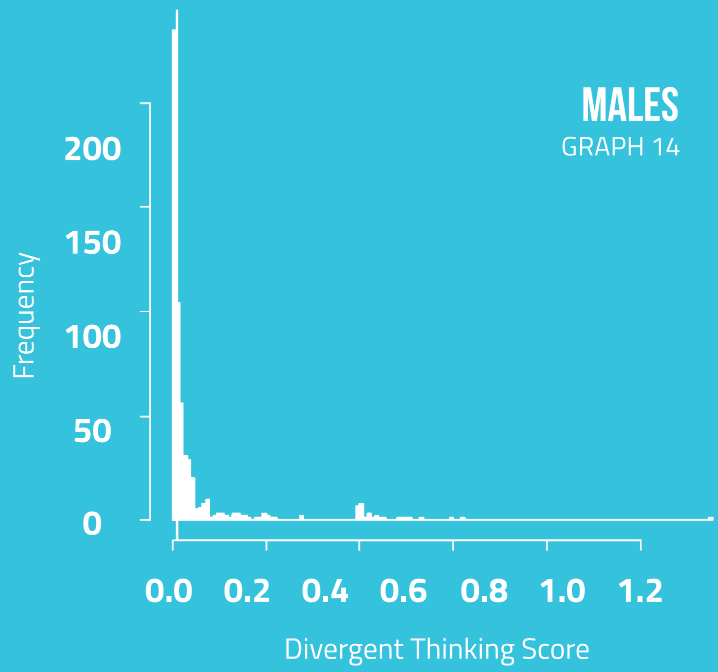


POST-GRADUATE DEGREE
GRAPH 12



GENDER-SPECIFIC HISTOGRAMS OF DIVERGENT THINKING SCORES





NO MEANINGFUL DIFFERENCE BETWEEN GENDER REGARDING DIVERGENT THINKING

When comparing the histograms measuring gender discrepancies, we observe no noticeable differences in the distribution shape, or maximum/minimum scores. On the other hand, the average male seems to perform almost identically to the average female, as shown by almost identical median scores for both groups (Note: highlighted with the red vertical lines in the histograms).

AGE IS ASSOCIATED WITH ENHANCED CREATIVITY

Through bivariate and multivariate analysis, our results suggest a statistically significant correlation between an individual's age and their divergent thinking score, as shown in Annex 1.

On average, seniority appears to be associated with a higher level of creativity. Simply put, our findings suggest age may heighten capacity for divergent thinking. This positive and significant association between age and divergent thinking score remains—even when controlling for gender, country and education.

When conducting a comparison by country for divergent thinking, we observe a statistically significant difference, with respondents residing in Belgium, Germany, Poland and Sweden scoring higher, on average, than those in France or Italy. As implied by the difference between the means and medians, as well as the distribution plots above, the higher average scores among respondents residing in Sweden, Poland, Germany and Belgium are because respondents in these countries exhibited a greater proportion of high-scoring individuals.

The average respondent scores similarly in all countries, and the lower average scores for France and Italy appear to be a result of a lower proportion of respondents with extremely high scores. In short, there seems to be fewer inventive outliers in France and Italy than in the other surveyed Member States.

Additionally, the multivariate linear regression model[32] (Shown in Annex 2) portrays a statistically significant positive association between age and divergent thinking, when controlling for gender, country and education. However, when controlling for age, gender, and education, we can no longer assert that there exists a statistically significant relationship between a respondent's divergent thinking score and their country of residence—based on multivariate linear regression results.

YOUNG EUROPEANS FAIL TO ACCURATELY GAUGE PERSONAL CREATIVITY

Respondents were asked to self-assess their creativity by self-reporting a score, which ranged from 1 to 10. As shown in the boxplot (Figure 1) in Annex 1, there is no visible association between self-reported creativity scores and actual divergent thinking scores.

The correlation tests conducted between the two variables—whose coefficients are shown in Table 8 of Annex 1—also suggest a lack of meaningful association. The analysis implies that young Europeans with an elevated level of creativity, on average, tend to underestimate their creative potential. The opposite holds true for those with a low level of creativity, as measured by divergent thinking scores.

CONCLUSION

The state of inventiveness in Europe appears to be marked by a few highly creative outliers and a large majority of low creativity individuals. Our analysis shows that creativity levels in Europe follow a long-tailed distribution, regardless of gender, education, or country—in which an overwhelming majority of individuals share similar creativity scores and few individuals demonstrate exceptional inventiveness.

Furthermore, the survey results suggest that in the EU, age appears to be positively associated with creativity. This association remains even when controlling by gender, country and education. It should be noted that further examination is needed to determine what factors linked to age drives this association (maturity, experience, time spent, and/or ability to understand the exercise).

While the divergent thinking survey is limited in terms of sample size and included countries, the results do show which factors correlate with inventiveness and this should be further explored.

Subsequent sections assess factors driving inventiveness and how to promote them.

32 Numerical variables in the dataset were normalised to better fit the assumptions of the liniar regression model.

WHAT MAKES AN INVENTOR?

Numerous factors correlate with inventiveness.[33] However, given this report's compact nature, we will only focus on core psychological traits of inventors and discuss why exposure to invention during childhood is essential.

People use many words to describe personalities in everyday language—energetic, creative, selfless or cautious. Most psychologists agree that we can reduce almost all personality traits to five fundamental factors: Extraversion vs Introversion; Openness vs Closedness to Experience; Conscientiousness; Agreeableness vs Antagonism; and Neuroticism vs Emotional Stability.[34] A wealth of rigorous research backs this categorisation, which psychologists call the Big-Five Model. Indeed, psychological studies have confirmed validity in cultures as varied as Chile, Iceland, Kuwait, South Korea, and the United Kingdom.[35]

The trait that psychologists most often associate with creativity and inventiveness is Openness to Experience. Individuals that score high on Openness are unprejudiced, inquisitive, and unconventional. By contrast, those with low Openness tend to be traditional, uncreative, and rigid.[36]

Openness and Closedness to Experience are distinct ways of interacting with the world. Neither is better than the other. Still, they are not equally conducive to revolutionary scientific, artistic, or technical contributions. This is mainly because even with outstanding cognitive abilities, a person with little curiosity is less likely to generate ground-breaking achievements.[37]

Numerous psychological studies also attest that Openness correlates strongly with creativity. In addition, a neuro-imaging study has shown that individuals scoring high on Openness have a brain structure that facilitates creativity.[38]

Since inventiveness is a type of creativity, inventors—like other creatives—tend to score high on Openness.

German social scientist Harald Mieg and his colleagues set out to study the traits of independent inventors in Germany.[40] After using standardised psychological questionnaires to measure the Big-Five personality factors, they found that independent inventors showed greater Openness to Experience than non-inventors.[41]

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33 Thomas Zwick et al., 'The Power of Individual-Level Drivers of Inventive Performance', Research Policy 46, no. 1 (1 February 2017): 121–37, https://doi.org/10.1016/j.respol.2016.10.007.
34 Robert R. McCrae and David M. Greenberg, 'Openness to Experience', in The Wiley Handbook of Genius (John Wiley & Sons, Ltd, 2014), 222–43, https://doi.org/10.1002/9781118367377.ch12.
35 McCrae and Greenberg; Robert R. McCrae and Paul T. Costa Jr, 'Personality Trait Structure as a Human Universal.', American Psychologist 52, no. 5 (1997): 509.
36 Christina E. Shalley, Jing Zhou, and Greg R. Oldham, 'The Effects of Personal and Contextual Characteristics on Creativity: Where Should We Go from Here?', Journal of Management 30, no. 6 (2004): 933–58.
37 McCrae and Greenberg, 'Openness to Experience'.
38 Linda S. Scratchley and A. Ralph Hakstian, 'The Measurement and Prediction of Managerial Creativity', Creativity Research Journal 13, no. 3–4 (2001): 367–84; Gregory J. Feist, 'A Meta-Analysis of Personality in Scientific and Artistic Creativity', Personality and Social Psychology Review 2, no. 4 (1998): 290–309.
39 Wenfu Li et al., 'Brain Structure Links Trait Creativity to Openness to Experience', Social Cognitive and Affective Neuroscience 10, no. 2 (2015): 191–98.
40 Harald A. Mieg et al., 'How Emotional Stability and Openness to Experience Support Invention: A Study with German Independent Inventors', Creativity Research Journal 24, no. 2–3 (1 April 2012): 200–207, https://doi.org/10.1080/10400419.2012.677341.
41 Mieg et al.

Psychologist Laura King and her colleagues also discovered that divergent thinking correlates with creative accomplishments, in particular for people scoring high in Openness to Experience.[42]

On the other hand, individuals scoring high on divergent thinking, but low on Openness reported fewer creative achievements. Here, it is essential to bear in mind that a high capacity for divergent thinking does not always lead to creative accomplishments. King's results imply that individuals who are high in Openness may be a promising source of untapped creative achievement if their divergent thinking skills are further developed.[43]

Beyond Openness to Experience, low Neuroticism is the second most substantial correlate with creativity and invention. Neurotic individuals tend to be anxious, self-pitying, tense, touchy, and worrying. They are also prone to experience hopelessness and a lack of energy to perform their duties.[44] By contrast, people low in Neuroticism tend to be level-headed and calm.

Mieg and his co-authors experimented with inventors by applying standard psycho-diagnostic instruments. They found that inventors showed low scores for Neuroticism.[45] They concluded that low levels of Neuroticism seem to be conducive to invention because it appears to help individuals endure in the face of recurrent disappointment associated with inventing.[46]

Several studies have additionally shown that perseverance is another common trait among inventors.[47]

Joseph Rossman's The Psychology of the Inventor might be the most influential study in this regard.[48] The 1931 book is unique in its pioneering nature and wealth of data it gathered from 710 inventors.[49] In it, a striking 71 percent of the respondents rated "perseverance"[50] as one of the most defining traits of a successful inventor.[51]

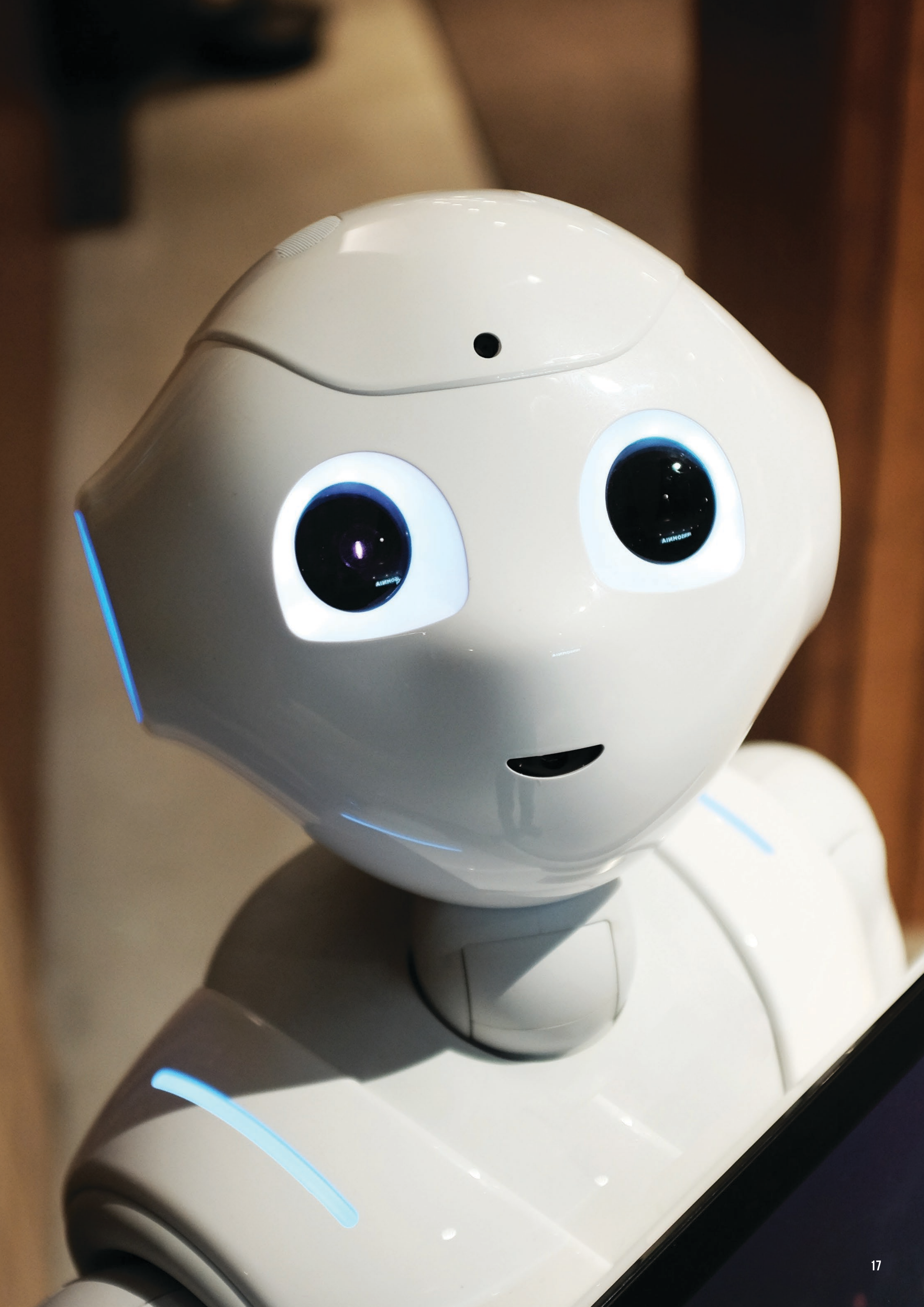
Indeed, some inventors see themselves as trying so many ideas that they give outsiders the impression of insanity.[52] Others consider that inventors need to have faith in an idea and refuse to take no for an answer.[53]

Likewise, exposure to innovation during childhood affects tendencies to invent later in life.[54] Economist Raj Chetty and his colleagues at Harvard University discovered that children whose families move to innovative regions while still young are more likely to become inventors.[55]

They also noticed that these exposure effects vary depending on gender and technological field. Children raised in regions or families with higher levels of inventiveness for a particular field appear more likely to generate patents in the same category.[56]

In other words, those growing up in Silicon Valley are more likely to work in Computer Science.[57] On the other hand, those from Minneapolis—which hosts numerous medical device manufacturers—are more likely to focus on such products. In parallel, they observed that females are more likely to invent in a specific field if they grow up in regions with women who are renowned in that same field.[58]

42 King, Walker, and Broyles, 'Creativity and the Five-Factor Model'.
43 King, Walker, and Broyles.
44 Amy E. Colbert et al., 'Interactive Effects of Personality and Perceptions of the Work Situation on Workplace Deviance.', Journal of Applied Psychology 89, no. 4 (2004): 599; Sun Young Sung and Jin Nam Choi, 'Do Big Five Personality Factors Affect Individual Creativity? The Moderating Role of Extrinsic Motivation', Social Behavior and Personality: An International Journal 37, no. 7 (2009): 941–56.
45 Mieg et al., 'How Emotional Stability and Openness to Experience Support Invention'; Mieg, 'A Two-Path Process Model of Invention'.
46 Mieg et al., 'How Emotional Stability and Openness to Experience Support Invention'; Mieg, 'A Two-Path Process Model of Invention'.
47 Flemings, 'Invention'; Robert J. Weber, 'Toward a Language of Invention and Synthetic Thinking', Creativity Research Journal 9, no. 4 (1996): 353–67; Mieg, 'A Two-Path Process Model of Invention'; Thomas Åstebro, Scott A. Jeffrey, and Gordon K. Adomdza, 'Inventor Perseverance after Being Told to Quit: The Role of Cognitive Biases', Journal of Behavioral Decision Making 20, no. 3 (2007): 253–72.
48 Tang, 'China's Young Inventors'.
49 J. Rossman, 'The Psychology of the Inventor; a Study of the Patentee.', 1931.
50 This attribute is crucial for companies relying on inventiveness, including Ericsson. See: https://www.ericsson.com/en/careers/working-here/our-culture
51 Rossman.
52 Kenneth A. Brown, Inventors at Work: Interviews with 16 Notable American Inventors (Microsoft Press, 1988); Mieg, 'A Two-Path Process Model of Invention'.
53 Brown, Inventors at Work; Mieg, 'A Two-Path Process Model of Invention'.
54 Alex Bell et al., 'Who Becomes an Inventor in America? The Importance of Exposure to Innovation', The Quarterly Journal of Economics 134, no. 2 (1 May 2019): 647–713, https://doi.org/10.1093/qje/qjy028.
55 Bell et al.
56 Bell et al.
57 Bell et al.
58 Bell et al.



FOSTERING INVENTIVENESS: COGNITIVE EMPOWERMENT AND INTELLECTUAL PROPERTY RIGHTS

There are multiple avenues for fostering inventiveness including psychological intervention, which can promote personality traits that correlate with invention. We also examine how nudged creativity can interrelate with personality characteristics. Finally, we explain how strong intellectual property rights (IPR) protection fosters and promotes invention.

PROMOTING OPENNESS TO EXPERIENCE AND LOWERING NEUROTICISM

As we have seen, Openness strongly correlates with inventiveness. Yet, psychologists still do not know if we can foster Openness in individuals.[59] Nevertheless, there is evidence suggesting genes shape personality traits, including Openness.[60]

In a study integrating data from 9,461 individuals from Canada, Germany, Japan, and Italy, McCrae and his co-authors estimated that genes account for 57 percent of the variability in Openness.[61] While psychologists still cannot grasp the remaining sources of variability, family upbringing seems to have little to no effect. For instance, the behavioural geneticist John Loehlin found that biologically distinct, adoptive children show almost no similarity in Openness once they become adults--despite being raised within the same family.[62]

Nevertheless, recent studies suggest that fostering Openness to Experience in individuals may be possible.[63] Psychologist Joshua Jackson and his colleagues asked older adults to complete a 16-week inductive reasoning exercise, accompanied by weekly crossword and Sudoku games.[64] The team then analysed variations in Openness to Experience with four measurements over 30 weeks, finding that participants' Openness increased compared to a control group.[65]

While evidence is sparse on promoting Openness to Experience, several studies suggest that lowering Neuroticism instead may be more

59 Scott Kaufman, 'What Happens When People Are Intentionally More Open to New Experiences? - Scientific American Blog Network', accessed 14 September 2021, https://blogs.scientificamerican.com/beautiful-minds/what-happens-when-people-are-instructed-to-be-more-open-to-new-experiences/.
60 Robert R. McCrae et al., 'Internal Consistency, Retest Reliability, and Their Implications for Personality Scale Validity', Personality and Social Psychology Review 15, no. 1 (2011): 28–50.
61 McCrae et al.; McCrae and Greenberg, 'Openness to Experience'.
62 John C. Loehlin, Genes and Environment in Personality Development. (Sage Publications, Inc, 1992); McCrae and Greenberg, 'Openness to Experience'.
63 Mirjam Stieger et al., 'Becoming More Conscientious or More Open to Experience? Effects of a Two-Week Smartphone-Based Intervention for Personality Change', European Journal of Personality 34, no. 3 (2020): 345–66.
64 Joshua J. Jackson et al., 'Can an Old Dog Learn (and Want to Experience) New Tricks? Cognitive Training Increases Openness to Experience in Older Adults.', Psychology and Aging 27, no. 2 (2012): 286.\
65 Jackson et al.

feasible.[66] After conducting a meta-analysis of several psychological interventions, the psychologist Anthony Jorm observed significant declines in Neuroticism following cognitive-behavioural therapy.[67]

Many other studies have provided evidence in favour of potentially addressing high Neuroticism.[68]

Still, for the most part, it is unclear whether psychological interventions can meaningfully foster certain personality traits that are conducive to inventiveness. At the same time, supporting individuals to adjust personalities may be controversial, even if done with the best intentions. If we aim to encourage invention, we should perhaps look beyond personality alone.

66 Stieger et al., 'Becoming More Conscientious or More Open to Experience?'
67 A. F. Jorm, 'Modifiability of Trait Anxiety and Neuroticism: A Meta-Analysis of the Literature', Australian and New Zealand Journal of Psychiatry 23, no. 1 (1989): 21–29.
68 Nathan W. Hudson and R. Chris Fraley, 'Volitional Personality Trait Change: Can People Choose to Change Their Personality Traits?', Journal of Personality and Social Psychology 109, no. 3 (2015): 490; Krystyna Glinski and Andrew C. Page, 'Modifiability of Neuroticism, Extraversion, and Agreeableness by Group Cognitive Behaviour Therapy for Social Anxiety Disorder', Behaviour Change 27, no. 1 (2010): 42–52.

FOSTERING CREATIVITY

In another approach, vast amounts of research have sought to analyse predictors of divergent thinking, particularly in children,[69] with some scholars claiming educators play significant roles to foster environments where students can articulate and nurture inventive ideas.[70]

In particular, research suggests that children's creative capabilities—including divergent thinking—benefit from more playful teachers that help make new learning meaningful for students and[71] generate higher levels of Openness.[72] In addition, parental behaviour appears to also play a crucial role, as attitudes such as respecting children and encouraging their autonomy can foster creativity.[73]

Adolescence is a critical time for the blossoming of specialised creativity.[74] As children enter puberty, they become more independent, and their extracurricular activities have a stronger sway on creative pathways.[75] In particular, activities that engage adolescents' creative problem-solving (e.g. escape rooms) and new challenges (e.g. expeditions in the outdoors) appear to also boost divergent thinking. [76]

Indeed, teenagers who spent considerable time in specific creative endeavours were more prone to develop abilities linked to that particular area.[77] The same went for teenagers who focused their interests and commitments on one specific creative task.[78] In line with these findings, psychologist Christopher Perleth and his colleagues showed that creatively gifted students stood out over time in artistic and social activities, especially in those beyond the classroom.[79]

As we have seen, multiple interventions boost creativity, even if they differ depending on age. Moreover, as we have observed, psychologist Laura King and her colleagues' findings suggest that people high in Openness have the potential for more remarkable creative accomplishments if their divergent thinking skills are better developed. In conclusion, it would appear to be more effective to target divergent thinking interventions for people with these personality characteristics.

INCREASING EXPOSURE TO INVENTION DURING CHILDHOOD

Chetty and his co-authors suggest programmes aimed at raising exposure to invention that could range from mentoring by current inventors to internship programmes at local firms.[80] Their findings do not offer guidance on which programmes are most effective, but provide suggestions on targeting them.

For instance, they conclude that targeting exposure programmes to disadvantaged children who stand out in maths and science may help increase inventiveness. Additionally, adapting programmes to participants' backgrounds may boost their potential—results suggest, for example, that women are more inspired by female inventors. In sum, the learning environment in and outside of school at an early stage has a sizable impact, where

69 Kristen M. Kemple and Shari A. Nissenberg, 'Nurturing Creativity in Early Childhood Education: Families Are Part of It.', Early Childhood Education Journal 28, no. 1 (2000): 67–71; Dean Keith Simonton, 'Creativity: Cognitive, Personal, Developmental, and Social Aspects.', American Psychologist 55, no. 1 (2000): 151; Danielle E. Delany and Cecilia S. Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.', Psychology of Aesthetics, Creativity, and the Arts 14, no. 4 (2020): 462.
70 Renee EL de Kruif et al., 'Classification of Teachers' Interaction Behaviors in Early Childhood Classrooms', Early Childhood Research Quarterly 15, no. 2 (2000): 247–68; Bob Jeffrey, 'Creative Teaching and Learning: Towards a Common Discourse and Practice', Cambridge Journal of Education 36, no. 3 (2006): 399–414; Erica McWilliam and Sandra Haukka, 'Educating the Creative Workforce: New Directions for Twenty-First Century Schooling', British Educational Research Journal 34, no. 5 (2008): 651–66; Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
71 Developmental psychologists call this elaboration, which consists in assisting students in making connections between their life and prior knowledge and new concepts and topics.
72 de Kruif et al., 'Classification of Teachers' Interaction Behaviors in Early Childhood Classrooms'; Il Rang Lee and Kristen Kemple, 'Preservice Teachers' Personality Traits and Engagement in Creative Activities as Predictors of Their Support for Children's Creativity', Creativity Research Journal 26, no. 1 (2014): 82–94; Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
73 Kemple and Nissenberg, 'Nurturing Creativity in Early Childhood Education'; Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
74 Baptiste Barbot and Todd Lubart, 'Creative Thinking in Music: Its Nature and Assessment through Musical Exploratory Behaviors.', Psychology of Aesthetics, Creativity, and the Arts 6, no. 3 (2012): 231; Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
75 Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
76 Delany and Cheung.
77 Baptiste Barbot and Pablo PL Tinio, 'Where Is the "g" in Creativity? A Specialization–Differentiation Hypothesis', Frontiers in Human Neuroscience 8 (2015): 1041; Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
78 Barbot and Tinio, 'Where Is the "g" in Creativity?'
79 Christopher Perleth, Wolfgang Sierwald, and Kurt A. Heller, 'Selected Results of the Munich Longitudinal Study of Giftedness: The Multidimensional/Typological Giftedness Model', Roeper Review 15, no. 3 (1993): 149–55; Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
80 Bell et al., 'Who Becomes an Inventor in America?'

teachers can encourage children's inventiveness by making learning relevant and playful. Offering teens extracurricular activities that enable them to participate in creative problem-solving might also enhance their capacity to invent.

Evidence suggests these activities should be prioritised for teens with an elevated level of curiosity (high on Openness to Experience). In addition, offering targeted mentorship and internship programs to young people who are less exposed to invention appears to be beneficial in fostering inventiveness. Beyond a fertile learning environment, a robust legal framework has a crucial role in promoting invention, as well.

INTELLECTUAL PROPERTY RIGHTS

INTELLECTUAL PROPERTY RIGHTS (IPR), INVENTION & EU COMPETITIVENESS

The development and commercialisation of inventions is an essential aspect to facilitate the green transition and achieve a successful digital transformation that boosts economic development and competitiveness.

To enable such progress, the EU must actively develop institutions that allocate time and money into R&D.[81]

One approach is to allocate public funds to finance innovative technologies.[82] The EU is strong in knowledge and innovation, representing about 20 percent of the world's total patenting, R&D expenditure, and scientific publications.[83] [84] At the same time, it lags behind global competitors in private investment into R&D.[85]

For the EU to bolster its global competitiveness, it needs to create the right incentives for individuals and businesses to invest private capital in R&D. In countries with a functioning patent system, such incentives take the form of a social contract, where the state offers temporary exclusivity to the inventor in exchange for disclosing an invention's specifications to society.[86]

Without safeguards against intellectual property (IP) infringement, companies and individuals tend to underinvest—as the prospect of imitation and other forms of IP theft make investments highly risky.[87]

This temporary exclusivity and the ability to license inventions to others are at the patent system's core. These features allow for the dissemination of knowledge and inventions, while incentivising reinvestment into R&D.

Revenue flow from successful products provides a reliable way to finance the research needed to develop next generation solutions. This creates a virtuous circle of innovation, which drives technologies onward.

The patent system has proven to be extraordinarily successful as it leads companies to continuously develop new products and processes. Indeed, based on a dataset of over 70 countries between 1981-2000, Albert Hu and Ivan Png found that patent protection is clearly associated with innovation.[88] [89] Similarly, they concluded that patentable inventions foster economic growth in developed countries.[90] [91] Numerous other studies have revealed a statistically significant association between patent strength and R&D spending or economic growth.[92]

81 Jaffe and Lerner, Innovation and Its Discontents.
82 Jaffe and Lerner.
83 The specific figures are: 20% of worldwide Patent Cooperation Treaty patent applications originating in the EU; 17 % of world R&D expenditure attributed to the EU; and a 21 % EU's share of global scientific publications.
84 European Commission, 'Science, Research and Innovation Performance of the EU, 2020 : 11 Recommendations for a Fair, Green and Digital Europe.', Website (Publications Office of the European Union, 19 March 2021), http://op.europa.eu/en/publication-detail/-/publication/07a0d2b8-8ac6-11eb-b85c-01aa75ed71a1/language-en/format-PDF.
85 European Commission, '2021 Strategic Foresight Report - The EU's Capacity and Freedom to Act - Communication from the Commission to the European Parliament and the Council'.
86 A more straightforward approach might be to reward the inventor with cash prizes. While prizes can be effective for developing concrete, desired technologies, they are not as effective for invention in general. First, it would be expensive to distribute enough prizes to reward the gamut of industrial innovation; raising the tax money would be unpopular and economically burdensome. Moreover, it would be difficult to figure out how large a prize to give to each invention. In many instances, the significance of discovery is uncertain at first. If the government tried to reward inventions mostly with prizes, in some cases it would set too much a reward and not enough in others. On the other hand, patents are inherently proportionate to the magnitude of the invention. It is unlikely that the exclusive right to a modest invention will be unbelievably valuable, while the exclusive right to important invention is generally very profitable.
87 Maureen K. Ohlhausen, 'Patent Rights in a Climate of Intellectual Property Rights Skepticism', Harv. JL & Tech. 30 (2016): 103.
88 Albert GZ Hu and Ivan PL Png, 'Patent Rights and Economic Growth: Evidence from Cross-Country Panels of Manufacturing Industries', Oxford Economic Papers 65, no. 3 (2013): 675–98.
89 Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'
90 Hu and Png, 'Patent Rights and Economic Growth'.
91 Delany and Cheung, 'Transactions between Adolescents' after School Activities and Divergent Thinking.'

EDUCATION ON INTELLECTUAL PROPERTY RIGHTS

Despite its critical role in promoting and rewarding invention, IPR is often overlooked in education curricula.[93] Teachers and students therefore may lack an appreciation for the value of intellectual contributions, including their own.

Having a better understanding of intellectual property may help students and instructors see how creative work directly relates to private property and the public domain.[94] Several innovative initiatives are now enabling students to create valuable intellectual property as a primary component of their learning experience.[95]

Looking at the maker movement in education,[96] students in such programmes take part in "digital fabrication labs" to invent and build their own gadgets.[97] The process combines the mental and physical work needed to create devices that students will eventually own.[98]

The experience students gain as they shift their views on intellectual property from passive consumers to seeing themselves as future producers of ideas can generate revenue.[99] Throughout this designing process, students become increasingly acquainted with the intellectual property rights contained in the devices they design, as well as how to produce and patent their inventions.[100]

Other teachers have had students create encyclopaedia of local history using wiki software, which is available via open-source software repositories.[101] The wiki experience provides students with vital insights into intellectual property by allowing them to participate in a self-organised, collective creation of knowledge.[102] This can help them perceive alternative approaches to intellectual property, including creative commons licensing.[103]

In short, schools must train students to engage in a global economy that is based on intellectual property to maximise educational investment. As students learn to operate under different rights of use, they will be more capable of appreciating the value of IPR as a safeguard for creative work.[104] Likewise, this learning process will help familiarise them with legitimate ways to disseminate common content without infringement.

INCREASED COLLABORATION IN INTELLECTUAL PROPERTY RIGHTS

Guarantees for inventors are crucial, yet it is equally essential to provide continued incentives for additional developments that build on the initial invention. Most marketable inventions today result from collaborative efforts and require long term financial support from organisations before they are ready for commercialisation. As such, patents protect an organisation's investments in developing an idea, as well as safeguarding the invention itself.

Patent trends through the last century reflect this trend of increased collaboration. In 1930, the United States and other industrialised countries awarded about half of all patents to independent inventors.[105] By 2010, independent inventors accounted for a mere 13.2 percent of United States patents (compared to about 17 percent in Germany).[106] [107]

92 J. Rothwell et al., 'Patenting Prosperity: Invention and Economic Performance in the United States and Its Metropolitan Areas. Metropolitan Policy Program at Brookings', Brookings, Washington, 2013; John Bound et al., 2. Who Does R&D and Who Patents? (University of Chicago Press, 2007); Georg Licht and Konrad Zoz, 'Patents and R&D an Econometric Investigation Using Applications for German, European and US Patents by German Companies', in The Economics and Econometrics of Innovation (Springer, 2000), 307–38; Ariel Pakes and Zvi Griliches, 3. Patents and R&D at the Firm Level: A First Look (University of Chicago Press, 2007); Sunil Kanwar and Robert Evenson, 'Does Intellectual Property Protection Spur Technological Change?', Oxford Economic Papers 55, no. 2 (2003): 235–64; Walter G. Park and Juan Carlos Ginarte, 'Intellectual Property Rights and Economic Growth', Contemporary Economic Policy 15, no. 3 (1997): 51–61; Ohlhausen, 'Patent Rights in a Climate of Intellectual Property Rights Skepticism'.
93 John Willinsky, 'Intellectual Property and Education', in Oxford Research Encyclopedia of Education, 2017.
94 Willinsky.
95 Willinsky.
96 Willinsky.
97 Paulo Blikstein, 'Digital Fabrication and 'Making'in Education', in FabLab (transcript-Verlag, 2014), 203–22; Willinsky, 'Intellectual Property and Education'.
98 Willinsky, 'Intellectual Property and Education'.
99 Willinsky.
100 Willinsky.
101 Robert M. Lucas, People Need to Know: Confronting History in the Heartland (Peter Lang Incorporated, International Academic Publishers, 2016); Willinsky, 'Intellectual Property and Education'.
102 Willinsky, 'Intellectual Property and Education'.
103 Willinsky.
104 Willinsky.
105 Mieg, 'A Two-Path Process Model of Invention'.

Inventions that are commercialised must be sufficiently rewarded to cover the initial costs of the invention and address any costs of failure. Companies and individuals require this to justify continued investment.

In short, much is at stake in creating incentives for invention. Due to inherent risks during the process, patents are often crucial to offering enough protection to attract investor funding for R&D.[108]

106 Mieg.
107 Several economists have found that collaboration boosts inventors' creative power. Jasjit Singh and Lee Fleming analysed the correlation between working alone and invention results by examining half a million patents. According to their findings, collaboration increases the probability of breakthrough inventions, and, in parallel, it decreases the likelihood of failures. Their results also suggested that thanks to collaboration, inventors combine and improve their ideas to achieve breakthroughs. Additionally, according to the so-called Pat-Val study on the value of European patents, two-thirds of inventions saw the participation of more than just one inventor, revealing the importance and efficacy of collaboration in inventiveness.
108 Jaffe and Lerner, Innovation and Its Discontents.

RECOMMENDATIONS

This report has investigated a series of initiatives to foster inventiveness in Europe. Given the limited scope of our research, we've focused on a limited number of measures. Based on our findings, ThinkYoung and Ericsson offer four recommendations to promote inventiveness:

1 Encourage schools and educators to explore playful and engaging techniques when teaching young children. Likewise, teachers should be encouraged to make learning more generally meaningful.

2 Facilitate access to extracurricular activities for teenagers, which allow them to engage in creative problem-solving and novel challenges. Evidence suggests that these interventions should target teenagers who show a high degree of curiosity (score high on Openness to Experience).

3 Promote mentoring for students by current inventors and offer internship programmes at innovative firms. This intervention would be particularly effective for students that are not exposed to invention in their daily environment.

4 Ensure solid IPR protection enables European industries to remain globally competitive. Likewise, schools should educate students on the fundamental role of intellectual property and prepare them to engage in a global knowledge economy that increasingly relies on intangible assets.

Inventors can help address challenges and seize the opportunities of the digital transformation and green transition. As Europe recovers from the Covid-19 crisis and sets bold targets for a greener and growing digital economy, an educational system that promotes creativity and a strong IPR framework to foster invention are key to remaining competitive in a global context. At the same time, efforts to raise younger generations' awareness about IPR (and patent protection, in particular) as a commercial asset are greatly needed.

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ANNEX 1
STATISTICAL TABLES

TABLE 1: SUMMARY STATISTICS FOR DIVERGENT THINKING SCORE

N	**Valid**	1168
	Missing	336
Mean		.1154
Median		.0400
Mode		.01
Std. Deviation		.25099
Skewness		4.578
Std. Error of Skewness		.072
Kurtosis		28.051
Std. Error of Kurtosis		.143
Minimum		.00
Maximum		2.88

TABLE 2: CORRELATIONS BETWEEN AGE AND DIVERGENT THINKING SCORE

Kendall's tau_b	**Divergent Thinking Score**	**Age**
Divergent thinking score		
Correlation Coefficient	1.000	.083**
Sig. (2-tailed)	.	<.001
N	1168	1168
Age		
Correlation Coefficient	.083**	1.000
Sig. (2-tailed)	<.001	.
N	1168	1504

**. Correlation is significant at the 0.01 level (2-tailed).

TABLE 3: MULTIVARIATE LINEAR REGRESSION MODEL FOR DIVERGENT THINKING SCORE AS A DEPENDENT VARIABLE: ANOVA TABLE

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1						
	Regression	8.177	11	.743	2.527	.004[b]
	Residual	340.009	1156	.294		
	Total	348.186	1167			

a. Dependent Variable: Divergent thinking score
b. Predictors: (Constant), Age, Country=Germany, Gender=Male, Education=Technical education, Education=Post-graduate degree, Education=Primary education, Country=Poland, Country=France, Country=Belgium, Education=University education, Country=Sweden

TABLE 4: MULTIVARIATE LINEAR REGRESSION MODEL FOR DIVERGENT THINKING SCORE AS A DEPENDENT VARIABLE: COEFFICIENTS

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-2.095	.215		-9.737	<.001
	Gender=Male	-.007	.032	-.006	-.220	.826
	Education=Primary education	.005	.099	.001	.047	.963
	Education=Technical education	-.045	.051	-.029	-.894	.371
	Education=University education	.018	.038	.016	.475	.635
	Education=Post graduate degree	.061	.060	.032	1.015	.310
	Country=Belgium	.093	.053	.065	1.742	.082
	Country=France	-.045	.053	-.031	-.847	.397
	Country=Germany	-.059	.056	-.038	-1.051	.293
	Country=Poland	.050	.054	.034	.929	.353
	Country=Sweden	.032	.057	.021	.555	.579
	Age	.490	.148	.101	3.308	<.001

a. Dependent Variable: Divergent thinking score

TABLE 5: MULTIVARIATE LINEAR REGRESSION MODEL FOR DIVERGENT THINKING SCORE AS A DEPENDENT VARIABLE: EXCLUDED VARIABLES

Excluded Variables[a]

Model	Beta in	t	Sig.	Partial Correction	Collinearity Statistics Tolerance
Gender=Female	.[b]	.	.	.	.000
Education=Secondary education	.[b]	.	.	.	.000
Country=Italy	.[b]	.	.	.	.000

a. Dependent Variable: Divergent thinking score
b. Predictors in the Model: (Constant), Age, Country=Germany, Gender=Male, Education=Technical education, Education=Post-graduate degree, Education=Primary education, Country=Poland, Country=France, Country=Belgium, Education=University education, Country=Sweden

TABLE 6: COMPARISON OF MEANS BY COUNTRY FOR DIVERGENT THINKING SCORE

DIVERGENT THINKING SCORE

Country	Mean	N	Std. Deviation	Median
Belgium	.1197	209	.27330	.0500
France	.0719	200	.13103	.0300
Germany	.1269	169	.32596	.0300
Italy	.0785	219	.14070	.0300
Poland	.1475	193	.27297	.0300
Sweden	.1589	178	.30855	.0300
Total	.1154	1168	.25099	.0400

TABLE 7: COMPARISON OF MEANS BY COUNTRY FOR DIVERGENT THINKING SCORE: ANOVA TABLE

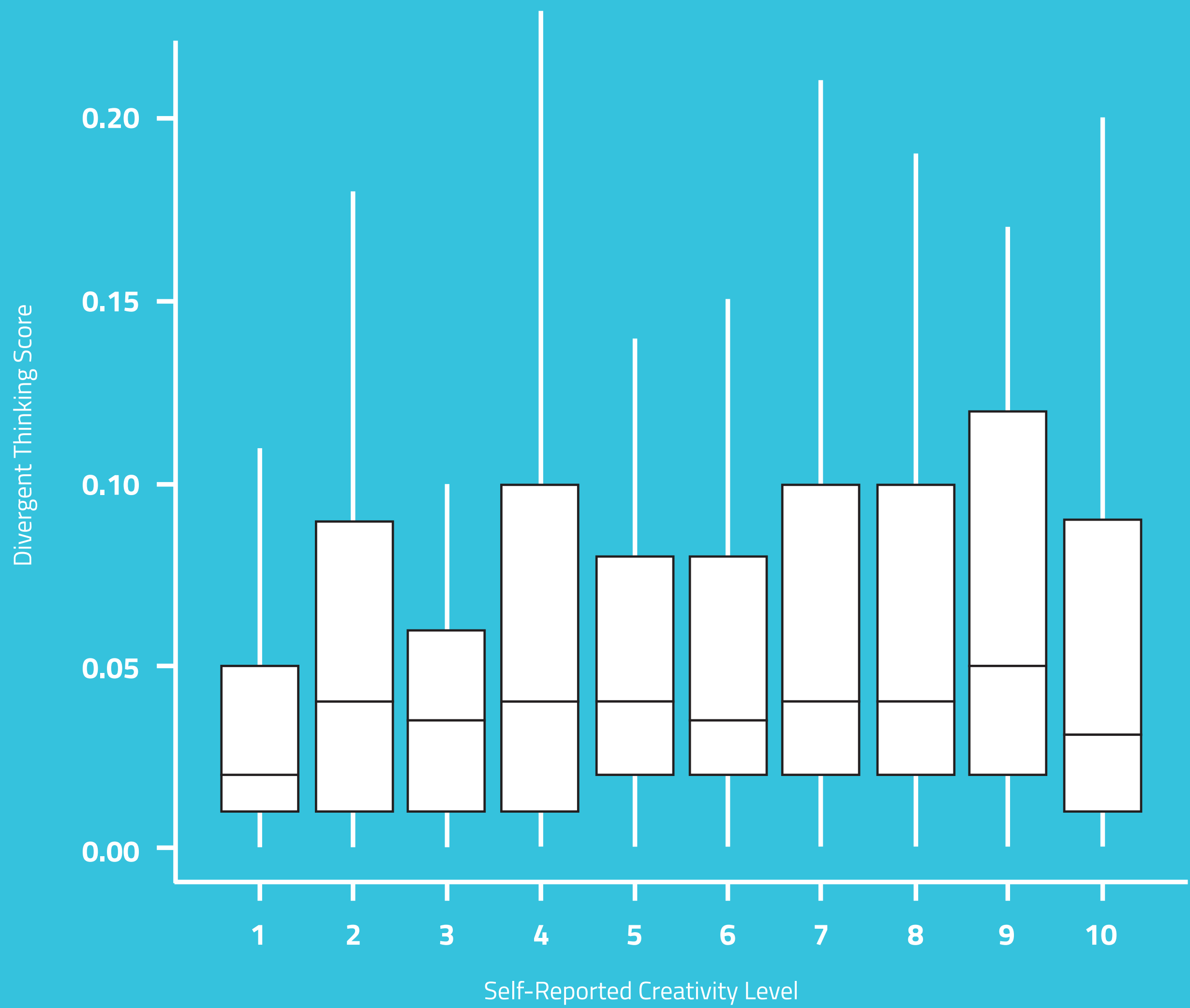
DIVERGENT THINKING SCORE*

Country (Combined)	Sum of Squares	df	Mean Square	F	.Sig
Between Groups	1.239	5	.248	3.985	.001
Within Groups	72.276	1162	.062		
Total	73.515	1167			

TABLE 8: CORRELATIONS BETWEEN SELF-REPORTED CREATIVITY LEVEL AND DIVERGENT THINKING SCORES

	Self Reported creativity level	Divergent Thinking Score
Kendal's tau_b		
Self Reported creativity level		
Correlation Coefficient	1.000	0.032
Sig. (2-tailed)		0.151
N	1431	1109
Divergent Thinking Score		
Correlation Coefficient	0.032	1.000
Sig. (2-tailed)	0.151	
N	1109	1168
Spearman's rho		
Self Reported creativity level		
Correlation Coefficient	1.000	0.043
Sig. (2-tailed)		0.148
N	1431	1109
Divergent Thinking Score		
Correlation Coefficient	0.043	1.000
Sig. (2-tailed)	0.148	
N	1109	1168

FIGURE 1: BOXPLOT OF DIVERGENT THINKING SCORE BY SELF-REPORTED CREATIVITY LEVEL



ANNEX 2: SURVEY QUESTIONNAIRE

1. Imagine a billboard, the kind that is normally used to display advertisements or information in public spaces. Your task now is to list any other potential uses for a billboard. This can also include any material and creative additions that expand on its original purpose. Remember, there are no wrong answers, so list as many original uses as possible. Please list your ideas below.

2. Could you please detail and elaborate further the answer you have given earlier, we would like to make sure we can understand very precisely your idea given the context?

3. Could you please finally think of anything else for this billboard, rather than the uses of advertising and other uses you might have thought of previously?

ANNEX 3 : DIVERGENT THINKING SCORE FORMULA

$$s_i = \sum_{j=1}^{m} \left(\frac{1}{u_j} \right)$$

Where *u* is the number of times for a particular idea *(j)* for an alternative use of a billboard has been mentioned, while *s* is the score obtained by respondent *i*.

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Partner