Gender differences regarding Spanish citizens' perception of Data Science

Diferencias de género en la percepción de la ciudadanía española sobre la Ciencia de Datos

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Abstract:

The aim of this article is to determine whether there are gender differences with regard to the knowledge and attitudes of Spanish citizens toward data science, and whether those perceptions have been altered by the pandemic. For this purpose, an online survey with closed questions was conducted with a representative sample of 1,105 male and female citizens in two phases (January and October of 2020), in order to compare the degree to which the Covid-19 pandemic has influenced such perceptions. The results show that knowledge regarding Big Data and Artificial Intelligence is modest, being higher among men, especially in relation to Big Data. Moreover, the level of interest decreased in the second phase in both genders, which points to several gender differences with regard to the perception of benefits and risks of their application, such as the following: men perceived more benefits than women, while women generally perceived more risks with all technological applications in the first phase, yet in the second phase their perception of benefits rose to a level nearly equal to that of men. It has also been observed that in the second phase the perception of risk increased for both genders, and that the differences between the two are not significant.

Keywords:

Gender; data science; scientific communication; Big Data; Artificial Intelligence.

Resumen:

Este artículo tiene como objetivo comprobar si existen diferencias de género en el conocimiento y actitudes de la ciudadanía española hacia la ciencia de datos, además de si estas percepciones se vieron modificadas por la pandemia. Para ello se ha realizado una encuesta online con preguntas cerradas a una muestra representativa de 1105 ciudadanos y ciudadanas con dos oleadas (enero y octubre de 2020) que permitieron comparar en qué grado la pandemia por Covid-19 ejerció influencia. En los resultados se observa que el conocimiento sobre Big Data e Inteligencia Artificial es moderado, siendo mayor en hombres, especialmente en Big Data; que el grado de interés disminuye en la segunda oleada en ambos géneros y apunta a varias diferencias de género en la percepción de beneficios y riesgos en sus aplicaciones: los hombres perciben más beneficios que las mujeres, mientras que las mujeres perciben más riesgos en general en todas las aplicaciones tecnológicas en la primera oleada, pero en la segunda sube su percepción de beneficios hasta casi igualar a los hombres. Se observa que en la segunda oleada los riesgos han aumentado para ambos géneros y que las diferencias entre ambos no resultan significativas.

Palabras clave:

Género; ciencia de datos; comunicación científica; Big Data; Inteligencia Artificial.

1. Introduction

The widespread and increasing public interest in scientific advancement has been directly related to the current Covid-19 pandemic, although recently this interest seems to stem from the media focus on issues of new technology, and especially on everything related to Big Data and Artificial Intelligence.

However, this matter involves the traditional dilemma posed by Umberto ECO between apocalyptic adherents who see technology as an existential threat to humanity in the event that machines become smarter than humans, and those who take an integrated approach in perceiving technological advancement as synonymous with progress and innovation.

A cross-sectional analysis of the knowledge and attitudes of Spanish citizens toward data science from a gender perspective has been carried out in order to prepare this article. An examination has been performed for the purpose of verifying whether there are differences between men and women in the perception of data science, Big Data and Artificial Intelligence in terms of familiarity and interest, as well as benefits and risks. In order to achieve the objective, survey results obtained during two different time periods have been observed. The first phase of the survey was carried out in January of 2020 and, by October of 2020, it was possible to carry out the second phase with a subsequent comparison of the two periods based on the selected variables. The Covid19 pandemic and the confinement in Spain occurred between the two phases, and therefore it is interesting to observe whether there were changes in perception before and after the health crisis.

The gender bias in Artificial Intelligence and Big Data has been widely noted due to the fact that the developers of these technologies are overwhelmingly male, as pointed out by Leavy (2018). From voice recognition applications to search engines, AI and BD-based algorithms can reproduce existing patterns of discrimination (Howard, 2018). The aim of this study is to measure citizens' perception of these realities in the Spanish context in order to determine whether there are perceptual differences between men and women in this regard.

2. State of the Issue

Today's society is characterised by the transmission of knowledge through multiple channels, with the mass media being one of the main sources of information. This has led to our experience of living in an era of globalisation. During the current pandemic, television has been the most heavily used news medium, closely followed by digital media (Montaña Blasco et al., 2020). Moreover, communication related to science has been frequently analysed in the European and international contexts (Miller, 2004; Miller, 2001; European Commission, 2014, 2017a, 2017b, 2020). Information and data represent a new, valuable market, while the considerable technological progress we are experiencing is the factor that builds and sustains the knowledge society (Palomares Ruiz, 2004). However, on this basis, science plays a fundamental role in the development of society, and efforts must be made to ensure that its dissemination reaches all audiences, thereby increasing the body of scientific knowledge.

The communication of science news fulfils a purpose aimed at informing, building culture, recognising, and supporting endeavours by researchers along with their work, which provides them with high social esteem (Pearson, 2001). Enhancing public understanding of science requires the involvement of all actors in the sector, and therefore calls for the mobilisation of scientists and resources capable of engaging the public, preparing the context, and developing actions that deliver results. With regard to the public, a willingness to participate is necessary in order to establish a dialogue between scientific/technological developments and their audiences (Bauer and Jensen, 2011). Studies of knowledge and social perception of science and technology provide information on how to reach the public, and the starting point as well. Such research allows us to understand the level of citizens' knowledge, as well as the way in which the risks and benefits are understood, and to identify social, cultural, and political issues in public opinion that may affect government decisions on this issue. These studies also facilitate knowledge

among different social actors (e.g. the media, research sector, academic community, private sector, and others), thus connecting scientists, communicators and scientific policy-makers (Felt, 2007).

The basic concepts of data science are not widely known in society, as it is both a novel and complex discipline.

Data science is a contemporary discipline that combines computer science with mathematical approaches in order to gain meaningful insights from data. It partially includes Big Data and Artificial Intelligence techniques.

Big Data is a discipline that involves the handling of data sets that are large in volume, complex, and growing at a high rate of speed, and therefore cannot be collected, processed, or analysed with conventional techniques (Mayer-Schönberger & Cukier, 2013).

Artificial Intelligence is a combination of techniques that studies how machines can solve complex problems through reasoning and choosing the best option. Although it is broader, AI is partly included in the discipline of data science. According to the European Union, artificial intelligence is the ability of a machine to exhibit the same capabilities as humans, such as reasoning, learning, creativity, and the ability to plan (Samoili et al., 2020).

However, negative attitudes toward the advancement of these techniques and their application in everyday life can be observed. At the national level, the Spanish Foundation for Science and Technology (*FECYT*) has been publishing a biannual study entitled "*Percepción social de la Ciencia y la Tecnología en España*" (Social Perception of Science and Technology in Spain) since 2002, which provides transversal information related to citizens' opinions on these issues. In 2018, the survey introduced the perception of risk regarding Artificial Intelligence for the first time, highlighting that 38.4% of the respondents consider it to be quite or very risky, along with mechanisation or robotisation of work processes, which was also considered quite or very risky by 45.9% of the respondents (*FECYT*, 2018). In the updated 2020 survey, the figures vary slightly, with the figure declining to 34.3 % among those who consider the risk to be fairly or very high, and an increase to 48% of those respondents who consider the risk to be fairly or very high regarding the mechanisation or robotisation of work (FECYT, 2021).

At the European level, studies also point to a certain scepticism toward technological discoveries, especially with regard to the fact that they might eliminate jobs or put our privacy at risk (European Commission, 2017a). With a practical orientation, previous studies have analysed opinions on the advancement of data science in the journalism profession, examining various points of view (Calvo-Rubio et al., 2020), or the perception by journalists of data science communication itself (Sánchez-Holgado et al., 2021).

In this context, data science is one of the cutting-edge fields at the present time, but it is also proving to be one of the most controversial and, consequently, its dissemination presents additional challenges to most fields of science communication, with a significant gap in the building of scientific literacy.

The gender approach in studies of the social perception of science has previously been explored in multiple studies, one of which is from Hayes and Tariz (2000), who examined whether women in the United States, Canada, Great Britain, and New Zealand had less knowledge and less favourable attitudes toward science than men, concluding that there were no gender differences, yet there were differences related to socioeconomic, educational, and cultural aspects due to social backgrounds, except in the case of the United States, where the differences were primarily due to the aspect of scientific literacy. Moreover, it is directly

related to the so-called "white male effect", which suggests that white men perceive the risks of health hazards and technology as low compared to white women and people of colour. White men's perception of low risk is associated with individualistic and hierarchical worldviews as opposed to an egalitarian approach. Similarly, Finucane et al. (2000) conducted a national study to measure perceptions of environmental health risks based on gender and race, and the results showed that women perceived the risks to be much higher than men (Finucane et al., 2000).

Berman and Bourne (2015) prioritise gender diversity in data science because of its strategic importance in information and communication societies, as well as the traditional gender gap in STEM (science, technology, engineering, and mathematics). Scientific evidence shows that "incorporating a sex-generic analysis into research can improve experimental reproducibility and efficiency, help reduce bias, enable social equality in scientific results, and foster opportunities for discovery and innovation" (Tannenbaum et al., 2019).

If Big Data is biased, such distortion is transmitted to the analysis that is carried out, and ultimately to knowledge. For this reason, there are already efforts to remove this bias, such as the tool proposed by Díaz Martínez et al. (2020), which performs its filtering in Spanish and in turn uses Big Data as both an object and a resource. However, while sex as a biological variable in science and engineering has traditionally been studied, gender as a cultural variable is complex and multidimensional, and "applications to technical fields often require collaboration with social scientists in order to understand the relevant aspects of gender for specific projects" (Tannenbaum et al., 2019). In this regard, in the journal Nature the same authors note that the "methodological challenges include moving beyond the binary aspect, female and male, women and men, in both sex and gender analysis". In their book entitled *Data Feminism*, D'Ignazio and Klein (2020) summarise the importance of the gender perspective in data science by explaining that cross-sectional feminism examines power inequality, and that data is power in today's world. Some critical observers warn of the routine production of race or gender bias, but the distant and multidimensional nature of machine learning correlations may result in more subtle forms of discrimination going unnoticed (McQuillan, 2018). In this sense, Jurgenson (2014) sees a major problem in what he calls "Big Data ideology" with regard to the fact that researchers whose work revolves around race, gender, and sexuality in culture refuse to acknowledge how their specific social point of view influences their entire research process.

The study of possible gender differences in the social perception of data science at two points in time, both in the pre-confinement and post-confinement caused by Covid-19, adds coherence and value to the study, as it allows us to assess the impact that extraordinary circumstances have had on the perception of technologies that use Big Data and Artificial Intelligence. In most sectors, the impact of the confinement on people has been, or is currently being assessed. Therefore, applying it at this point is relevant to the findings of this research.

In the case of women, it has been shown that the responsibility of family care has directly affected their attitudes, perceptions, and health, and the effects they have experienced from Covid 19 have been studied by the United Nations (UN Women, 2021). Understanding the gender perspective is essential in responding to the pandemic and its effects, according to a report published by the Women's Institute ((*Instituto de las Mujeres y para la Igualdad de Oportunidades*, 2020), and women's equal participation in decision-making are central to recovering from the crisis, according to the Organisation of American States (OAS) (Inter-American Women's Commission, 2020).

Therefore, the gender approach is relevant with regard to the knowledge and perception of the benefits and risks of data science, Big Data, and Artificial Intelligence, and this research aims to fill the gap.

3. Objectives

The main purpose of this article is to highlight the structural connections between perceptions of data science communication and gender.

With this premise in mind, and based on the literature review, the following research questions (RQ) have been posed:

RQ1: Are there gender differences in the level of knowledge and interest in data science, Big Data, and Artificial Intelligence in Spain?

RQ1a: Have there been any changes when comparing the situation before and after the Covid-19 confinement?

RQ2: Are there gender differences in the perception of benefits and risks of data science, Big Data, and Artificial Intelligence in Spain?

RQ2a: Have there been any changes when comparing the situation before and after the Covid-19 confinement?

4. Methodology

4.1. Sample and procedure

The results of two phases of a survey involving a representative sample of Spanish society within the framework of the DATASCIENCE SPAIN project were analysed. For this purpose, a questionnaire with closed questions was designed and validated. The distribution was carried out online in both phases through the Qualtrics platform, with a sampling service having been solicited from the company in order to have a randomised sample with the aim of guaranteeing an adequate, representative distribution of respondents stratified by gender, age, and autonomous region, both in the first and the second phases.

The first phase was conducted from 20-24 of January 2020, based on a sample of 684 people, while the second phase was carried out from 7-12 of October 2020, using a sample of 421 people.

Thus, the total sample is quite extensive, consisting of 1,105 respondents. Moreover, in the nearly nine-month period between the two phases, the Covid-19 pandemic and the confinement in Spain significantly defined the time period between the two. Therefore, the extent to which this situation influenced the respondents must be analysed as well. In order to make a longitudinal comparison between the two phases, this study focuses on 4 specific areas that were replicated in both phases: familiarity, interest, benefits, and risks.

4.2. Measurements

In order to measure the degree of knowledge and answer the first research question, a five-point Likert-type scale with the following variables was used:

– *Familiarity with the concept of Big Data and the concept of Artificial Intelligence*: the scale ranges from 1 (not familiar at all, I know nothing about it), to 5 (very familiar, I understand its use and I utilise it), which measures the extent to which respondents are familiar with the subject and their level of use.

– *Level of interest, knowledge, or use of Big Data and Artificial Intelligence*: the scale ranges from 1 (not at all interested) to 5 (very interested), which measures the degree of citizens' interest in the subject.

– For measuring the perception of benefits and risks, and for the purpose of answering the second research question, the same type of measurements were used with the following variables:

– *Benefits of Big Data and AI applications*: from 1 (no benefit) to 5 (many benefits), in order to measure the level of benefits perceived in each of the selected applications.

– *Application risks of Big Data and Artificial Intelligence*: from 1 (no risk) to 5 (many risks), measuring the level of perceived risk in each of the selected applications.

4.3. Analysis

The responses obtained were anonymous, and a descriptive analysis of frequencies and means was carried out as well. Inferential statistical tests were applied: Student's t-tests for independent samples for the purpose of investigating whether gender differences existed were conducted using the IBM SPSS package, version 25. Finally, Cohen's d value was calculated using the means and standard deviations of the groups.

5. Results

5.1. Socio-demographic characteristics

Of the 684 people in the sample, 375 were women and 306 men (Table 1).

Table 1. Distribution of the sample by gender

Gender	% of the sample
Women	54.82%
Men	44.74%
Other	0.,44%

Source: Prepared by the authors

In terms of age distribution, the predominant option is in the 35 to 49 year age group, and the one with the lowest coverage is in the 18 to 24 age group (Table 2).

Table 2. Sample distribution by age

Age group	% of the sample
18 to 24 years	8.19%
25-34 years	25.00%
35 to 49 years	30.26%
50 to 64 years	19.30%
Over 65 years old	17.25%

Source: Prepared by the authors

The representativeness of the sample was verified in order to ensure that it was balanced with the population in such a way that 62.87% of the respondents lived in the Autonomous Regions of Madrid, Catalonia, Andalusia, and Valencia (Table 3). These data are in line with the number of inhabitants of the populations, among which the respondents reside, with 24.7% living in cities with more than 500,000 inhabitants, and 24.6% residing in cities with populations between 100,001 and 500,000 inhabitants. The figure of 36.4% of the respondents live in towns and cities with between 10,000 and 100,000 inhabitants, and 12.6% reside in communities with a population of less than 10,000 people.

Table 3. Geographical distribution of the sample

Autonomous Region	% of the sample
Andalusia	14.62%
Aragon	3.07%
Cantabria	1.75%
Castilla La Mancha	2.49%
Castilla and Leon	5.70%
Catalonia	15.06%
Ceuta	0.15%
Autonomous Region of Madrid	20.91%
Chartered Community of Navarra	0.58%
Autonomous Region of Valencia	12.28%
Extremadura	2.49%
Galicia	4.97%
Balearic Islands	1.17%
Canary Islands	2.78%

La Rioja	0.88%
Melilla	0.15%
Basque Country	4.97%
Principality of Asturias	3.22%
Region of Murcia	2.78%

Source: Prepared by the authors

As for the level of education, almost half of the respondents (48.89%) have higher education, so they are people who, a priori, have had contact with science (Table 4).

Table 4. Distribution of the sample by level of education

Educational level	% of the sample
No education	0.44%
Primary school or equivalent	2.63%
Compulsory Secondary Education or equivalent	8.19%
A Levels	16.81%
Vocational training or equivalent	21. 93%
University education, master's degree, and postgraduate studies	39.78%
Third-cycle studies (Doctorates)	10.09%

Source: Prepared by the authors

5.2. Gender differences in the level of familiarity with and interest in data science, Big Data, and Artificial Intelligence in Spain

In terms of the degree of familiarity with Big Data or Artificial Intelligence, and regarding the first question posed (RQ1), if we look at the first phase from January 2020, the data we have analysed in this study show homogeneous values between men and women. Thus, the only finding in this area was that men seem to be more familiar with the concept of Big Data than women. In the case of Artificial Intelligence, there is hardly any difference (Table 5).

If we look at the second phase from October of 2020, the values obtained show a significant difference between men and women, indicating that men are more familiar with Big Data and Artificial Intelligence than women (Table 6). As one can observe, familiarity with Big Data and Artificial Intelligence in the second phase is significant, whereas this was not the case in the first phase. Thus, gender differences increased in this area in October.

Focusing on the degree of interest, and in order to complete the answer to RQ1, we have observed that the first phase from January of 2020 shows homogeneous values between men and women in terms of interest in Big Data and data related to Artificial Intelligence (Table 5).

Looking at the second phase from October 2020, men were more interested in Big Data and Artificial Intelligence than women, yet the differential with regard to the data is not significant (Table 6).

Table 5. Familiarity with and interest in Big Data and Artificial Intelligence in the first phase in January 2020

FIRST PHASE - JANUARY 2020									
	No. Men	M Men	SD Men	No. Women	M Women	SD Women	t(679)	p-value	d
Familiarity									
Big Data,	306	2.97	1.432	375	2.77	1.449	1.819	0.069	0.14
Artificial Intelligence	306	3.48	1.244	375	3.41	1.300	0.731	0.465	0.05
Interest									
Big Data	306	3.64	1.265	375	3.64	1.230	0.012	0.991	0.00
Artificial Intelligence	306	3.91	1.196	375	3.89	1.212	0.186	0.853	0.02

*p<0.05; **p<0.01; ***p<0.001
Source: Prepared by the authors

Table 6. Familiarity with and interest in Big Data and Artificial Intelligence in the second phase in October 2020

SECOND PHASE - OCTOBER 2020									
	No. Men	M Men	SD Men	No. Women	M Women	SD Women	t(679)	p-value	d
Familiarity									
Big Data*	208	3.00	1.436	211	2.66	1.532	2.352	<0.05	0.23
Artificial Intelligence *	208	3.45	1.281	211	3.16	1.280	2.363	<0.05	0.23
Interest									
Big Data	208	3.36	1.266	211	3.27	1.317	0.641	0.522	0.07
Artificial Intelligence	208	3.57	1.249	211	2.49	1.197	0.662	0.508	0.06

*p<0.05; **p<0.01; ***p<0.001
Source: Prepared by the authors

With regard to RQ1a, which asked whether there had been any changes between the two periods, what can be observed is that in the second phase in October, both the level of familiarity and the level of interest among both men and women decreased.

In the case of Familiarity, women were less familiar, yet in October their level dropped more than that of men, both with regard to Big Data and Artificial Intelligence, with the gender differences between men and women being significant in the second phase. In the case of men, even in October they raised their level of familiarity with Big Data slightly, resulting in a significant

difference with women, and with a high effect size. Regarding Artificial Intelligence, despite the fact that men also displayed a slight decrease, they still showed a significant difference from women with regard to a high effect size.

In relation to level of interest, there are no significant variations between men and women, while from the first to the second phase, the level of interest in both Big Data and Artificial Intelligence decreased (Table 7).

Table 7. Comparison by gender of the first phase in January and the second phase in October.

Familiarity		No. Men	M Men	SD Men	No. Women	M Women	SD Women	df	t	p-value	d
JANUARY	**BD**	306	2.97	1.43	375	2.77	1.45	679	1.819	0.069	0.14
OCTOBER	**BD***	208	3.00	1.43	211	2.66	1.53	417	2.352	<0.05	0.23
JANUARY	**AI**	306	3.48	1.24	375	3.41	1.30	679	0.731	0.465	0.05
OCTOBER	**AI***	208	3.45	1.28	211	3.16	1.28	417	2.363	<0.05	0.23

Interest		No. Men	M Men	SD Men	No. Women	M Women	SD Women	df	t	p-value	d
JANUARY	**BD**	306	3.64	1.26	375	3.64	1.23	679	0.012	0.991	0.00
OCTOBER	**BD**	208	3.36	1.26	211	3.27	1.31	417	0.641	0.522	0.07
JANUARY	**AI**	306	3.91	1.19	375	3.89	1.21	679	0.186	0.853	0.02
OCTOBER	**AI**	208	3.57	1.24	211	3.49	1.19	417	0.662	0.508	0.06

Note: BD=Big Data; AI= Artificial Intelligence *p<0.05; **p<0.01; ***p<0.001

Source: Prepared by the authors

5.3. Gender differences regarding the perception of benefits and risks of data science, Big Data and Artificial Intelligence in Spain

With regard to the second research question (RQ2), after analysing the perception of benefits and risks that citizens identify in a series of applications associated with both Big Data and Artificial Intelligence, differences by gender have been observed. In the case of Big Data, the applications analysed are the following: making decisions based on data, gaining knowledge about the market and consumers, making predictions based on data, the use of large volumes of data, cybersecurity, protecting personal data, using social networks, and improving transport and mobility systems. On the other hand, in the case of Artificial Intelligence, the applications analysed are as follows: work automation, detecting online fraud, personnel selection, armaments and defence, applications to medicine in order to detect illness, disaster prevention, and real-time emergency management.

Regarding Big Data, in the first phase in January we can see that there were several applications with significant differences by gender regarding perceived benefits. The use of large volumes of data is more beneficial according to men than women, as

well as making decisions based on data, improving transportation and mobility systems, making predictions based on data, and cybersecurity. In the rest of the applications, although the differences are not significant, it can be observed that men perceive greater benefits than women in all cases (Table 8).

As for the risks of Big Data in the first phase in January, the differences between men and women are not significant either, and it can also be observed that men perceive more risks than women in nearly all applications, except in the case of using large volumes of data, although the differences are much smaller than in the area of benefits. We see that the largest effect size on risk is in the protection of personal data (Table 8).

Table 8 . Gender perceptions of benefits and risks of major Big Data applications in the first phase of January 2020

	Big Data	MEN No. = 306		WOMEN No. = 375		df	t	p-value	d
		M Men	SD Men	M Women	SD Women	df	t	p-value	d
BENEFITS	Making data-driven decisions **	3.78	1.222	3.5	1.330	679	2.89	<0.01	0.22
	Market and consumer insights	3.88	1.226	3.71	1.257	679	1.772	0.077	0.14
	Data-driven predictions *	3.82	1.201	3.61	1.229	679	2.202	<0.05	0.17
	The use of large volumes of data ***	4.04	1.170	3.68	1.258	667.424	3.853	<0.001	0.30
	Cybersecurity *	3.86	1.285	3.6	1.399	669.505	2.461	<0.05	0.19
	Protecting personal data	3.79	1.321	3.66	1.422	679	1.251	0.211	0.09
	Using social networks	3.59	1.273	3.56	1.321	679	0.315	0.753	0.02
	Improving transport and mobility systems **	4.04	1.188	3.77	1.296	669.863	2.851	<0.01	0.22
	TOTAL	**3.85**	**1.235**	**3.64**	**1.147**				**0.18**

RISKS	Making data-driven decisions	3.25	1.364	3.17	1.408	679	0.702	0.483	0.06
	Market and consumer insights	3.18	1.423	3.1	1.417	679	0.771	0.441	0.06
	Data-driven predictions	3.31	1.349	3.26	1.312	679	0.474	0.636	0.04
	Using large volumes of data	3.23	1.443	3.25	1.390	679	-0.231	0.817	0.01
	Cybersecurity	3.53	1.374	3.47	1.458	679	0.554	0.58	0.04
	Protecting personal data	3.58	1.394	3.41	1.416	679	1.567	0.117	0.12
	Using social networks	3.5	1.380	3.41	1.405	679	0.832	0.406	0.06
	Improving transport and mobility systems	3.15	1.457	3.06	1.516	679	0.776	0.438	0.06
	TOTAL	**3.34**	**1.398**	**3.27**	**1.241**				**0.05**

*p<0.05; **p<0.01; ***p<0.001

Source: Prepared by the authors

In the first phase in January, only two significant differences in perceived benefits by gender are apparent with regard to Artificial Intelligence. In the case of work automation, men perceive more benefits than women, and in armaments and defence, men also perceive significantly more benefits than women. In the rest of the applications, we can see that the benefits perceived by men are generally higher than those perceived by women (table 9).

In terms of the risks of Artificial Intelligence, there are no significant differences between men and women, but in some applications the perceived risks are higher for women than for men, such as in the case of work automation, disaster prevention, and real-time emergency management. This might lead use to perceive that the level of distrust among women is higher than among men. The higher effect size can be observed in the application of new recruitment methods, with a greater perception of risk among men (Table 9).

Table 9. Gender perceptions of benefits and risks of the main applications of Artificial Intelligence in the first phase in January of 2020

	Artificial Intelligence	MEN No. = 306		WOMEN No. = 375					
		M Men	SD Men	M Women	SD Women	df	t	p-value	d
BENEFITS	Work automation ***	3.86	1.261	3.48	1.308	679	3.855	**<0.001**	0.30
	Detecting online fraud	4.10	1.186	3.94	1.199	679	1.747	0.081	0.13
	New recruitment methods	3.68	1.253	3.6	1.246	679	0.857	0.392	0.06
	Armaments and defence *	3.83	1.346	3.59	1.335	679	2.389	**<0.05**	0.18
	Application to medicine to detect illness	4.23	1.142	4.07	1.197	679	1.67	0.095	0.14
	Disaster prevention	4.24	1.169	4.10	1.169	679	1.517	0.130	0.12
	Real-time emergency management	4.23	1.142	4.11	1.181	679	1.272	0.204	0.10
	TOTAL	**4.02**	**1.214**	**3.84**	**1.230**				**0.15**
RISKS	Work automation	3.28	1.434	3.29	1.355	679	-0.71	0.944	0.01
	Detecting online fraud	3.01	1.437	3.00	1.454	679	0.083	0.934	0.01
	New recruitment methods	3.35	1.425	3.15	1.393	679	1.818	0.07	0.14
	Armaments and defence	3.61	1.436	3.45	1.404	679	1.463	0.144	0.11
	Application to medicine to detect illness	3.04	1.442	3.03	1.397	679	0.085	0.932	0.01
	Disaster prevention	2.89	1.517	2.94	1.462	679	-0.406	0.685	0.03
	Real-time emergency management	2.88	1.492	2.94	1.471	679	-0.569	0.569	0.04
	TOTAL	**3.15**	**1.454**	**3.11**	**1.419**				**0.03**

*p<0.05; **p<0.01; ***p<0.001

Source: Prepared by the authors

When analysing the second phase of October 2020, in terms of the perceived benefits of Big Data, the differences between men and women are not significant in any case, but men continue to perceive greater benefits than women, although the gap between them had narrowed, and women's perceptions had increased, surpassing men in some applications.

Thus, in the second phase, women perceived more benefits than men in protecting personal data, gaining knowledge about the market and consumers, using large volumes of data, cybersecurity, and the use of social networks (Table 10).

The mean of the overall benefit of Big Data in the first phase was 3.85 for men and 3.64 for women (d=0.18), while in the second phase the mean was 3.75 for men and 3.74 for women (d=0.01), which shows a rise in the perception of benefits for women that balances the gender difference (Tables 9 and 10).

Upon reviewing the perceived risks of Big Data in the second phase, we observe only one significant difference, which is the case of using large volumes of data, where women perceive greater risks than men with a larger effect size than in the rest of the cases. However, it can be clearly seen that the perception of risk in all applications had risen among women, surpassing that of men. In the first phase there was only a perception of increased risk for women in work automation, disaster prevention, and real-time emergency management. In the second phase, however, this risk perception rises, and although men also increased their perception of risks, women outnumbered men in all cases (Table 10).

The mean of perceived risk of Big Data in the first phase was 3.34 for men and 3.27 for women (d=0.05), and in the second phase it was 3.59 for men and 3.71 for women (d=0.09), which clearly shows an increase and widening of the gap (Tables 9 and 10).

Table 10. Perceptions of benefits and risks of the main Big Data applications in the second phase in October of 2020, by gender

	Big Data	MEN No. = 208		WOMEN No. = 211					
		M Men	SD Men	M Women	SD Women	df	t	p-value	d
BENEFITS	Making data-driven decisions	3.67	1.354	3.53	1.385	417	1.098	0.273	0.10
	Gaining knowledge about the market and consumers	3.78	1.350	3.8	1.265	417	-0.098	0.922	0.01
	Data-driven predictions	3.72	1.333	3.61	1.331	417	0.843	0.399	0.08
	Using large volumes of data	3.74	1.380	3.79	1.365	417	-0.381	0.703	0.04
	Cybersecurity	3.68	1.440	3.73	1.440	417	-0.335	0.738	0.03
	Protecting personal data	3.77	1.346	3.82	1.372	417	-0.382	0.703	0.04
	Using social networks	3.62	1.367	3.72	1.350	417	-0.719	0.473	0.07
	Improving transport and mobility systems	4.03	1.347	3.92	1.453	417	0.799	0.425	0.08
	TOTAL	**3.75**	**1.364**	**3.74**	**1.370**				**0.01**

RISKS	Making data-driven decisions	3.46	1.376	3.64	1.395	417	-1.317	0.189	0.13
	Gaining knowledge about the market and consumers	3.46	1.354	3.5	1.399	417	-0.304	0.761	0.03
	Data-driven predictions	3.53	1.266	3.63	1.308	417	-0.769	0.443	0.08
	The use of large volumes of data *	3.5	1.322	3.82	1.281	417	-2.515	<0.05	0.24
	Cybersecurity	3.74	1.387	3.87	1.448	417	-0.951	0.342	0.09
	Protecting personal data	3.69	1.405	3.72	1.405	417	-0.239	0.811	0.02
	Using social networks	3.85	1.287	3.88	1.276	417	-0.282	0.778	0.02
	Improving transport and mobility systems	3.48	1.407	3.59	1.494	417	-0.821	0.412	0.07
	TOTAL	**3.59**	**1.350**	**3.71**	**1.375**				**0.09**

*p<0.05; **p<0.01; ***p<0.001

Source: Prepared by the authors

In the second phase in October, the perceived benefits with regard to Artificial Intelligence declined for men yet remained the same for women. Consequently, women surpass men in this aspect. The only application for which men outperform women in perceived benefits is in work automation, and it is the one with the largest effect size of all the other applications. In terms of effect size, the largest effects for women, who perceive more benefits than men, are in its application to medicine for illness detection and real-time emergency management (Table 11).

The mean of perceived benefits of Artificial Intelligence in the first phase was 4.02 for men and 3.84 for women (d=0.15), while in the second phase it was 3.77 for men and 3.79 for women (d=0.01), which shows a decrease in both cases, and also demonstrates that women now outnumber men in perceived benefits (Table 10 and Table 11).

As for the perceived risks of Artificial Intelligence in the second phase, there are no significant data regarding gender differences either. Perceived risks decreased slightly for men, making them somewhat more balanced. The largest effect sizes are found in detecting online fraud, which men perceive to be more risky than women, and the same is true for new recruitment methods. There are only two applications where women perceive more risk than men, which are disaster prevention and real-time emergency management (Table 11).

The mean of perceived risks of Artificial Intelligence in the first phase was 3.15 for men and 3.11 for women (d=0.03), while in the second phase it was 3.48 for men and 3.43 for women (d=0.03), which shows that the perception of risk had risen in both cases, although men still outnumber women, yet they are closer than in the case of Big Data, and the differences have become more balanced (Table 10 and Table 11).

Table 11. Perception of benefits and risks of the main applications of Artificial Intelligence in the second phase of October 2020, by gender

	Artificial Intelligence	MEN No. = 208		WOMEN No. = 211		df	t	p-value	d
		M Men	SD Men	M Women	SD Women				
BENEFITS	Work automation	3.62	1.403	3.40	1.432	417	1.534	0.126	0.15
	Detecting online fraud	3.86	1.322	3.87	1.298	417	-0.127	0.899	0.01
	New recruitment methods	3.52	1.315	3.61	1.288	417	-0.687	0.493	0.01
	Armaments and defence	3.45	1.347	3.47	1.487	417	-0.159	0.874	0.01
	Application to medicine to detect illness	3.96	1.285	4.06	1.295	417	-0.794	0.428	0.08
	Disaster prevention	4.01	1.300	4.06	1.265	417	-0.414	0.678	0.04
	Real-time emergency management	4.00	1.287	4.10	1.264	417	-0.798	0.425	0.08
	TOTAL	**3.77**	**1.322**	**3.79**	**1.332**				**0.01**
RISKS	Work automation	3.51	1.383	3.51	1.435	417	0.019	0.985	0.00
	Detecting online fraud	3.47	1.410	3.27	1.466	417	1.430	0.154	0.14
	New recruitment methods	3.62	1.310	3.47	1.381	417	1.112	0.267	0.11
	Armaments and defence	3.85	1.276	3.76	1.422	417	0.665	0.506	0.07
	Application to medicine to detect illness	3.45	1.375	3.4	1.405	417	0.326	0.745	0.03
	Disaster prevention	3.25	1.406	3.29	1.489	417	-0.276	0.783	0.03
	Real-time emergency management	3.2	1.420	3.31	1.526	417	-0.737	0.462	0.07
	TOTAL	**3.48**	**1.368**	**3.43**	**1.446**				**0.03**

*p<0.05; **p<0.01; ***p<0.001

Source: Prepared by the authors

In response to RQ2a, it can be seen that perceived benefits decreased, and risks increased in the second phase, whereby the differences changed and in some cases became negative, with risks outweighing benefits. Women showed a greater increase in perceived risks, while men's perception of benefits did not decrease as much, yet this is seen in cases of specific applications that do not always coincide with those of women.

In Big Data, the first phase shows a mean total benefit for men of 3.85 (SD=1.235) and for women of 3.64 (SD=1.147) (d=0.18), while the mean total risk for men is 3.34 (SD=1.398), and for women it is 3.27 (SD=1.241) (d=0.05) (Table 8). In both risk and benefit perception, men outnumber women.

In the second phase, the mean of total benefit in men is 3.75 (SD=1.364) and in women it is 3.74 (SD=1.370) (d=0.01), and the mean total risk in men is 3.59 (SD=1.350) and in women it is 3.71 (SD=1.375) (d=0.09) (Table 10). Perceived benefits had risen among women to nearly the same level as men, while perceived risks had risen for women to the point of surpassing men.

Regarding Artificial Intelligence, the first phase shows a mean total benefit for males of 4.02 (SD=1.214) and for females of 3.84 (SD=1.230) (d=0.15), while the mean total risk for males is 3.15 (SD=1.454) and for females it is 3.11 (SD=1.419) (d=0.03) (Table 9). Men also see more benefits than risks, yet they outperform women in both categories in the first phase.

In the second phase, the mean of total benefits for men is 3.77 (SD=1.322) and for women it is 3.79 (SD=1.332) (d=0.01), while the mean total risk for men is 3.48 (SD=1.368) and for women it is 3.43 (SD=1.446) (d=0.03) (Table 11). Perceived benefits decrease for both men and women. However, women outnumber men in terms of benefits, yet not in terms of risk, although women show an increase in terms of the perception of risk.

6. Discussion and conclusions

Today's society is accustomed to hearing and reading terms such as Big Data and Artificial Intelligence as a result of their use (and overuse) in the media in recent years. However, the fact that they have become common language terms does not mean that most people are actually aware of all the nuances and aspects involved in this terminology. Not only has science journalism been gaining ground the specialised press, but in the mainstream press as well, and the "war" for data has only reaffirmed the power of data, as well as the power of those who know how to handle and interpret it. The use of data allows the media to offer better news content, especially in investigative journalism, and its insertion in an attractive way makes the public value the information more positively due to the allurement of the information conveyed. A vindication that has been gaining influence in recent years is the fact that science is associated with that which is masculine, a gender debate that is currently very much in vogue.

The incorporation of these new technological applications has ramifications in terms of work processes, but also in terms of the knowledge base that citizens must acquire in order to handle them safely and feel confident with their use. This article has analysed society's knowledge of data science, specifically regarding the understanding of Big Data and Artificial Intelligence, but has also included an assessment of the relationship to gender of such knowledge. Thus, the research questions posed were intended to measure whether there were gender differences in the degree of knowledge and interest and in the perception of benefits and risks of data science, Big Data, and Artificial Intelligence. We have also measured whether Spain's confinement between March and June of 2020 due to the Covid-19 pandemic had an impact on the answers given by the respondents.

The sample analysed showed a high degree of familiarity with the concepts of data science, Big Data, and Artificial Intelligence, with the latter being the most common. Artificial Intelligence was of greater interest to men than to women, while the other two concepts, Data Science and Big Data, were of similar interest to both groups. The pandemic, along with the resulting explosion of information based mainly on data-filled information with little time for analysis, did not change the respondents' interest in these terms to a great extent, but the observation was made that it decreased slightly.

Regarding the perception of benefits and risks, both men and women perceive more benefits than risks in data science, Big Data, and Artificial Intelligence, although it was men who showed higher scores in terms of benefits, while women generally showed a higher perception of risk. With regard to this question, the confinement resulting from Covid-19 influenced the answers due to the fact that in the case of Big Data applications, for example, the overall sample perceived more benefits than risks with most applications. In the gender comparison, women perceived more risks than benefits in almost all applications, while men continued to perceive more benefits than risks.

No significant differences have been observed in the results regarding gender, yet there are trends that point to what has been observed in previous studies, due to the fact that women have a higher perception of risk than men, whereas the latter show a greater interest in Artificial Intelligence, so there is still a long way to go to disassociate science from men, although there is a downward trend in this regard.

This survey seems to contradict the interpretation of Bustamante Alonso and Guillén Alonso (2017), who have stated that society is immersed in a disruptive era and technologies are evolving faster than the capacity for social adaptation, since according to the responses collected, the interviewees are acquainted with data science, Artificial Intelligence, and Big Data, and value them positively. In this sense, it seems that when confronted with the fear that these concepts might have generated in society years ago, their advantages have been gaining in importance compared to the possible disadvantages, thanks to the normalisation and incorporation not only of these concepts, but also of what is disseminated by the media, which is increasingly using these ideas to accompany information with data visualisation. Furthermore, the fact that data from official institutions must be published and accessible to citizens is generating greater confidence in their usefulness by strengthening the transparency of institutions in the interest of creating greater trust.

Contrasting the results herein with the recent survey related to *Percepción Social de la Ciencia y la Tecnología* (The Social Perception of Science and Technology), a similar trend can be observed. Men generally perceive more benefits from Artificial Intelligence than women, except in the younger age group (15-24 years), where men have a higher perception of risk than women of the same age. Women perceive more risk than men in the 25-44 age group, and in the 65+ age group in particular. As for the robotisation of work, which is the other variable that can be compared in the FECYT study, men perceive more risk than women in the 15-34 age group, which coincides with the completion of their studies and the period of incorporation into the labour market. With regard to this aspect, women are not convinced, because the majority of responses are somewhere in the middle, perhaps because it would be necessary to provide more information to citizens in order to increase their ability to critically assess the use of these technologies in their work environment without feeling threatened (*FECYT*, 2021).

The power of data science, Artificial Intelligence, and Big Data in solving some of humanity's biggest problems should not be overlooked in the current context, which is the so-called Fourth Industrial Revolution in which data and its control are, and will

be, essential. This revolution has also led to the emergence of new professions linked to the sector, such as those of data manager, data engineer, data scientist, information security manager, and data protection officer, among others.

Prodigiously massive amounts of data have become part of everyday life, not only at the information level, but also as a significant component of the business world, as companies understand that such data is vital for generating business. Data science has also led to job growth, as the data-driven economy has stimulated research and innovation, providing more business opportunities and increasing the availability of knowledge and capital, especially for small and medium-sized companies (*PYMES* [SMEs]) across Europe (Monleón-Getino, 2015). This might be the main reason why respondents perceive more benefits than risks in data science, Artificial Intelligence, and Big Data. Furthermore, it is also significant that the answers of the respondents do not show significant differences between men and women. As such, it can be said that the gender gap in this field is becoming increasingly smaller.

In this regard, it would be useful to carry out another study of a similar nature in the future that would allow a longitudinal investigation to be performed in order to determine whether these results are isolated events, or whether they predict a changing trend in this field of study. It would also be interesting to augment this study with a combination of different methodologies, such as in-depth interviews, which would allow us to delve deeper into the data with answers that could explain the reasons for the results obtained. The topic addressed in the study herein is sufficiently important and relevant for today's society, as evidenced by the fact that the number of data science professionals has doubled in the last four years (LinkedIn, 2015). In order to explore the issue further, it would be beneficial to conduct a survey with a larger sample in the future.

7. Acknowledgements

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