An Acad Bras Cienc (2021) 93(4): e20200204 DOI 10.1590/0001-3765202120200204
Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences*
Printed ISSN 0001-3765 I Online ISSN 1678-2690
www.scielo.br/aabc | www.fb.com/aabcjournal

SOCIAL SCIENCES

Science in society: What young Brazilians think about S&T

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Abstract: In this article, we present the main findings of the first survey conducted in Brazil on the public perception of science and technology (S&T) among youth ages 15 to 24 years old. The study was designed around a survey of 2,206 young people residing in urban areas. Results suggest that young people have a great interest in S&T (67%) and related topics, such as medicine and health (74%), and the environment (80%). They have a positive view of science and scientists and are in favor of investments in scientific research despite the country's current economic crisis (94% said Brazil should not cut its investments in S&T). Most of them believe science affords humanity many (69%) or some (27%) benefits, while it also presents some (53%) or few (30%) risks. The study identified shortcomings in these young people's knowledge: few were able to name a Brazilian scientist (5%) or scientific institution (12%). These young people are not frequent visitors to science museums (6%) or other spaces for communicating science, such as parks or botanical gardens (25%). The respondents voiced their opinions about social and political controversies in the realm of scientific research, such as vaccination, climate change, and the theory of evolution.

Key words: science communication, young people, youth, public perception of S&T.

INTRODUCTION

The public communication of science and technology (S&T) encompasses often times controversial discussions of concepts and models involving today's complex scientific issues and the ongoing public debate surrounding these issues, two examples of which are climate change and vaccination. According to Lewenstein & Brossard (2010), all members of the general public should be able to understand these topics, especially so that they can weigh in on the shaping of public policy regarding controversial matters.

Political and academic interest in the public perception of S&T has been growing in Brazil and elsewhere, fueled by the need to better understand how S&T is disseminated, how technical and scientific knowledge can be more broadly appropriated, and how to find efficacious means for public participation in S&T. When grounded in reliable indicators comparable within and across countries, surveys of public perception can be valuable in guiding public policy debate and definitions and can contribute to enhancing practices in science communication (Castelfranchi et al. 2016).

One of the social groups that engage with S&T has witnessed profound changes in information and communication technology: young Brazilians aged 15 to 24. This is the first generation whose primary socialization went beyond school and family to include the Internet and social platforms. Born between

1995 and 2004, these young people came of age along with the Internet, commercially available in Brazil since 1995. They interact and attain information and knowledge in an environment rife with fake news and disinformation.

The Internet environment affords broad access to diversified content, at the same time that this content is often edited, published, shared, and debated without the mediation of such professionals as educators, journalists, or scientists. What comes across the Internet is also often devoid of any element of critical thinking, spawning weak, decontextualized arguments about a gamut of topics, some controversial, some not. Moreover, these arguments frequently draw from opinion shapers who vary according to an individual's interests and background. This all suggests that young Brazilians constitute a group worthy of special attention in an environment where S&T topics are part of a new ecosystem of content sharing and access.

Public communication aimed at young people must do a more comprehensive job of covering S&T topics, while incorporating changes brought by the development of communication and information technologies. Our survey, conducted in 2019, was the first nationwide study focused on the public perception of S&T among young Brazilians. The goal was to devise a methodological protocol and indicators to measure this public's attitudes, interests, and access to S&T information, based on the current state of the art and the databanks available in Brazil and abroad. The study is also meant as a contribution to the theoretical and methodological debate surrounding the production, appropriation, and communication of scientific culture, based on what is unique to Brazil.

The study was developed by the Brazil's National Institute of Science and Technology in the Public Communication of Science and Technology (INCT-CPCT). It explored opinions, access to knowledge, the perception of fake news, controversial aspects of scientific theories, and how one's background and moral and political attitudes influence perceptions of S&T. It also contributes relevant data and advanced methodology that can be used in assessing and implementing public policies and in developing innovative initiatives in the fields of science education and communication.

Young people: our target public

The definition and comprehension of the term "youth," whose social subject is the young person, has varied with social, economic, and cultural contexts and over time, shifting in meaning and representation (Abramovay & Castro 2015, Cassab 2011). Different periods of history have framed the notion of youth in diverse ways, while different experiences of youth have also coexisted across time and space, shaped by differentiated access to social, economic, and cultural resources, in accordance with social class, gender, and ethnicity (Cassab 2011).

When conducting empirical studies and establishing public policy, most institutions and public agencies Brazil and abroad employ socio-demographic criteria to define "youth." UNESCO Brazil defines it as "the period of life when people move from childhood to adulthood and during which important biological, psychological, social, and cultural changes take place, varying according to society, culture, ethnic group, social class, and gender"; age cycles are demarcated in order "to compare the situations of youth in different contexts and follow their evolution over time" (UNESCO 2004, p. 23). Incorporating both biological and psychological metrics, UNESCO follows guidelines set out by the United Nations General Assembly of 1985 and defines youth as encompassing people aged 15 to 24, allowing for

flexibility at both ends of the range depending on context.

According to estimates by the Brazilian Institute of Geography and Statistics (IBGE 2019), the population of Brazil reached 208.5 million in 2018, with 16.17%, or roughly 34 million, aged 15 to 24. Further according to IBGE data (2015), the genders were roughly balanced, with 51% male and 49% female; the majority were urban (85%); and nearly all were literate (99%). It should be pointed out that more than one-third of Brazilians in the 15-to-29 age group were overage for their reported educational attainment[1] (National Department of Youth/ Secretaria Nacional de Juventude 2013).

Another interesting finding comes from a research project conducted among urban residents aged 15 to 24 in nine countries (Brazil, Chile, Colombia, El Salvador, Haiti, Mexico, Paraguay, Peru, and Uruguay). Twenty-one percent of those surveyed neither study nor work, thus accounting for the label "*geração nem-nem*" – the "neither-nor generation." Of the remainder, 21% only work; 41% only study or train; and 17% work and study at the same time (Novella et al. 2018). In Brazil, the unemployment rate among the 18-to-24 age group was 25.2% in the last quarter of 2018. Considering that the unemployment rate drops to 10.7% among ages 25 to 39, 6.9% among ages 40 to 59, and 4.0% among those 60 and older (Lameiras et al. 2019), it is apparently harder for this group to join the labor market.

[1] Those who reported that they had completed middle school (first nine years of schooling in Brazil, typically ending when the child is 15 or 16) and were 15 to 16 years old were categorized as "not overage"; if they were in this age bracket and had not completed middle school, they were categorized as "overage." Those who reported that they had not completed high school and were between the ages of 15 and 18 were categorized as "not overage." Of those 18 years of age, if they were in the first of the three years of Brazilian high school, they were categorized as "overage"; if they were in the second year, they were categorized as "not overage."

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Most young people aged 15 to 24 are active, intense, and curious; in many cases, they are preparing to take on, or have already taken on, adult-world commitments. Their engagement with the socioeconomic world is mediated by their skills and potential as well as by their anxiety and need to make choices in our intense digital world. Their language, tone, and ways of communicating and acquiring new information and knowledge all very much reflect the contexts in which they grew up. They want to connect with others and are thirsty for knowledge, expertise, and access to information and sharing tools. Accordingly, they constitute a prime territory for empirical research.

Young people and science

The earliest surveys on the public perception of S&T were conducted in 1957 in the United States, from there spreading into other countries over the years. Brazil did its first survey in 1987, with similar initiatives following in 2006, 2010, and 2015. The most recent, released in 2019, is entitled "Percepção Pública da C&T no Brasil - 2019" (Public perception of S&T in Brazil, 2019) (CGEE 2019).

In our review of national and international studies on the public perception of S&T conducted and published over the past fifteen years by public and private institutions, we identified sixteen quantitative studies that involved numerous researchers and eighteen institutions (Haste 2004, MCT 2006, Tolentino Neto 2008, European Commission 2008, MCT 2010, FAPESP 2011, FECYT 2011, Polino 2011, Castelfranchi et al. 2016, Pinafo 2016, CGEE 2017, 3M 2018, 3M 2019, CGEE 2019, Gallup 2019). Three were conducted by private enterprises and the rest by public institutions, which included governmental agencies, universities, and research funding agencies.[2] Nine of these studies took place solely in Brazil; three in European countries; one in six Latin American countries (including Brazil) plus Spain; and three in fourteen countries across several continents.

Of the sixteen studies, seven offer information on the 15-to-24 age group, do not focus on formal science teaching in schools, and are not restricted to students enrolled in regular courses (Haste 2004, MCT 2006, European Commission 2008, FAPESP 2011, FECYT 2011, Castelfranchi et al. 2016, CGEE 2017). These seven studies indicate that young people are interested in S&T or closely related topics, like the environment, medicine, and health, and that the Internet is an important source of information, alongside television. These young people generally have a positive image of science and the work done by scientists; they recognize its benefits, especially those that afford a better quality of life and communication. Some interviewees also indicated problems caused by S&T. Most favored increased investments in certain areas of S&T, prioritizing the research they deemed most relevant.

Some findings are common to these studies, regardless of any differences in approach. How respondents view science or scientists and think about investments in scientific research depends somewhat on the field of science in question. Governments have watched their images erode, because they are seen as failing to ensure the public's well-being by not defining limits in the realm of S&T. The same is true of businesses, which young people view as caring solely about profit. Respondents also said that science fails to solve such social problems as emotional well-being, hunger, and poverty not because more scientific research discoveries are needed, but because of the decisions that have been made in different socioeconomic contexts. Questions were raised about pathways to participation in the decision-making process in the field of science, including participation on the part of the public.

METHODOLOGY

The present study was designed around a survey of 2,206 young people aged 15 to 24 residing in urban areas, across all regions of Brazil (representative sample of the young national population). The population interviewed in this survey were selected based on data from the Brazilian 2010 Census. The focus was on people that, at the time, was between 7 and 16 years old age, corresponding to the age group between 15 and 24 years old in July 2018.

Interviewees were selected using probability sampling, with the application of sampling quotas by gender, age, and educational level during the final stage. Considering the national distribution, 550 interviews were planned per geographic regions (North/Midwest, Northeast,

[2] This was not an exhaustive review of national and international surveys. For example, surveys conducted in China and India were not included. For an overview of Ibero-American surveys, see "Las encuestas de percepción pública de la ciencia en América Latina: estructura, evolución y comparabilidade," in "RedPOP: 25 años de popularización de la ciencia en América Latina" (Polino 2015).

Southeast and South). The sample of 550 young people in each region was then proportionally distributed by size: large, medium and small cities. With a small adjustment in the values found, each stratum of size included around 700 young people.

The confidence level was 95%, with a 2% error margin. Data were collected through the household, face-to-face interviews by trained interviewers. It occurred during March and April 2019, in 79 cities from 22 states in the four geographic regions. The distribution of interviews by cities size and geographic regions is shown in table I.

A pre-test consisting of 70 interviews was conducted to standardize meaning and comprehension of the intended concepts, explore interviewees' interpretations, and assess the suitability of the statements and terminology used in the questions. The pre-test comprised ten modules, 195 variables, and twenty-three cognitive questions; the results were used to design the final questionnaire.

During a qualitative phase, in-depth interviews and focus groups were conducted among forty-three young people in two Brazilian cities, Rio de Janeiro and Belém. The detailed results of the qualitative phase conducted in Rio de Janeiro is explored by Mendes (2019) and appointments about the discussion in Belém will be presented in a later article (Fagundes et al. 2021). By conjoining quantitative and qualitative results, we were able to gain a better understanding of certain aspects that help shape young Brazilians' opinions about S&T, such as their understanding of the words "science" and "technology", how their consumption habits of S&T information were affected by the growth of fake news, how they choose reliable sources to talk about S&T, among others. In this article we will concentrate only on the quantitative results.

RESULTS

When presented with a list of seven topics, these young Brazilians expressed interest in S&T (67% were "interested" or "very interested") and in closely related scientific matters, such as the environment (80%) and medicine and health (74%). All three of these topics are in the top of the ranking, followed by sports (62%), art and culture (58%), and politics (30%). S&T ranked the same as religion (67%).

Bivariate analysis shows that respondents' interest in S&T is associated to educational level: 80% of those with a college education said they

Table I. Distribution of interviews carried out in the three sizes of cities, distributed across four geographic regions.

SIZES OF CITIES	GEOGRAPHIC REGION				Total
	South	Southeast	Northeast	North/Midwest	
City's size per region					
Large	129	243	174	249	**795**
Medium	224	197	142	171	**734**
Small	201	112	228	136	**677**
Total	**554**	**552**	**544**	**556**	**2206**

were "very interested" or "interested" in the topic, while 55.5% of those who had completed middle school responded similarly (associations are significant and strong, with gamma = 0.240 and sig < 0.001). We built a simple logistic regression model, including only major sociodemographic variables, to corroborate the influence of educational level to interest toward S&T. The independent variables were: sex, age, income, education, region of the country, size of city\ town, religion, and race\ethnicity. The dummy dependent variable was interest (1 = interested or very interested in S&T; 0 = not so much interested or not interested in S&T). Actually, education is the strongest sociodemographic predictor for interest: for each increase in school level (basic to high, high to university degree), the chance of a young Brazilian declaring interest in S&T increases by 188% (model´s chi square = 103,628; Hosmer & Lemeshow test confirmed with sig = 0.632; Nagelkerke R Square = 0.07; Exp(B) for educational level = 1.883 with sig < 0.001). Models with more variables and stronger Nagelkerke R Square confirm such results.

In terms of gender, women in general were more interested in topics related to the environment (81.2% women and 79.3% men) and to medicine and health (79.7% women and 67.6% men). A slightly higher percentage of men than women expressed interest in S&T on the whole (64.3% women and 69.1% men). Bivariate analysis confirm association among sex and the above variables (interest in environmental issues, health and S&T), being all significant for chi square, lambda and gamma, respectively with sig < 0.05, sig < 0.001 and sig < 0.005).

Through correlation analysis and regression models, we also saw associations among interest in S&T and verifying information; engaging in such cultural behaviors as visiting museums, accessing libraries, and participating in S&T activities; and consuming information on the topic. We summarize here only some major results by means of bivariate tables which indicates that interest in S&T is positively associated to checking information with experts (sig < 0.001); having visited libraries, science museums or science centres, or participated in activities of the Brazilian Nacional S&T Week in the last 12 months, among other cultural activities (sig < 0.001); remembering the name of a Brazilian scientist and Brazilian research institutions (sig < 0.001) ; searching frequently for information on S&T topics (sig < 0.001).

While most of these young people expressed interest in S&T topics, only 5% were able to recall the name of a Brazilian scientist and few could cite the name of a Brazilian institution devoted to scientific research (12%). Predictably, the higher a respondent's educational level, the more likely he or she would be able to reply to both of these questions. Only 1.9% of those with a middle school education alone could recall the name of a Brazilian scientist, while 19.6% of those with a college education could; only 5.3% of those with a middle school education could name a research institution, while 41.1% with a college degree could (bivariate association significant with p < 0.001).

Further on the matter of the actual social appropriation of knowledge, respondents displayed low participation in scientific and cultural activities. During the twelve months prior to the survey, libraries (35%) were the most frequently scientific or cultural spaces visited by the young people, followed by botanical gardens or environmental parks (25%). These percentages are low compared to surveys from other countries, especially if we take the age range of the interviewed public into account. From 22% to 24% of respondents had taken part in lectures on science or medicine, science fairs or science/math Olympics, or exhibitions and other S&T activities, while only 9% took part in

Brazil's National Week of Science and Technology. Only 6% of the respondents reported visiting a science museum or center in the previous year.

The main reasons cited for not visiting these places had less to do with respondents' interest and more to do with accessibility or affordability. The top reason (26%) for not visiting a science museum or center was because there were none where the respondent lived. Another 17% said they had not had the time, 9% said they did not know where to find such a facility or that the facility was too far away, and 6% said they could not afford to visit. Only 11% said they were not interested in visiting such a facility.

Only moderate interest was expressed in seeking S&T information on the radio, in books and newspapers, or even on the television and Internet. Focusing on the thirty days prior to the survey, a little over half said they had watched a related program or video on TV or online, read about the topic (print or online books, newspapers, or magazines), or spoken to friends or family about it, even if only occasionally. Radio programs or podcasts (25%) ranked lowest.

When asked to choose their two most frequent means of accessing S&T content on the Internet, 79% marked the Google search engine and 73% marked YouTube; these were followed by the social media WhatsApp (51%), Facebook (50%), and Instagram (36%). Blogs (15%), Twitter (11%), and podcasts (5%) ranked much lower. About half of these young people said they had talked about an S&T topic in the previous thirty days, 44% with teachers, 41% with friends, 12% with their mothers, 10% with their fathers, and 21% with other relatives.

Of the professions listed on the survey, teachers were the most important source of information for the respondents. When asked to pick two of the most trustworthy sources of information, 50% of respondents marked teachers, while the categories "scientists at universities or research institutes" and "doctors" were both selected by 37%. The data were even more telltale when it came to the least trustworthy sources. The same three categories not only ranked top in terms of trustworthiness; they were also rarely listed as the least trustworthy, while politicians (81%) and performers (35%) ranked highest in this regard. Respondents expressed relative confidence in journalists, as seen in Figure 1.

If, on the one hand, 93% of the young people felt it is "hard" or "very hard" to follow a career as a scientist, on the other, 84% said it was a "very attractive" or "attractive" profession. According to the respondents, the traits that were "very likely" or "likely" to be displayed by these professionals were creativity and a facility to learn new things (both 96%) and organization (93%), along with traits associated with low sociability, like avoiding parties and not having a social life (77%), spending lots of time alone (75%), having few friends (70%), and being "weird" (60%). Scientists were also seen as people who think a lot about their families (88%). The respondents showed concern about the work done by scientists, with 71% agreeing totally or in part that scientists have knowledge that can make them dangerous and 53% believing they are responsible for the misuse of their discoveries by other people.

The survey also looked at traits associated with scientists from different fields. Figure 2 shows how respondents view scientists who study the universe, who look for a cure for cancer, and who study the social phenomenon of poverty. Perceptions were highly aligned in some regards. More than 90% associated intelligence with all three types of scientists, and all three were also seen as engaged in interesting work, which fits with the notion that this is an attractive profession. Relevant differences were noted, however, in other regards. On average,

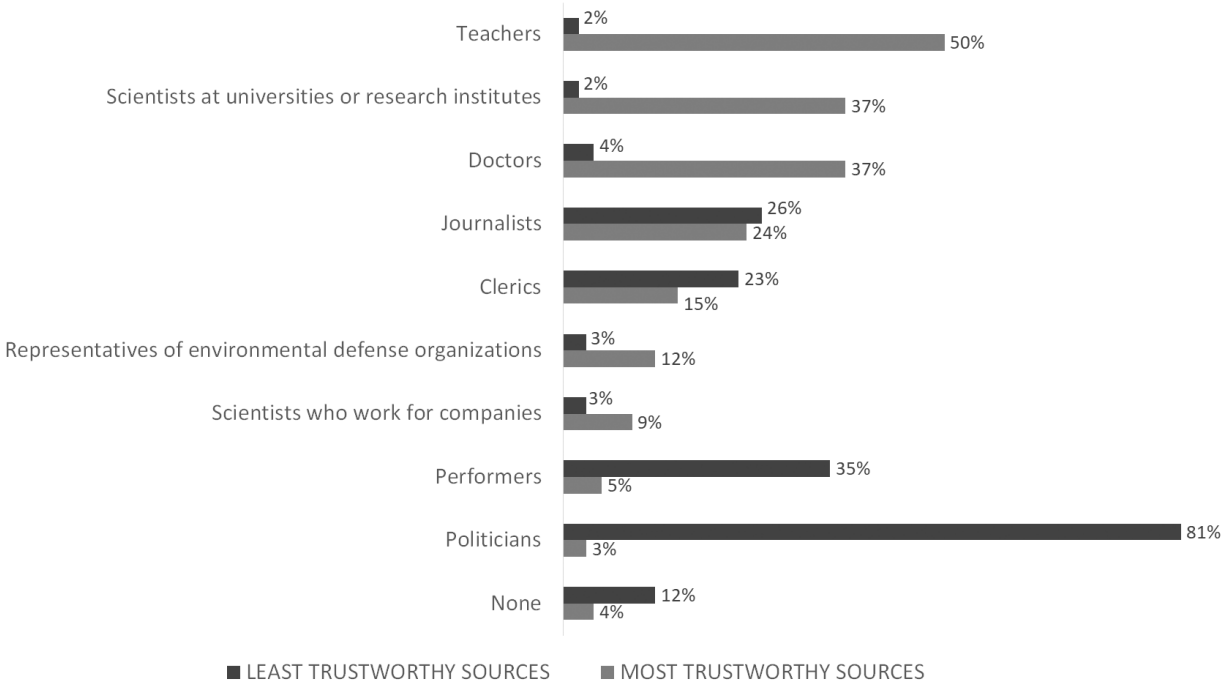

Figure 1. Sources of information deemed most and least trustworthy (respondents could choose two).
Survey questions related to Figure 1:
a) Which of these do you consider the MOST trustworthy sources of information about topics that are important to you and society?
b) Which of these do you consider the SECOND-MOST trustworthy sources of information about topics that are important to you and society?
c) Which of these do you consider the LEAST trustworthy sources of information about topics that are important to you and society?
d) Which of these do you consider the SECOND-LEAST trustworthy sources of information about topics that are important to you and society?

respondents thought that scientists who study the universe are less likely to believe in God and less likely to be women than the other two types of scientists. Scientists who study poverty are seen as less likely to spend much time alone, use hard-to-understand words, or think about making money. Scientists who look for a cure for cancer ranked highest in terms of having an interesting job and being concerned with making money.

Most respondents agreed totally or in part that S&T makes our lives more comfortable (82%), indicating that they clearly recognize the benefits of S&T. However, these young Brazilians also realize that these benefits do not come without some risk, that is, they recognize both the positive and problematic aspects of technical and scientific development. Most believe science affords humanity many (69%) or some (27%) benefits, while it also presents some (53%) or few (30%) risks, as shown in Figure 3.

While all social groups in Brazil are optimistic about the benefits of S&T, the opinion that S&T affords humanity "many benefits" increases with educational level, scoring 61.6%, 68.7%, and 82.4% among those with a middle school, high school, and college education, respectively. Bivariate analysis of perceived benefits versus risks (table II) show that most of these young people are optimistic about S&T, seeing more

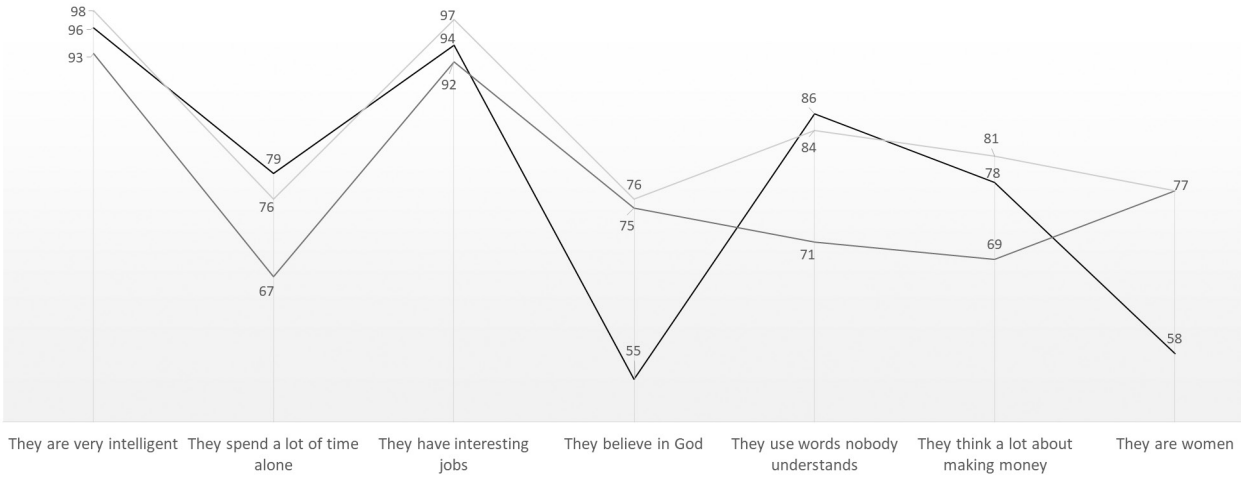

Figure 2. Traits attributed to scientists from different fields ("likely" + "very likely").
Survey questions related to Figure 2:
a) When you think about scientists who study the universe, which of these traits do you imagine them having? (very likely, likely, not very likely, don't know).
b) When you think about scientists who study the social phenomenon of poverty, which of these traits do you imagine them having? (very likely, likely, not very likely, don't know).
c) When you think about scientists who look for a cure for cancer, which of these traits do you imagine them having? (very likely, likely, not very likely, don't know).

benefits than risks (highlight in the first column), while very few (only 1%) have a more negative perception, responding "many risks" plus "few benefits" (highlight in the third column).

This positive perception of the results and application of S&T comes hand in hand with the respondents' support for the area. These young people said that in a context of economic crisis, S&T investments should be maintained or increased, even if the allocation of resources to one area might mean cuts to another; 94% said Brazil should not cut its investments in S&T, 60% said resources should be increased, and 34% said they should be maintained. This willingness to increase investments was expressed at all levels of education, but ranked highest among the college-educated (71.7%).

Support for science is not, however, without a critical eye. Only 20% of respondents agreed totally that S&T development will decrease inequality in Brazil or that S&T will help do away with world hunger and poverty, reflecting a realistic understanding that unequal access to the benefits of S&T stems from economic and political interests.

Some of such attitudes are associated to educational level, but not all of them, sometimes not linearly and usually the association is modulated also by variables linked to moral values and political positions. Bivariate associations show, for example, an interesting aspect of "optimism" toward S&T. Some of the more optimistic opinions about the benefits of S&T were expressed more often by those with lower educational levels. For example, 26.7% of respondents who have only a middle school education agreed totally with the idea that "science and technology will help do away with world poverty and hunger," compared with only 10% of those with a college education (gamma = 0.144, sig < 0.001). Women tend to be less optimistic: 60.5% of the males agreed totally or

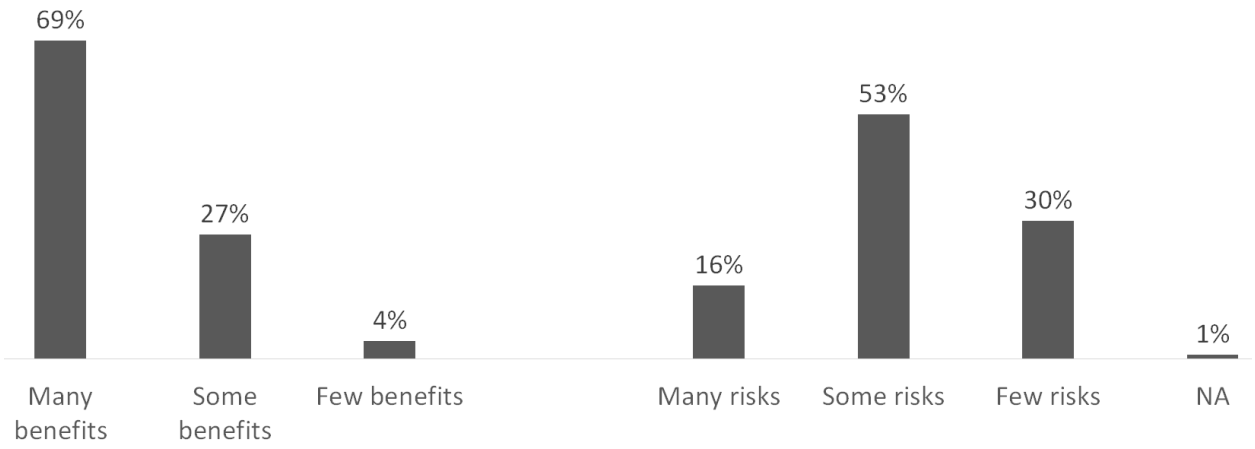

Figure 3. Benefits and risks of S&T.
Survey questions related to Figure 3:
a) In your opinion, does science afford humanity many benefits, some benefits, or few benefits?
b) In your opinion, does science afford humanity many risks, some risks, or few risks?

in part with this statement, compared to 53.8% of the females (lambda = 0.115, sig < 0.001).

Sixty-eight percent of these young Brazilians agreed totally or in part that the government should heed the guidance offered by scientists, 70% see current environmental problems as having more to do with economic and political interests than with S&T, and more than half feel that Brazilian science is behind the times. While they believe the government should heed the guidance offered by scientists, 80% agree totally or in part that the public should be heard when it comes to major decisions on the direction of S&T, indicating a desire for greater social participation and control by both scientists and the general public.

Questions were also posed about controversial topics where certain social groups have questioned scientific proof. For example, as regards the theory of evolution, 40% of those interviewed disagreed totally or in part with the statement "human beings evolved over time and descend from other animals"; 54% agreed totally or in part that scientists are exaggerating the effects of climate change; and 38% believe at least in part that one's sign of the zodiac influences one's personality. As to vaccines, even though the large majority (74.5%) disagreed totally or in part with the statement that "vaccinating children can be dangerous," this means that 25.5% agreed totally or in part, as shown in Figure 4. These attitudes vary sharply between groups of young people. There is a complex relation between attitudes and independent variables, each of which was influenced by specific factors (for a discussion of the complex relation between knowledge

Table II. Bivariate table: Benefits versus risks of S&T. Ordinal by ordinal association significant with gamma = -0.124, sig<0.001).

	Many benefits	Some benefits	Few benefits
Many risks	11%	4.2%	1%
Some risks	35.1%	17%	1.4%
Few risks	22.9%	5.9%	1.6%

Survey questions related to Table II:
a) In your opinion, does science afford humanity many benefits, some benefits, or few benefits?
b) In your opinion, does science afford humanity many risks, some risks, or few risks?

and attitudes, see Castelfranchi et al. 2013). An in-depth statistical modeling of these data, identifying the processes that influence these perceptions, will be published in a later paper. Some basic observations follow.

In the case of the statements "vaccinating children can be dangerous" and "scientists are exaggerating the effects of climate change," educational level is an important factor. Of young people with only a middle school education, 29.7% agree with the statement about vaccination, while 60.7% believe that scientists exaggerate climate change; in both cases, these were the highest percentages recorded among the three educational levels. But this pattern does not repeat itself in relation to the theory of evolution. The responses by young people with a middle school, high school, and college education were statistically the same: 42.2%, 41.6%, and 41.2%, respectively, did not agree that human beings evolved over time and descend from other animals. Attitudes on this topic are quite likely influenced not by educational level but by religion.

Some questions also tested the respondent's basic notions of science. They generally made frequent mistakes, indicating limited knowledge of these topics, as shown in Figure 5.

DISCUSSION

Taking into account differences in method, approach, and socioeconomic context, our findings bear much in common with those that offer information on the 15-to-24 age group, do not focus on formal science teaching in schools, and are not restricted to students enrolled in regular courses (Haste 2004, MCT 2006, European Commission 2008, FAPESP 2011, FECYT 2011, Castelfranchi et al. 2016, CGEE 2017). The positive view of S&T expressed by Brazilian young people is also shared by young people surveyed in European countries (Haste 2004, European

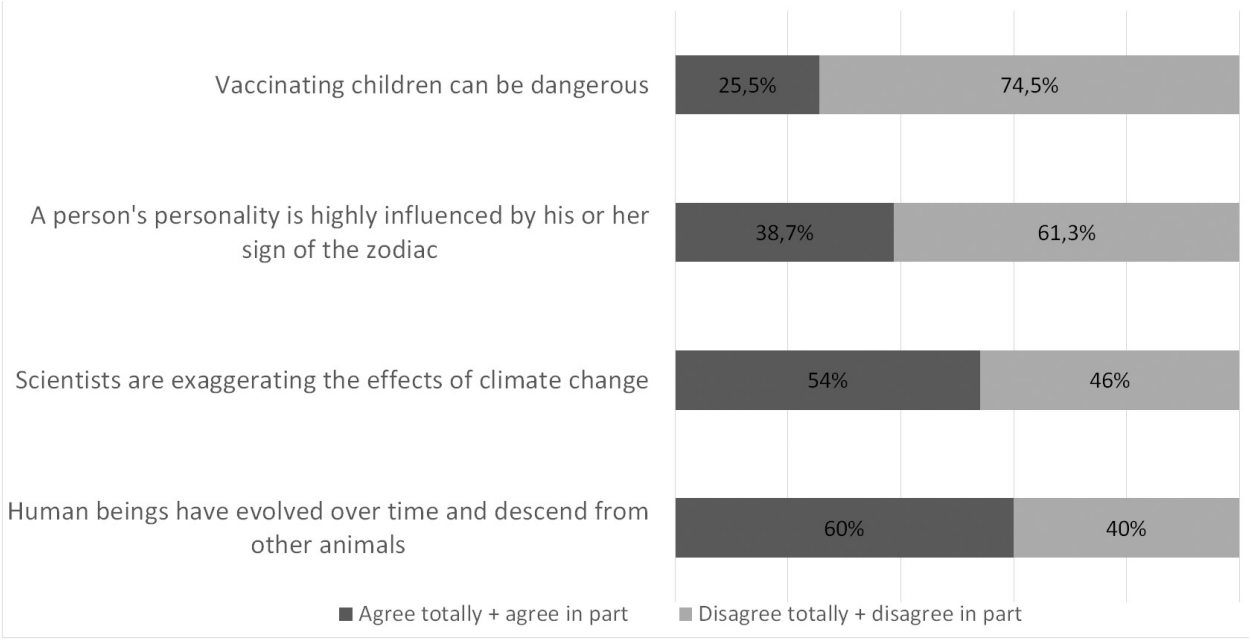

Figure 4. Opinions about controversial topics
Survey question related to Figure 4:
I'm going to read some statements about science and technology. Tell me to what extent you agree or disagree with each one. (agree totally, agree in part, disagree in part, disagree totally).

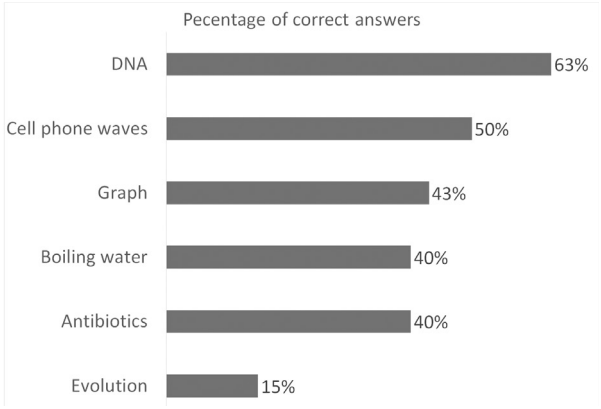

Figure 5. Correct responses about basic notions of science.
[8]Basic notions about science related to Figure 5:
a) DNA: Plant cells do not contain DNA; only animal cells contain DNA. From what you know, this is (true / false).
b) Cell phone waves: From what you know, what type of waves are used to communicate between your cell phone and other cell phones? (sound waves / gravitational waves / electromagnetic waves / none of these).
c) Graph: This graph shows the speed of an object in relation to time. From what it looks like to you, which statement best describes the data on the graph? (The object has stopped / The object is moving in a straight line at a constant speed / The object is accelerating / The object is braking / I don't know).
d) Boiling water: If you boil the same pan of water at the top of a tall mountain and on a beach, the water in the pan will boil at a lower temperature on the mountain than on the beach (true / false)
e) Antibiotics: As far as you know, antibiotics kill viruses. (true / false).
f) Evolution: Charles Darwin and Alfred Wallace proposed the theory of natural selection to explain the origin of species. As far as you know, according to them, natural selection: (is responsible for the survival of the strongest in nature. / leads to the survival of the fittest. / selects organisms whose characteristics are less adapted to the environment. / allows a given organism to adapt to the environment by modifying parts of its body. / I do not believe in this theory as the explanation for the appearance of new species.).

Commission 2008, González 2011). Benefits are seen as outweighing risks, and opinions are that the field's discoveries and achievements afford improvements in quality of life, making our lives easier and more comfortable.

However, as in our survey, studies conducted elsewhere suggest that respondents see science as having limitations. European youth tend to have divided opinions about science and technology's ability to solve social problems such as poverty and social inequality (Haste 2004, European Commission 2008). A possible interpretation is that, at least indirectly, S&T activities depend on socioeconomic and political interests and, consequently, on private enterprise, which is motivated by profit – ergo, there is unequal access to the benefits produced by this field.

Like young Brazilians, young Europeans are in favor of increased investments in S&T, even in contexts that require funding cuts (Haste 2004, European Commission 2008, González 2011). However, British young people's support for increased investments depends on the field in question; research related to nuclear energy and the development of robots, for instance, is not among their priorities (Haste 2004). European youth also believe that European Union member nations should do a better job of coordinating their research efforts, indicating that respondents would like to see resources optimized (European Commission 2008).

The interest that our study detected in S&T and such related topics as medicine, health, and the environment has been found among young people surveyed in other Brazilian and international studies (Haste 2004, MCT 2006, European Commission 2008, FAPESP 2011, González 2011, Castelfranchi et al. 2016, CGEE 2017). At times, this interest is higher among young people than among older groups (Castelfranchi et al. 2016, CGEE 2017).

Given the diversity of topics within S&T, some might prove more interesting to young people than to others. For example, half of young British say they want to know more about new technological advances and the fields of science that affect their personal lives (Haste 2004). For European youth, the topics "new inventions and technology," "Earth and the environment," "human body and medical discoveries," and "information and communication technologies" are more interesting than "the sky, stars, universe" (European Commission 2008). If someone expresses interest in a topic, it does not necessarily mean he or she will acquire or enjoy access to this knowledge. Furthermore, expressing interest in S&T essentially means a person considers the topic socially relevant; yet for a large share of young people, this does not translate into an active quest for information or knowledge, primarily given sharp inequalities in access to knowledge, resources, materials, or cultural capital.

Young Brazilians, even if only moderately, watch videos; read magazines, newspapers, and books; listen to the radio and podcasts; and talk to friends, teachers, and relatives about S&T, both online and offline. These young people inform themselves about S&T in ways that are part of our current information ecosystem, where the Internet – with all its resources and limitations – plays a central role.

The data are in accordance with studies like the 2017 Ongoing National Household Sample Survey (Pesquisa Nacional por Amostra de Domicílios Contínua, or PNAD contínua), which found that 69.8% of Brazilians over the age of ten, or 126.3 million people, had accessed the Internet in the three months prior to the survey. Among youth ages 14 to 17, the figure was 85%, while for those 18 to 24, it was 88% (IBGE 2018). The study "Juventudes e conexões - Edição 3" (Youth and connections – Edition 3), conducted in 2018 and 2019 by the Fundação Telefônica, found that 97% of those aged 15 to 29 who had used the Internet in the three months prior to the survey had averaged 5.5 social network accesses per week, while 80% had posted content on social media three times a week on average (Fundação Telefônica 2019). Leveraged by smartphones, the Internet has gained firm footing in Brazil in recent years. (González 2011, Castelfranchi et al. 2016, CGEE 2017).

Another important finding here was that 84.3% of the Brazilian public had a personal cell phone; more specifically, the rate was 71.2% among the 14-to-17 age group and climbed with age, reaching 86.6% among those ages 20 to 24. The central role of smartphones in providing access to the Internet is confirmed by data from the Information and Communication Technology for Households (TIC Domicílios) survey for 2018 (CGI.br/NIC.br 2019), where we find that 97% of Brazilian users accessed the Internet primarily from their cell phones in 2018; the computer ranked second, at a much lower 43%. Information, misinformation, and fake news circulate in this environment, often spread and shared by unqualified people.

When asked to select from a list provided by the survey, young Brazilians said that teachers, doctors, and scientists from universities or research institutes were the most trustworthy sources of information on S&T. For youth in Spain, the most trustworthy institutions in the realm of S&T were hospitals, universities, professional colleges (*colegios profisionales*), and public research agencies (González 2011). While the two studies posed somewhat different questions, their findings were similar and suggest that even though youth have free access to different sources of information, they value exchanges with professionals and institutions of sound epistemic authority. It should be emphasized that even though young people in

Brazil and Spain value epistemic authority, the proportion of them who can name a scientist or scientific institution is concerning. In Brazil, a mere 5% of the young people surveyed could recall the name of a Brazilian scientist, while only 12% could cite the name of a Brazilian institution devoted to scientific research. These percentages are higher in Spain, but still not substantial, that is, 35% and 20%, respectively (González 2011). These findings tell us something else of concern: even among young people with a college education, only a minority could link scientific research to a Brazilian university or institution, and only a very small fraction could name a Brazilian scientist.

The positive view of scientists and scientific careers expressed by young Brazilians' was also detected among European youth. Most believe that these professionals are devoted and work for the good of humanity; however, like Brazilian youth, most also think that they can represent a danger, given the knowledge they possess (European Commission 2008). When asked to select the reason why scientists devote themselves to S&T, young people in Spain ranked positive motivations at the top, that is, the quest for new knowledge and the desire to help solve social problems (González 2011). In Britain, half feel that scientists make responsible decisions about the risks of their work; these youths also have a non-monolithic perception of scientists, that is, they attribute significantly different traits to them depending on field (Haste 2004). Young people in Spain also have a positive view of science as a career; they rank personal reward as the top benefit, followed by the fact that this career is attractive and financially rewarding (González 2011).

Brazilian studies, as mentioned earlier, have found that young people sometimes express more interest in S&T as compared to older groups (Castelfranchi et al. 2016, CGEE 2017). Looking at people age 18 and older across 14 countries in several continents, the study "State of science index 2018 - global report" (3M 2018) found that most respondents would like their children to know more about science and that they would encourage them to follow a career in this field, suggesting that they would instill in their children a positive, encouraging view of the profession. The second statement was endorsed by the 2019 study (3M 2019). Also like our study, surveys have found that European youth would like the general public and scientists to have a greater voice in defining the applications and directions of S&T.

Based on our results, and in line with findings from other countries, scientists, politicians, and the government face major challenges in the public communication of science. It will be important to take young people's interests, attitudes, perceptions, and engagement into account. The challenges will be to devise stronger mechanisms capable of reaching all social groups; reduce misinformation; facilitate debates, discussions, and the learning and appropriation of knowledge; and strengthen a body of scientific citizens. Institutions and public policy must provide top-quality, consistent, and trustworthy information to these young people, opening the path to increased social participation and engagement in S&T topics.

Acknowledgments

This work was supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, grant number 440675/2015-4) and by the Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ, grant number 232681). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) - Finance Code 001. Three authors thank CNPq for Productivity Grants (Bolsa Produtividade); one thanks FAPERJ for a Scientist of our State grant (Cientista do Nosso Estado); and one thanks Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) for a grant. Massarani thanks to CNPq for the Productivity

Fellowship 1B and to Faperj for the Cientista do Nosso Estado. Moreira thanks to CNPq for the Productivity Fellowship 1C.

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How to cite

MASSARANI L, CASTELFRANCHI Y, MENDES I, FAGUNDES VO & MOREIRA I. 2021. Science in society: What young Brazilians think about S&T. An Acad Bras Cienc 93: e20200204. DOI 10.1590/0001-3765202120200204.

Manuscript received on February 1, 2020;
accepted for publication on August 23, 2020

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All the authors participated of the design of the study and the analysis of the data. Massarani, Castelfranchi, Mendes and Oliveira Fagundes participated of the writing of this paper. Massarani coordinated the study and the article.