ESTUDOS DE PSICOLOGIA
Psychological Studies

REVIEW ARTICLE
ARTIGO DE REVISÃO

Social Psychology
Psicologia Social

Editor
André Luiz Monezi de Andrade

Support
Agence Nationale de la Recherche, *Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco* (Process nº APQ-0058-7.07/19) and *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (Process nº 306187/2019-1).

Conflict of interest
The authors declare they have no conflict of interests.

Received
May 16, 2021

Final version
February 23, 2022

Approved
October 28, 2022

Gene editing of the human embryo: tensions and controversies among scientists

Edição genética do embrião humano: tensões e controvérsias de posicionamentos entre cientistas

Maria de Fátima de Souza Santos[1], Renan Harmes Eskinazi[1], Thémis Apostolidis[2], Lionel Dany[2]

[1] Universidade Federal de Pernambuco, Centro de Filosofia e Ciências Humanas, Programa de Pós-Graduação em Psicologia. Recife, PE, Brasil. Correspondence to: M. F. S. SANTOS. E-mail: <santos.fatima9@gmail.com>.
[2] Université Aix-Marseille, Laboratoire de Psychology Sociale, Maison de la Recherche. Aix-en-Provence, France.

Article based on one of the studies from the project entitled "Interventions on the human embryo: a comparative psychosocial approach Brazil/France (INTEMBRYO)". Universidade Federal de Pernambuco, Université Aix-Marseille, Université de Lyon 2, 2021.

How to cite this article: Santos, M. F. S., Eskinazi, R. H., Apostolidis, T., & Dany, L. (2023). Gene editing of the human embryo: tensions and controversies among scientists. *Estudos de Psicologia* (Campinas), *40*, e210091. https://doi.org/10.1590/1982-0275202340e210091

Abstract

Objective
This study analyzed the relation between the position of scientists on embryo editing and the different types of knowledge involved.

Method
A lexical analysis of 151 scientific articles in the PubMed and Web of Science databases was conducted using the IRAMUTEQ software.

Results
The results showed that gene editing in embryos is presented in two argumentative branches: the first refers to the editing technique and its possibilities; the second discusses the impacts of these techniques on the public arena. The results demonstrate a consensus regarding the potential of editing; however, dilemmas about its effectiveness were also highlighted.

Conclusion
The presence of ethical conflicts with embryo editing among the specialists was evidenced especially regarding the birth of genetically modified babies. Therefore, gene editing is marked by conflicts that are not limited only to biological contexts, but that encompasses different aspects of social life.

Keywords: Bioethics; Gene editing; Human embryo; Social representation.

Resumo

Objetivo

O objetivo deste trabalho foi analisar a relação entre o posicionamento dos cientistas sobre a edição de embriões e os diferentes tipos de conhecimento envolvidos nesses debates.

Método

Utilizando o software IRAMUTEQ realizou-se uma análise lexical de 151 artigos científicos nas bases de dados PubMed e Web of Science.

Resultados

Os resultados demonstraram que a edição genética de embriões se apresenta em dois blocos argumentativos: o primeiro se refere à técnica de edição e suas possibilidades e o segundo discute os impactos dessas técnicas na arena pública. Os achados demonstram consenso sobre as potencialidades da edição, contudo dilemas sobre a sua eficácia foram também destacados.

Conclusão

Evidenciou-se a presença de embates éticos sobre a edição de embriões entre os especialistas em relação ao nascimento de bebês geneticamente modificados. Observou-se que a edição genética é marcada por conflitos que não se limitam apenas a contextos biológicos, mas que tangem diferentes aspectos da vida social.

Palavras-chave: *Bioética; Edição de genes; Embrião humano; Representação social.*

Gene editing refers to the process in which certain parts of the DNA are "deleted", thus making it possible for new gene segments to be introduced into the given space. In the process, specific areas of DNA are cut out and new gene sequences are put in place. As stated by Nogueira Furtado (2019), gene editing tools have recognition mechanisms, thus making it possible to associate them with specific DNA sequences, in addition to cleavage mechanisms that help break the nucleotides of the chosen DNA sequence.

Although the process has been known to the scientific community since the 1990s, currently with the discovery of the CRISPR tool and, more specifically, the Cas9 nuclease, gene editing has become one of the main potentialities for the treatment of genetic diseases and somatic therapies. Prior to the CRISPR/Cas9 technique, gene editing studies were based on procedures such as ZFNs (Zing-Finger-Nucleases) and TALENs (Transcription Activator-Like Effector Nucleases). It has become one of the main methods of gene editing, due to its greater effectiveness when compared to other techniques, as well as its cost, being currently one of the most used tools in gene editing experiments.

The discussion about the applicability of gene editing is mainly based on two areas: the first is the application to germ cells (such as sperm and eggs), that is, cells in which the alteration performed will propagate in the future generations and the second in somatic cells, which represent the rest of the body's cells, in which gene editing is not transmissible to subsequent generations. From this, it is understood that the editing of human embryos is configured in a territory of tensions, both in the biological and health areas as well as in the social areas. In this sense, the manipulation of the human embryo implies a series of concerns: personal, scientific, social, political, family, legal, and ethical. Scientific controversies within the scientific community are strongly present, especially in relation to the discussion on gene correction versus gene improvement (Lander et al., 2019).

Following the argument proposed by Lander et al. (2019), the gene editing of human embryos, despite showing strong future potential, is inserted in socio-biological conflicts due to its ability to not only cure diseases but also improve human characteristics, something that can lead to processes of "biological inequalities", in which certain individuals have certain genetic characteristics that would put them ahead of other individuals. The use of human embryo gene editing techniques

opens the possibility of creating individuals with specific genetic materials and characteristics, called "designer babies", in addition to the emergence of side effects, such as mosaicism and the so-called "off target effects". These are the arguments that appear in discourses favorable to a moratorium or possible ban on gene editing in germ cells and, more specifically, human embryos. However, arguments proposed by other members of the academic community, such as Savulescu et al. (2015), propose that regulatory institutions and global agreements already exist on the performance of experiments with high risk to the participant, without any other type of specific regulation.

Debates about the gene editing of human embryos intensified from 2015 onwards, with experiments conducted with human embryos to correct a mutation related to beta-thalassemia. The studies managed to change a certain mutation in the HBB gene, responsible for encoding the beta-globin protein. The study was done with embryos that would be discarded and not used by in vitro fertilization methods. After carrying out this experiment, American researchers conducted a study that aimed to correct the mutation in the MYBPC3 gene in human embryos. The mutation is related to hypertrophic cardiomyopathy, a disease that makes it difficult for the heart to pump blood. Currently, the debate about gene editing in human embryos has gained great prominence, due to the announcement, made by Professor He Jiankui in China in 2019, of the birth of twins who underwent gene editing with the aim of making them resistant to the HIV virus.

From this, it is clear that the gene editing of human embryos is configured as an environment of disputes and conflicts. Analyzing gene editing as a technology that mobilizes beliefs and attitudes, it is evident the emergence of new thoughts and values in society, influencing new social practices. In this sense, it is important to think about the debates about gene editing in embryos as dynamic manifestations of discussions that are constantly changing, both at individual and social levels, as well as at scientific and common-sense levels. Thus, the importance of discussions within the scientific community regarding the gene editing of human embryos is evidenced as mechanisms that help in the understanding of controversies and different positions among scientists. The analysis of the debates by scientists and specialists makes it possible to understand the social objects related to gene editing in embryos, as well as their ethical and scientific issues, in addition to helping to understand the implications of the social context in the scientific arena, and vice versa. Thus, investigating the way in which specialists position themselves in the ethical-scientific discussion about a scientific innovation will make it possible to identify the conflicts (scientific, ethical, moral, social) that are objectified by scientific debates and controversies and to analyze the different types of knowledge involved in the discussion among experts on technological innovations in human embryo editing.

In this perspective, it was considered that the Theory of Social Representations, proposed by Serge Moscovici, could contribute to the analysis of meanings, knowledge and knowledge attributed to gene editing by scientists and specialists. Although initially Moscovici (1961) made a separation between the consensual universe (common sense) and the reified universe (scientific knowledge), he draws attention a few years later (Moscovici, 2012) that people use different ways of thinking and different modes of representation, both in common sense and in the production of scientific knowledge. All human knowledge is characterized by cognitive polyphasia, that is, by the coexistence of different forms of knowledge. The "pure", "neutral" scientific knowledge would only be possible if scientists were not humans, if they were not subjects who are constituted in interactions and communications with the other in a specific sociocultural context.

According to Moscovici (1981, p. 181), social representations would be "a set of concepts, propositions and explanations created in everyday life in the course of inter-individual communication".

The elaboration of social representations would be based on two processes: anchoring and objectification. Anchoring is related to the categorization process, in which new social objects are recognized from previously known categories. In this way, new objects called "strange" are inserted into an existing network of representations with the aim of transforming them into familiar knowledge. Objectification, in turn, is the process through which representations pass from an imaginative field to a material conception. In this sense, objectifying would be related to the process of giving dimension and materiality to social objects and inserting them into social dynamics. Based on this, the socio-genetic approach to social representations was chosen as the theoretical framework for this study. According to Kalampalikis and Apostolidis (2020, p. 2) the socio-genetic perspective seeks to "understand the representational object as a dynamic phenomenon, its genesis as a trajectory in the present and in the past, its expression as practical and social knowledge, a product of historical, political, and cultural situations, as well as social communications".

Allied to this, the object of social representation in the socio-genetic approach would have a situated and holistic character. According to the authors, every representational object is an object crossed by zones of tension. In this sense, the tension zones would be essential for the type of object discussed and also for the perspective that the subjects have of it. From this, it can be thought that the object in question in this paper, the gene editing of human embryos, is configured as an object of tension, marked by conflicts and discussions that relate to the positions of different social groups. Furthermore, according to the approach, objects influence how individuals think and act in the groups they belong to, thus helping to build a network of shared thoughts. In this sense, each social group understands the object according to specific systems of representation. Thus, the objective of this research was to analyze the relationship between the position of scientists on embryo editing and the different types of knowledge involved in these debates.

Method

Within the scope of this project, a lexical content analysis of scientific articles published from 2015 onwards in the health and biomedical databases was carried out. The articles were collected through the PubMed and Web of Science databases, which bring together several scientific journals from different countries, such as Nature, Molecular Therapy, Current Biology, Frontiers in Immunology, Yakugaky Zasshi-Journal of the Pharmaceutical Society of Japan, World Bioethics, and Human Gene Therapy Methods.

The articles were selected in their electronic format with the descriptors embryo editing, CRISPR, embryo manipulation, embryo intervention, genetic enhancement, genetic improvement, gene therapy, genetic engineering, genome editing, bioethics. From the descriptors, 151 articles were selected, all in the areas of medicine, biology, bioethics, cytology, and genetics.

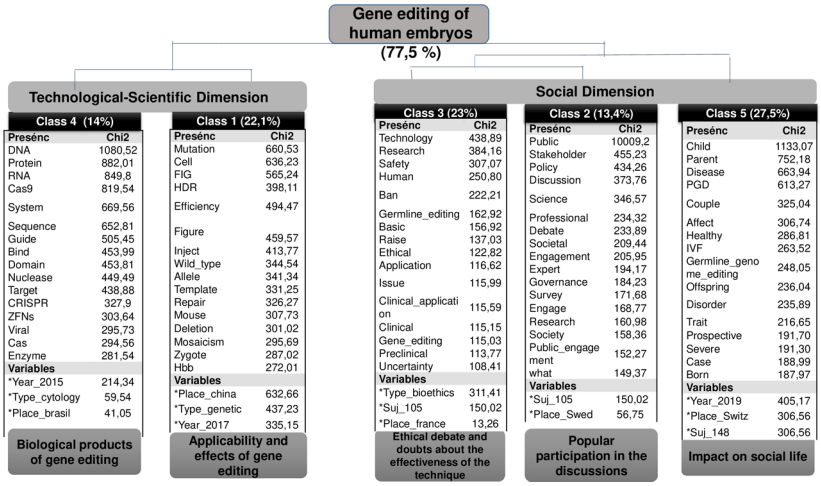
The articles were analyzed with the support of the IRAMUTEQ software (version 0.7 alpha), which allows the analysis of textual data. Initially, a Descending Hierarchical Classification (DHC) was conducted, responsible for identifying type-contexts and separating them into classes/categories, presenting the relationships between them in the shape of a dendrogram. Then, a Correspondence Factor Analysis (CFA) was carried out, which allows the description of the existing links between different qualitative variables, in search of a global idea or major factors of the data collected. From this, content analyzes were performed (Bardin, 1977; R. L. S. Aléssio et al., 2008) of the typical articles of each class obtained with the objective of identifying the positions and conflicts involved in the discussion between specialists on embryo editing. The variables applied

were subject (*subj_), year of the article (*year_), type of the article (*type_), and the country of the study (*place_). As this is an article using a public domain document, there was no need to submit the project to the Ethics Committee.

Results and Discussion

Figure 1 presents the dendrogram from the Descending Hierarchical Classification (DHC). It was evidenced that 77.5% of the original corpus was preserved and analyzed using the IRAMUTEQ software. From the DHC, it was observed that the corpus called "Gene editing of human embryos" was divided into two main subcorpora. The first, represented on the left side of the figure, is formed by two classes that share the idea of a technological and scientific dimension regarding gene editing: Class 4 called "Biological products of gene editing", and Class 1 entitled "Applicability and effects of gene editing". The second subcorpus relates to a dimension focused on the social, marked by contents that relate to social dynamics and clashes arising from the use of the technique in the social sphere: Class 3 called "Ethical debate and doubts about the effectiveness of the technique", Class 2 which was named "Popular participation in discussions", and Class 5 entitled "Impact on social life"

Figure 1
Descending Hierarchical Classification



Source: Based on the IRAMUTEQ software (version 0.7 alpha 2).

Technological and scientific dimension (Classes 4 and 1)

Class 4 – Biological products of gene editing: has the most representative words: *DNA, Protein, RNA, Cas9, System, Sequence, Guide, Link, Domain, Nuclease, Target, CRISPR, ZFNs, Viral, Cas, and Enzyme*. In this sense, it is clear that the contents that surround this class are related to the organisms and techniques associated with gene editing. Class 4 groups the discourses that deal with the functions and units that structure gene editing, such as DNA and proteins. In this way, the class discusses the products that enable gene editing to occur, as well as the systems that operate the editing processes, such as enzymes and Cas9. It is clear, therefore, that Class 4 addresses content originating in the biological field and knowledge of areas such as genetics and cytology. In this sense, it is understood that in this class the meanings linked to gene editing are guided by information

related to organic and biological structures. With this, the class in question lists the structures that are part of the gene editing process in embryos and their functionalities, as the following excerpts illustrate (the words in italics are characteristic of the class):

> Genome editing, using site-specific nucleases, can be performed very efficiently and accurately, with the help of targeted transgenic integration experiments, the researchers used the nuclease engineered to perform double-strand breaks, where cellular DNA repair mechanisms may be occurring. (subj_89, year_2017, type_genetics, place_india)

As stated by Gross (2015) the discovery of the Cas9 nuclease revolutionized the field of gene editing. Recently discovered from an adaptive immune response in bacteria, the Cas9 nuclease can be programmed to edit DNA target sequences. In this sense, the nuclease in question may provide opportunities for human gene editing not only in somatic cells, but also in germ lines. Regarding the gene editing process, Nogueira Furtado (2019) explains that editing tools have mechanisms that allow the recognition of sequences and specific targets of nucleotides and proteins in DNA. Thus, these tools make it possible to remove specific stretches of the target DNA, allowing the replacement of a certain sequence by the desired gene.

Regarding the linked variables, it is evident that Class 4 groups most articles published in countries where the technique of gene editing of embryos is prohibited or do not have clear legislation on the subject, such as Brazil and Russia, respectively. Karagyaur et al. (2019) state that despite the authorization to create embryos for infertility treatments, the Russian Federation considers that the introduction of hereditary modifications to the human genome must be carried out in accordance with international recommendations and legal procedures, without prescribing specific norms to the process. In another scenario, in the Brazilian context, despite the 2005 Biosafety Law that authorizes research with embryos and the culture of genetically modified organisms, the gene editing of embryos is still prohibited in the country (R. L. D. S. Aléssio et al., 2011). Thus, it is evident that among Class 4, the production of studies and articles about gene editing is focused on the discussion of the potentialities and organisms that are used in the editing process and not so much about the applications of these techniques in clinical scenarios. In this sense, the class is organized from a more theoretical-biological understanding of editing tools.

Intricately linked to Class 4 in the technological-scientific dimension, Class 1 called "Applicability and effects of gene editing" (ECU: 22.1%) has as its most representative words: *Mutation, Cell, Fig, HDR, Efficiency, Figure, Wild -Type, Allele, Template, Repair, Mouse, Delete, Mosaic, Zygote, and HBB*. It is observed that Class 1 groups the contents related to the application possibilities of gene editing, that is, it dialogues with the uses and results of the procedures involving the gene editing of embryos. Unlike Class 4, Class 1 presents contents aimed at the practical field, evidenced from discourses that surround about the functionality and execution of such tools in different genetic structures, as well as the possible consequences of such use. It was evident that the class groups two main argumentative branches: the first is related to the possibilities of applications of the technique, that is, what is possible to relate to editing tools and future editing perspectives. Thus, this first branch groups the discourses related to procedures involving gene editing, from human embryos. These discourses are based mainly on the two experiments carried out with human embryos, by Chinese and American researchers.

The second argumentative branch, present in Class 2, also groups discourses related to the applicability of gene editing. However, the contents are mainly focused on the effects and sequelae of the technique. In this sense, it was observed that this argumentative branch encompasses contents related to unpredictable effects or collateral results. Thus, within Class 1, the question of the

applicability of editing human embryos is discussed, as well as the possible biological repercussions of these applications. Among the unpredictable effects of the technique are the off-target effects and mosaicism. According to Baumann (2016) mosaicism refers to the process in which not all cells affected by gene editing are modified, thus, cells that have undergone gene editing and cells that have not undergone such process coexist in the genome. According to the author, the occurrence of mosaicism can limit therapeutic effects, thus, it would be necessary that high levels of precision be performed in order to exclude modifications of unintended sequences. The second side effect that permeates the discussion of Class 1 are the so-called off-target effects, which are related to processes where unwanted changes occur in other parts of the genome, that is, when it is intended to edit a certain gene sequence and ends up accidentally altering another part of the DNA as well. This phenomenon is also related to possible mutations that may occur in the genome after carrying out the editing process, called off-target-mutagenesis. In this sense, although the experiments carried out in embryo editing have great potential and innovation, doubts about possible side effects of the technique are present in the discussion. The possibility of unexpectedly editing a certain gene or provoking a certain reaction that interferes with the functionality of a certain sequence is still a problem among scientists. This discussion can be exemplified from the following Elementary Context Unit (ECU):

> Recent studies using gene editing tools such as Crispr/Cas9 have shown an enormously broad spectrum of potential future applications. This genetic engineering technique allows researchers to easily disable, insert, or replace DNA fragments, while increasing risks such as incomplete or inaccurate editing of target mutations and other unintended consequences. (subj_33, year_2016, type_bioethics, place_usa)

When observing the variables present in Class 1, one can think about raising some hypotheses about the organization of discourses. First, it was evident that the class encompasses most of the articles published in 2017. As mentioned earlier, the contents present in Class 1 were organized mainly from the experiments carried out by Chinese and American researchers. Thus, by showing that these experiments were conducted respectively in 2015 and 2017 and that discussions about scientific research usually take place between the year in which it was carried out and the year after it was carried out, one can think that Class 1 comprises most 2017 discourses.

In addition, Class 1 covers most items from China. According to Cyranoski (2019) China, along with the United Kingdom, which has an intermediate legislation, is one of the few countries in the world where the editing of human embryos has a certain permissive character. Despite new regulations being proposed after experiments were carried out in 2019, China remains one of the few countries that has a more open legislation regarding gene editing. In this sense, when showing that the articles published in the country are mostly included in Class 1, it is noted that because it has a so-called more permissive legislation in relation to gene editing, the Chinese scientists' discourses have a more practical connotation, thus related to the issue of applicability and editing effects. The Chinese articles are part of an approach that focuses on the issue of functionality and use of these techniques.

Social dimension

The set of discourses gathered in Classes 3, 2, and 5 refer to the relationship between scientific innovation and society. On the one hand (Classes 3 and 2), the discourses on ethical-regulatory issues that emerge from the application of gene editing in human beings. Linked to ethical-regulatory issues, Class 5 brings together discourses on the impact of gene editing on society.

Ethical-regulatory issues

Class 3, called "Ethical debate and doubts about the effectiveness of the technique", has as the most representative words: *Technology, Research, Security, Human, Banning, Genome Editing, Basic, Lifting, Ethical, Applications, Clinical Applications, Clinical, Gene editing, Preclinical, and Uncertainty*. From this, it can be seen that the class groups contents related to ethical discourse and its implications for the development of embryo gene editing techniques. These contents, organized from doubts about the effectiveness and precision of gene editing, are also present in this class. Thus, it is possible to show that ethical and moral issues are shown as central factors in the discussion about possible applications of these tools. Thus, Karagyaur et al. (2019) argue that genome editing, since it raises ethical and legal dilemmas due to doubts about its effectiveness, is one of the most controversial technologies today.

Besides this, it is observed that the ethical debate is constituted mainly from the possible doubts regarding the competence of such tools, that is, the uncertainties about the effectiveness of the gene editing technique that foment the discussions about the ethical limits and morals. It is also observed that the ethical discussion has as one of its main points the clinical possibilities, that is, the application of these tools. Lanphier et al. (2015) argue that editing the genome of embryos can generate unpredictable effects in future generations, thus, according to the authors, such research is part of a dangerous and ethically unacceptable scenario. Such contents can be observed in the ECU below:

> In this debate, a broad spectrum of topics was discussed, including medical issues related to safety and efficacy, potential health risks and unintended risks and consequences for future generations, and ethical issues such as individual and collective responsibility. (subj_33, year_2016, type_bioethics, place_usa)

In this sense, Class 3 addresses content related to the need to think about scenarios that demarcate which practices can be carried out and which should be prohibited in relation to gene editing. This type of discussion demonstrates not only the controversial and plural nature of the tool, but how different countries (scientists) have different attitudes towards the object of the edition, resulting in different practices that may cross ethical boundaries and cause dangerous consequences for the entire human species.

Class 2 (entitled "Popular participation in discussions") represented about 13.4% of the corpus and has the most representative words: *Public, Stakeholder, Policy, Discussion, Science, Professional, Debate, Societal, Engagement, Expert, Governance, Research, Engage, Society, Public Engagement, and What*. From this, it is evident that the class groups contents related to the need for society's participation in debates about gene editing and, more specifically, its applications and possibilities. Class 2 discusses the importance of decisions about the use of gene editing in embryos reaching society in general, that is, mobilizing different groups and spheres of social life. Lander et al. (2015), when discussing the need for a moratorium on the editing of human embryos, reveal that such a process can only be done with the broad participation of the rest of civil society. Class 2 also concerns opinion polls conducted in society to measure the positions of individuals on the subject of gene editing of human embryos.

In addition to consulting with the rest of society on the applications of such techniques in human embryos, the class also has content related to the public and interested parties' own engagement in these discussions. In this sense, it is worth thinking that, according to scientists, the resolution of norms and rules for gene editing can only be really effective from the involvement of society in the discussions, that is, expanding the debate to the social field of public spheres and not

limiting the discussion to medical and academic contexts. In this sense, Mohr and Raman (2012) state that public engagement generates multiple perspectives, visions, and values relevant to the science and technologies in question and can lead to more socially diverse results than those initially predicted by the scientific community. From this, it is observed that Class 2 is organized based on the need for people outside the scientific community to give their opinion and have a voice in the discussion, with the aim of obtaining a broad overview of attitudes towards gene editing. Allied to this is the creation of public policies aimed at greater involvement and participation of the rest of society in these matters and future decisions. Such findings can be observed in the following ECU:

> He presented his work as a fait accompli, while the prevailing political and academic consensus remains that it is still neither safe nor desirable without global public discussion to begin testing germline editing technologies in humans given the uncertain long-term effects. (subj_131, year_2019, type_bioethics, place_netherlands)

Class 5, called "Impact on social life", responsible for grouping 27.5% of the corpus, has as the most representative words: *Child, Parents, Disease, PGD (Preimplantation Genetic Diagnosis), Couple, Affect, Healthy, IVF (In-Vitro Fertilization), GGE (germline genome editing), Offspring, Disorder, Trait, Prospective, Severe, Case, and Birth*. From this, it can be seen that this class groups discourses related to the consequences and repercussions of gene editing of embryos in the social spheres. It is evident, therefore, that Class 5 discusses the repercussions in different contexts, such as the possibility of treating genetic and hereditary diseases, in addition to the different groups included in these discussions, such as interested families and children who will be born with the genomes edited. It is also observed that Class 5 groups most of the corpus, evidencing its importance in the discussion about the positions of scientists. In this sense, it is clear that the gene editing of embryos would lead to new lifestyles, as well as new ways of understanding social reality. Thus, the class gathered the contents related to the consequences of using embryo editing technology in the social sphere.

One of the first points discussed regarding the consequences of using gene editing techniques in the social field is related to the treatment and prevention of genetic and hereditary diseases. In this sense, gene editing could help in the treatment of disorders that currently do not have an effective cure, since their composition is based on genetic factors and often related to mutations in DNA sequences. Thus, single-gene diseases are one of the main ways of correcting mutations and genetic problems. When discussing the possibilities of correction of Huntington's Disease in the field of gene editing, Gumer (2019) argues by presenting scenarios in which one of the partners has the disease gene, with a 50% chance that the naturally generated child would have the gene for Huntington's disease. This probability increases when both partners have the gene for the disease in question. In this sense, the use of gene editing in the latter case is extremely relevant.

Another point highlighted by the class relates to future children who will be born with genomes modified from gene editing. In this way, questions arise about the autonomy of subjects and about human dignity. In this perspective, Hammerstein et al. (2019) argue that there are discussions about the dangers of violating human dignity in the field of gene editing of embryos, by modifying the genome of a future child in order to meet not only the parents' expectations, but also to social values, thus compromising the right of self-determination. Thus, some scientists point to the question of the child's autonomy in choosing whether or not to perform such procedures.

It can be seen that the discussion about the repercussions of editing on future children who will be born from these tools is based on the very understanding of what the embryo would be and if it is a subject with rights. As verified by R. L. D. S. Aléssio et al. (2011), the human embryo is currently the center of a multiplicity of concerns, in addition to being marked by a plurality of

understandings and meanings attributed. According to these authors, the polymorphic characteristic of the notion of human embryo is reflected, among other points, in articles and studies carried out with the embryo itself. In this way, concerns about the impact of these techniques on future children are part of a larger debate about determinations regarding what is considered the individual. Such discussions can be observed in the ECU below:

> They are questions about our responsibilities to our children and our children's children, where the imprint of our actions will be inscribed on their bodies and lives. What, then, justifies the notion that this emerging technology has taken us by surprise or that it is appropriate for experts to retreat to isolated spaces to define the parameters of public debate?. (subj_23, year_2015, type_bioethics, place_usa)

Thus, it is understood that the conception of the individual in these discussions is related to the very configuration of modernity, in which individualism is a central part. In this way, the positions of scientists in class 5 are configured from an understanding of the rational and mainly autonomous subject, thus resulting in discourses that privilege the individual to the detriment of the technique itself. Such discussions can be exemplified in the debate on the human embryo itself, marked by the search for an understanding of whether or not the embryo is a "possible individual in formation". These debates also end up entering the issue of gene editing of embryos, exemplified from contents that assess the autonomy and independence of future children who will be born from this technique, as well as the groups that permeate such discussion, such as possible parents.

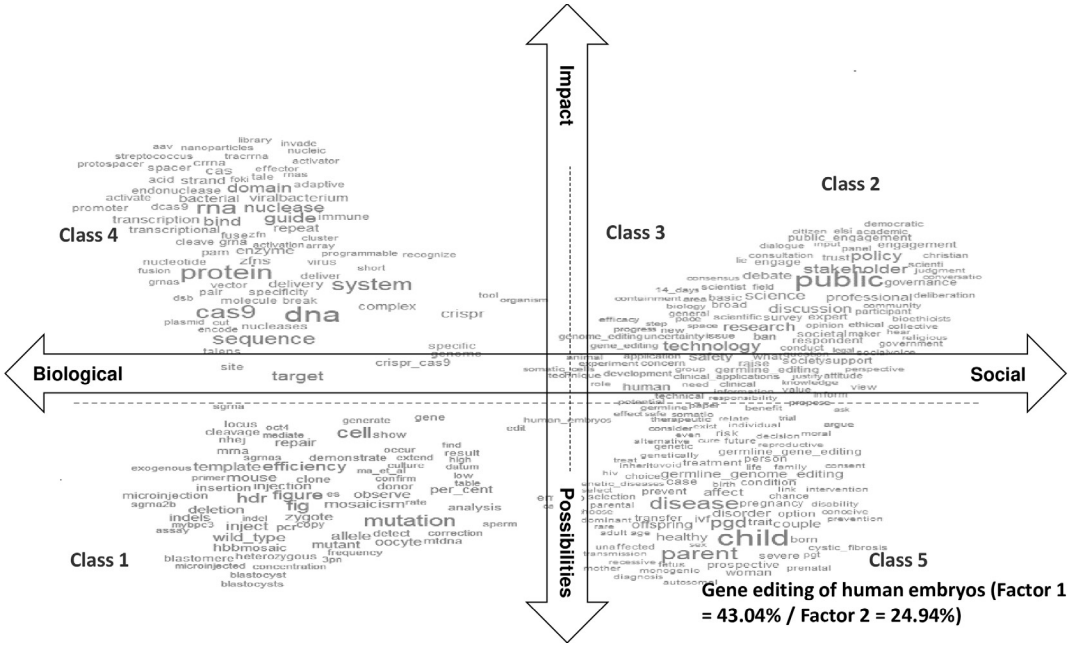
It is observed that Class 5 also discusses the issue of gene editing of embryos from two main points mentioned above: In-Vitro Fertilization (IVF) and Preimplantation Genetic Diagnosis (PGD). It is evident that these two themes have functions related to the process of anchoring social representations. As mentioned earlier, anchoring is related to the categorization process, based on the understanding that new social objects are recognized from previously known categories. In this sense, it appears that the IVF and the PGD already serve as known representations that help in the understanding of this "New object" that would be the gene editing of embryos. It is worth noting that IVF was discovered in 1978, and its major milestone was the birth of the first "test tube baby" in the UK. PGD, on the other hand, is a method of prenatal diagnosis that helps prevent the transfer of embryos that have certain diseases or genetic disorders. In this way, it can be seen that these two methods in question were already present in reality and more specifically in social thought, before the experiments with gene editing. Thus, PGD and IVF serve as elements that help in understanding gene editing itself. Thus, familiar representations of these methods are used to make sense of the new object.

Scientific consensus and dissent

In addition to the Descending Hierarchical Classification (DHC), the Correspondence Factor Analysis (CFA) was carried out, which made it possible to portray the relationships between the different variables chosen, thus helping in an integral understanding or of major factors of the data obtained (Figure 2).

Figure 2 shows a polarization between the two ends of the horizontal axis (X). On the horizontal axis on the left, it is evident that the discourses are organized from a biological understanding of the gene editing of embryos. Classes 1 (Applicability and effects of gene editing) and 4 (Biological properties of shape editing) are part of this pole. In this way, the classes that present the technological-scientific dimension are present at this end. It is also evident that at this end of the X axis, there are discussions about the natural and organic phenomena of gene editing,

Figure 2
Correspondence Factor Analysis



Source: Based on the IRAMUTEQ software (version 0.7 alpha 2).

that is, related to organisms and the repercussions of the technique in the biological field, either through the editing tools themselves such as CRISPR and the Cas9, as well as the consequences of such technologies and processes in the biological field, such as mutations and mosaicism. However, at the other end of the X axis, on the right side, we can observe the discourse of gene editing of embryos from a social perspective, related to the field of social reality, its agents, and repercussions. The right end focuses on the understanding of gene editing processes from a social perspective, that is, the individuals who will use such tools, the agents who will regulate such technologies and the groups that must be consulted for the formulation of rules and limits for use.

On the vertical axis (y) we can also observe two semantic fields of their own at the ends. The upper vertical axis is related to contents concerning the impacts and repercussions of embryo gene editing. Thus, it can be seen that the group discusses the consequences of using embryo editing. In this way, it can be thought that the upper axis deals with the consequences of gene editing of embryos in the most diverse fields, both in biological contexts and also from the repercussions on the social environment.

On the lower vertical axis, the grouped discourses are related to the possibilities of human embryo gene editing technology. The axis deals with both possibilities in the field of genetics and social reality. Initially, one can think about the possible mutations that gene editing can correct, in addition to discussing the so-called side effects such as mosaicism. Besides this, the axis also groups contents related to the possibilities of the technique in the social environment, highlighted from the birth of genetically modified babies and the new opportunities for assisted reproduction technologies.

The social debate highlights questions about symbolic consequentialism, having as a background the image that man is what he makes of himself. As Le Coz (2018, p. 99) states, "what it is about avoiding is more the dread that would result from a disfigurement under the

effect of an increasing artificialization of its conditions of existence or a modification of its genome". From a biological point of view, the articles are centered on the applied character of their findings.

Conclusion

It is clear, therefore, that the gene editing of human embryos is currently a field of conflicts and tensions. The possibility of editing the human genome becomes increasingly tangible, provoking debates about the use and dilemmas of this technology. The positions of scientists have plural characteristics, marked by multiple understandings and questions about the repercussions of applying the technique. The debates present in the scientific environment revealed some consensus regarding the potential and capabilities of the embryo gene editing tool. However, there are still doubts about its effectiveness, as well as the way in which this scientific innovation will be received in society. It is evident that the relationship between the individual (scientists) and the meanings about editing are directly related and permeate the dilemmas and social representations. In this sense, analyzing the gene editing of embryos today is to consider the social, cultural, and political conjunctures subjects and groups are experiencing at the moment of taking positions. The ethical discussion about the use of these technologies permeates cultural and socially shared understandings in social thought.

In this way, it can be seen that the discussion in scientific articles about the gene editing of human embryos is formed from an opposition between two main argumentative branches, which reveal two conceptions of science: the first a perspective of autonomous science aiming at the scientific and technological knowledge of the technique, that is, the biological processes and organisms that help in the editing per se and future applications in the clinical field. The second branch would be composed from a vision of science focused on society, explaining a social perspective on technology. From this perspective, the technique is understood from a collective conception, related to the repercussions of its development in the public sphere and in social reality, such as the impact on children who will be born from this technology or the possibility of treating genetic and hereditary diseases.

From the analysis of data, it is observed that the debates regarding the gene editing of embryos are based on both biological and social knowledge. It is interesting to note that despite treating these two types of knowledge as separate and even antagonistic, their interdependence and the way they relate to each other to make sense of social reality are evident. Thus, the tensions and controversies that cross the scientific debate should be considered to understand how scientific knowledge will be disseminated in society. In perspective, it is also important to investigate how these tensions will be appropriated by society in order to understand how post-scientific common sense is nourished and constituted from these tensions.

Finally, it should be noted that when discussing technological innovations, it is not just about biological and genetic issues, but also social understandings and representations that surround the most diverse individuals and social groups. It is important to think of this knowledge as producers of meanings and possessors of functionality in social life. Understanding how these new technologies will produce new social representations and questions about the future of humanity can help in studies of this type in the field of Social Psychology, thus analyzing the subject and society as an interactive unit.

References

Aléssio, R. L. D. S., Apostolidis, T., Santos, M. D. F. D. S., & Dany, L. (2011). Représentations sociales et embryon humain: une étude comparative Brésil/France. *Les Cahiers Internationaux de Psychologie Sociale, 4*, 371-395.

Aléssio, R. L. S., Apostolidis, T., & Santos, M. F. S. (2008). Entre o aborto e a imprensa. *Psicologia Reflexão e Crítica, 21*(3), 465-463.

Bardin, L. (1977). *L'analyse de contenu*. Presses Universitaires de France.

Baumann, M. (2016). CRISPR/Cas9 genome editing-new and old ethical issues arising from a revolutionary technology. *Nano Ethics, 10*(2), 139-159.

Cyranoski, D. (2019, May 20). China set to introduce gene-editing regulation following CRISPR-baby furore. *Nature News*. https://doi.org/10.1038/d41586-019-01580-1

Gross, M. (2015). Bacterial scissors to edit human embryos? *Current Biology, 25*(11), 439-442.

Gumer, J. M. (2019). The wisdom of germline editing: an ethical analysis of the use of CRISPR-Cas9 to edit human embryos. *The New Bioethics, 25*(2), 137-152. https://doi.org/10.1016/j.cub.2015.05.027.

Hammerstein, A. L. V., Eggel, M., & Biller-Andorno, N. (2019). Is selecting better than modifying? An investigation of arguments against germline gene editing as compared to preimplantation genetic diagnosis. *BMC Medical Ethics, 20*(1), 1-13. https://doi.org/10.1186/s12910-019-0411-9

Kalampalikis, N., & Apostolidis, T. (2020). Challenges for social representations theory: the socio-genetic perspective. In S. Papastamou & P. Moliner (Dir.), *Serge Moscovici's work. Legacy and perspective*. Éditions de la Méditerranée.

Karagyaur, M. N., Efimenko, A. Y., Makarevich, P. I., Vasiluev, P. A., Akopyan, Z. A., Bryzgalina, E. V., & Tkachuk, V. A. (2019). Ethical and legal aspects of using genome editing technologies in medicine. *Modern Technologies in Medicine, 11*(3), 117-133. http://doi.org/10.17691/stm2019.11.3.16

Lander, E. S., Baylis, F., Zhang, F., Charpentier, E., Berg, P., Bourgain, C., Friedrich, B., Joung, K. J., Li, J., Liu, D., Naldini, L., Nie, B. J., Qiu, R., Seifert, S. B., Shao, F., Terry, S., Wei, W., & Winnacker, L. E. (2019). Adopt a moratorium on heritable genome editing. *Nature, 567*, 165-168. https://doi.org/10.1038/d41586-019-00726-5

Lanphier, E., Urnov, F., Haecker, S. E., Werner, M., & Smolenski, J. (2015). Don't edit the human germ line. *Nature, 519*(7544), 410-411. https://doi.org/10.1038/519410a

Le Coz, P. (2018). *L'éthique médicale*. Presses Universitaires de Provence.

Mohr, A., & Raman, S. (2012). Representing the public in public engagement: the case of the 2008 UK Stem Cell Dialogue. *Plos Biology, 10*(11), e1001418. https://doi.org/10.1371/journal.pbio.1001418

Moscovici, S. (1961). *La psychanalyse, son image et son public*. PUF.

Moscovici, S. (1981). On social representations. Perspectives on everyday understanding. In J. Forgas (Ed.), *Social Cognition* (pp. 181-209). Academic Press.

Moscovici, S. (2012). *Representações sociais. Investigações em psicologia social*. Vozes.

Nogueira Furtado, R. (2019). Gene editing: the risks and benefits of modifying human DNA. *Revista Bioetica, 27*(2), 233-233. https://doi.org/10.1590/1983-80422019272304.

Savulescu, J., Pugh, J., Douglas, T., & Gyngell, C. (2015). The moral imperative to continue gene editing research on human embryos. *Protein and Cell, 6*(7), 476-479.

Contributors

M. F. S. SANTOS was responsible for the research project conception and planning; data collection; analysis, writing and critical review. R. H. ESKINAZI was responsible for the data collection; analysis and writing. T. APOSTOLIDIS was responsible for the research project conception and planning; contributed to the data collection, analysis, writing and critical review. L. DANY contributed to the analysis and interpretation of data, discussion of results, and review and approval of the final version of the article.