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Science by means of memes? Meanings of Covid-19 in Brazil based on Instagram posts

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Abstract

This study aimed at analyzing Brazilian memes posted on Instagram about Covid-19, in which scientific concepts were intertwined with the message. The research was based on virtual ethnography and the analysis considered the multimodal structure of memes following principles of the Grammar of Visual Design. Only twelve memes out of a universe of 83 identified (14.5%) presented knowledge about science interdependently with meanings that could be produced. One of the core aspects is the complexity of both representations and scientific concepts in memes about Covid-19. Scientific aspects, humor and irony were associated with social and political criticism through different multimodal interactions.

Keywords

Representations of science and technology; Science and media; Science education

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Introduction

The use of digital technologies, and particularly social networks, has become increasingly popular in modern life, transforming the way by which people communicate in both their personal and professional relationships. Accordingly, the language used in online communication has also been constantly changed. Digital media transmit not only verbal texts but also images, sounds and movements, which are composed of different semiotic modes that are used to produce meanings (meaning-making) [Kress, Jewitt, Ogborn & Charalampos, 2001]. These modes are "socially and culturally shaped resources for meaning-making" [Jewitt, 2013, p. 253], including words, gestures, icons, images or sound. The combination of different semiotic modes to produce meaning gives rise to multimodality [Jewitt, 2013]. All these aspects represent the organization of modern texts, especially those that circulate in the digital world, which are characterized for being increasingly multimodal.

In digital space these various semiotic modes are combined to provide discourses with new effects, allied to new layouts, textual sources and available software. A very typical example of this combination of semiotic modes in cyberspace is the 'meme' genre. Memes emerge as "dynamic entities that spread in response to technological, cultural and social choices made by people" [Shifman, 2012, p. 189]. This form of multimodal communication stands out for its composition and rapid dissemination, which are usually inspired by events that have gained prominence in the media [Pulos, 2020]. In general, they reuse the structure of previous memes to publicize the new event, using humorous and ironic meanings for different purposes, including social, political and cultural criticism [Chagas, Freire, Rios & Magalhães, 2019; Greene, 2019; Mortensen & Neumayer, 2021].

The rapid spread of memes means that a variety of topics is covered, including science [Zeng, Schäfer & Allgaier, 2021; Gartley, 2022]. The speed at which memes were produced was already conspicuous even before the Covid-19 pandemic started, but the latter further boosted their circulation due to the digital surge in social activity on the Internet [Murru & Vicari, 2021; Dynel, 2021; Priyadarshini et al., 2022]. Given that the spread of memes has also increased the possibility of disseminating information and ideas that can strengthen or discredit science efforts in the fight against Covid-19 [Palácio & Takenami, 2020; Brotas, Costa, Ortiz, Santos & Massarani, 2021; Massarani, Waltz, Leal & Modesto, 2021], the role of memes in social media in relation to public health and science has become a relevant object of investigation. In this context, it is therefore important to understand how knowledge and information about science spreads and what effects it can produce. Ultimately, such understanding can help create strategies to reduce possible deleterious effects.

Within this framework, this work endeavors to answer the following question: what aspects of science are present in Brazilian memes about Covid-19 and what is their purpose in the process of communication about the pandemic? The aim of this study was to analyze memes posted on Instagram about Covid-19, in which science was central to the message. To this end, the research was based on the multimodal structure of memes as a way of understanding the role of science in them, and their opportunities for expanding knowledge about science and Covid-19.

Memes: digital and multimodal discourse

The term meme was coined in 1976 by the evolutionary biologist Richard Dawkins in his work *The Selfish Gene*. Dawkins uses the term with the meaning of unit of imitation or replication. In this context, the meme can be a cultural unit (or idea) that works as a vehicle of replication aimed at ensuring survival, and may undergo changes during this process [Shifman, 2014]. A contemporary approach, however, distinguishes Internet memes from Dawkins' replicator memes. According to Wiggins [2019], Dawkins' original definition is based on the idea of mimicry, i.e., memes as cultural replicators. In the opinion of Wiggins [2019], the concept is ambiguous, since memes may be ideas, representations, texts or practices and can be spread through different vehicles. Therefore, the concept of meme originating from memetic studies, which precede the advent of online social networks, would not correspond to the practices that are currently experienced from Internet.

While Dawkins' definition emphasizes characteristics such as the replication capacity and longevity of memes, contemporary studies point out the discursive

characteristic and its critical component in the digital context. Therefore, it is possible to comprehend, according to Wiggins [2019, p. 1–2]: "Internet memes as a digital phenomenon marked not by imitation but by the capacity to propose or counter a discursive argument through visual and often also verbal interplay; the emphasis here is on those internet memes which inhere a critical component of society, politics, etc."

Digital culture also favors new perspectives for interacting with the public, which becomes an active participant through comments and shares. Within this context, memes can be understood "as a remixed, iterated message that can be rapidly diffused by members of participatory digital culture for the purpose of satire, parody, critique, or other discursive activity" [Wiggins, 2019, p. 11]. Internet memes, or i-memes, are "a form of visual communication that can appear in different formats: an image, an animated gif or a short video" [Gómez García, 2015, p. 149]. Thus, current memes are digital items with multimodal characteristics transmitted over the internet, which have a socio-discursive activity strongly based on humor [Wiggins, 2019; Gartley, 2022]. They can be considered "a communicational phenomenon typical of digital culture" [Gómez García, 2015, p. 148].

Memes have also been shaped by events, replication, instantaneity, ease of creation, absence of authorship, predominance of the use of images combined with words, parody, satire and social and political criticism [Pulos, 2020; Costa & Albuquerque, 2021; Mortensen & Neumayer, 2021]. The concise information disseminated by memes is enabled by its small structure, quickly read, which allows for rapid reproduction.

In this digital context, the production of meanings via memes is based on multimodal characteristics. Multimodality, according to Kress and van Leeuwen [2006], is an area of study focusing on the forms of communication produced by various semiotic resources, and on how these resources operate to build signs in concrete social situations. In the multimodal context, images are endowed with their own syntactic structure, with codes that convey potential meaning [Kress & van Leeuwen, 2006]. Such images thus enable many interpretations and cannot be considered neutral vehicles devoid of social, political and cultural context. Therefore, memes consist of images that convey this multimodality as a reflection of how individuals born in the digital age interact with each other, bringing to communication, whether verbal or written, the influence of others and their particular way of expressing themselves.

Memes are interpreted in different ways, since each individual adds to the text visual and sensory stimuli internalized from previous experiences. Therefore, the construction of their meanings is influenced by contexts, scenarios and who or how they are visualized. Based on the proposals of Kress and van Leeuwen [2006], three main aspects will be useful for multimodal analysis: patterns of representation (narrative and conceptual representations); patterns of interaction (representation and interaction); and the meaning of composition.

Patterns of representation refer to the visual structures and participants presented in the image, as well as their behavior. The arrangement of the participants may present an idea of movement and causal relationships of action (narrative

representations) or of structural organization established in the image among the participants themselves (conceptual representations).

Narrative representations present "unfolding actions and events, process of change, transitory spatial arrangements" [Kress & van Leeuwen, 2006, p. 79]. The authors point out that: "What in language is realized by words of the category of action verbs is visually realized by elements that can be defined as vectors. What in language is realized by locative prepositions is visually realized by the formal characteristics that create the contrast between foreground and background" [Kress & van Leeuwen, 2006, p. 46]. Conceptual representation, in turn, presents "participants in terms of their more generalized and more or less stable timeless essence, in terms of class, or structure or meaning" [Kress & van Leeuwen, 2006, p. 78]. They can express the idea of classification and grouping, be it in a hierarchical, genealogical or evolutionary way.

Representation and interaction emphasize the relationship/interaction that may take place between the represented participant and the observer/reader, designated as an interactive participant. The relationship between the reader and the image can be defined through four processes: contact, social distance, perspective and modality. Thus, the engagement between the represented participant and the interactive participant depends on the angle in which the former appears to the latter. Characteristics such as the direction of gaze, the positioning of the represented participants (demand or offer) and the attitude of the interactive participants are analyzed in this category.

The third pattern proposed by Kress and van Leeuwen [2006] is the compositional meaning that links the image with representational and interactive meanings through the value, salience and framework of information, which are interrelated systems. These three principles employ "composites that combine text and image, and perhaps other graphic elements" [Kress & van Leeuwen, 2006, p. 177]. The value of information refers to the "placement of elements (...) attached to the various zones of the image: left and right, top and bottom, center and margin" [p. 177]. Salience pertains to the position of the elements, sizes, colors and contrasts in the image that serve to draw the reader's attention. The framework refers to resources that connect or disconnect elements of the image, such as dividing lines, quadrants and others.

Within the digital culture, therefore, memes stand out as a genre that includes these multimodal structures in its composition and dissemination of current information and ideas on the most diverse topics, requiring a look at such characteristics that intersect with the social, cultural and political context. As Guerreiro and Soares [2016] point out, these three patterns within the structure of this digital genre influence the proximity to the observer, his reactions and interpretations, giving the visual analysis the potential to ponder about meanings to be created.

Methodological approach

This research assumes an empirical perspective characterized as netnography or virtual ethnography, whose interest is the study of social practices on the Internet, as well as the senses and meanings constructed for participants [Hine, 2000]. This perspective envisions the Internet as both a culture and a cultural artifact, focusing

on personal experiences and communicative processes established by the mediation of virtual space [Hine, 2000].

Initially, an immersive activity was carried out involving non-participant direct observation for a preliminary search of information, in this case, accounts on the social network Instagram, in Brazilian Portuguese, whose focus was the publication of memes. The descriptor "meme" was used for the search, and 60 pages were identified. The second activity involved netnographic monitoring. The publications of all the pages were read and monitored from March 2020 (beginning of the pandemic in Brazil) to December 2021 in order to build the corpus analysis. To this end, only publications in Portuguese, identified as memes and that provided natural sciences content pertaining to Covid-19 were considered. In the first round, 83 memes were identified. After this initial selection (carried out independently by two researchers — a chemist and a biologist — both with master's degree on Science Education), a new analysis was performed to identify the memes whose scientific content would result in the production of very specific meanings about the message. A total of seventeen memes were selected. In order to increase certainty, the 83 memes were also analyzed independently by two more experienced researchers (a chemist and a pedagogue — both with Ph.D. on Science Education). This process resulted in twelve memes that had also been selected by the first researchers. The corpus for analysis consisted of these twelve memes that showed concordance between the pairs of researchers.

The next step consisted of meme analysis based on the assumptions of the Grammar of Visual Design (GDV), specifically regarding the metafunctions of language: representational, interactional and compositional. The analysis was conducted in pairs, initially separately and individually by two researchers and then validated by the two more experienced researchers who discussed the initial categorization until a consensus was reached. Table 1 summarizes the main aspects considered for each category.

The combination of visual design elements enabled us to establish categories for the messages conveyed by memes. The categories emerged based on the possible meanings to be inferred through multimodal reading, resulting in three groups: i) memes about preventive measures (four); ii) memes about Covid-19 "treatments" (seven), and (iii) memes about how the virus works (one).

The last stage of the research, which consisted of interpreting the results, considered the representation of scientific knowledge about Covid-19 in interaction with the public and its multimodal composition, namely, how knowledge about

Table 1. Patterns and characteristics of the Grammar of Visual Design.

Analysis patterns of GDV	*Characteristics*
Representations (narrative/conceptual)	Analysis of the characters, how they are positioned (the design of social action and social constructs).
Representation and interaction	Relationship/interaction, aspects such as direction of gaze, positioning and attitude.
Composition	Analysis of the environment of the image, its composition and arrangements.

science is represented in memes and its possible interference in the process of constructing meaning. To this end, in addition to the referent GDV, the scientific content represented in memes was discussed, proposing a dialogue involving science communication with other research works that also addressed Covid-19 using digital media.

Results and discussion

As mentioned earlier, the corpus of analysis consisted of twelve memes that were initially grouped into three categories (memes about preventive measures; memes about "treatments", and memes about how the virus works), which are described and discussed below.

Memes about preventive measures

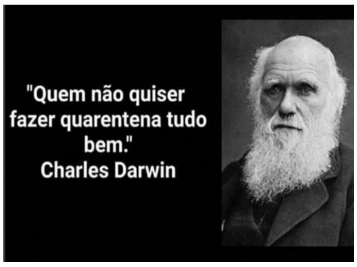
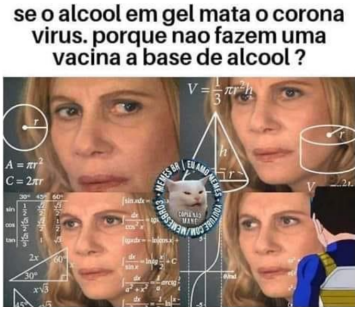
Memes about preventive measures comprise representations about actions widely publicized to avoid contamination by the Covid-19 virus. Two memes were placed in this group, basically referring to the habit of hand hygiene and social isolation (Table 2).

The use of soap was a widely publicized measure to prevent the spread of the virus. In the meme, an analysis of the composition is essential to infer the meanings to be elicited in the interaction with the reader. Goalkeeper Alisson, representing soap (the word "soap" written on the goalkeeper's image makes this idea evident), has his foot raised above a red ball (which represents Covid-19 — also identified by a caption), about to stomp on it. The image occupies the central position in the meme and depicts the ball bursting as a result of this action, in analogy to the action of soap on the virus. Because of its characteristics, soap interacts with the lipid layer that surrounds the generic material of the virus, forming van der Waals interactions that result dissolve this layer, thereby inactivating the possibility of contamination.

Thus, the meme offers a strong representational narrative function conveyed by the action of stomping on and thereby destroying the viral structure (Covid-19). At the same time, features of conceptual representation may be denoted by implicitly demonstrating the scientific concept of soap breaking the lipid layer of the virus (analogous to bursting the ball). The meme develops the interactional function of offering contact (when the participant does not look directly at the reader/observer). Its aim is to produce meaning from the soap's action to beat the coronavirus, without requiring the reader's direct engagement. At the same time, this action can only be understood by means of the conceptual dimension.

The main message of the second and third memes both symbolize the action of social distancing aimed at preventing the spread of Covid-19. The second meme (M2) depicts an image that is little recognized by the general public, concerning the distribution of bosons and fermions. The verbal message combined with the composition of the image enables the reader of the meme to make a conceptual association with the practice of social isolation, which public health agencies and scientific entities recommend as a means to control the spread of the pandemic. Thus, the meaning produced by the image is easily recognized based on the visual arrangement in conjunction with the verbal message, although the properties of bosons and fermions from which the image is derived are not, in addition to being

Table 2. Memes categorized as preventive measures and its descriptions.

Memes	*Description*
	*Meme M1*: the image shows Alisson (Soap), the goalkeeper of Brazil's national football team, who is almost bursting a plastic ball (Covid-19). The meme represents the action of soap in destroying the viral structure of Covid-19. The coronavirus is basically an RNA virus protected by a membrane of proteins and lipids. Because they are nonpolar, lipids are easily dissolved by soap.
 "Protect yourself during this quarantine, be more like Fermions and less like Bosons"	*Meme M2*: this image represents the possible states of bosons and fermions, according to Pauli's exclusion principle. This is one of the most relevant principles in physics, because the three types of particles that make up matter — protons (positively charged), neutrons (neutral particles) and electrons (negatively charged) — must satisfy this principle. The figure shows the standard model that describes two types of fundamental particles: fermions and bosons. Fermions are particles that have half-integer spins and obey the Pauli exclusion principle, which states that no two fermions can share the same quantum state (they are in different quantum states and more "distant" from each other). Bosons have whole integer spins and do not obey the Pauli exclusion principle (they share the same quantum state).
	*Meme M3*: the meme consists of a picture of Charles Darwin on the right and the phrase: "It's OK if some people don't want to quarantine", in reference to Darwin's description of the process of natural selection, in his Theory of Evolution. The message highlights the importance of social isolation as a preventive measure against Covid-19, and serves as a warning to people who do not follow it.
	*Meme M4*: the four pictures of this meme represent an iconic character of a Brazilian soap opera in a moment of mental confusion. At the top is a question: "If hand sanitizer kills the coronavirus, why can't an alcohol-based vaccine be produced?" This disorientation can be seen as incomprehension about the scientific aspects involved in the pandemic, which resulted in the widespread adoption of ineffective preventive measures.

simplified. These characteristics result from quantum mechanics, including the Pauli exclusion principle, according to which two fermions cannot occupy the same state, while bosons tend to gather in the same state, as in the case of laser rays and in Bose-Einstein condensates. An analogy is created between the states that are formed. Bosons, which tend to share the same state, represent agglomeration, in which people cluster together or occupy the same physical space. Fermions, on the

other hand, which do not occupy the same state, represent social isolation, each one in their home, or social distancing, even though in physically close places there would be a state (space to be occupied) by each person.

The predominant pattern of representation is conceptual, since it aims to present the states of social clustering and distancing, in physical terms. As for its interactional function, the meme stands out for its verbal message to catch the reader's attention, i.e., it is a demand contact observed in the use of the verb of imposition: "be", which translates an order to be followed. An underlying meaning of this meme is the double meaning that is produced between the sound of the word "bosons" and "Bolso(naro)" (Brazil's former president is often referred to on social media as "bozo", whose sound in Portuguese is almost identical to boson). On several occasions, the then president did not defend the guidelines established by the World Health Organization — WHO to control the pandemic, and was characterized by his discourse of science denialism [Paes, Brasil & Massarani, 2022]. Like "bosons" that do not follow Pauli's exclusion principle, the president and his followers did not respect the WHO guidelines concerning the mandatory use of face masks and social isolation.

Meme M3, in turn, contains an image of Charles Darwin and a phrase attributed to him. There is an implicit allusion (analogy) to the process of natural selection. Understanding the meme requires knowledge about Darwin and his contribution to science, which is characteristic of the conceptual function. At the same time, a verbal message (occupying more than the half space of the meme) was used to draw the reader's attention to the consequences (natural selection) of Covid-19 contamination. Thus, the narrative representation can also be observed through the cause and effect, as well as by the direction of Darwin's glance. These features denote a reactional process in which an outside participant reacts to the message (the outside participant who looks at the meme and at whom Darwin's glance is directed). People that refuse to engage in social distancing (reacters) would die differently due to their norm-divergent behavior, analogously to the concept of natural selection.

The fourth meme portrays a situation of mental confusion concerning the (im)possibility of producing alcohol-based vaccines. This meme portrays a conceptual process evidenced by the knowledge required to understand the principles of vaccine preparation. The patterns of interaction are especially relevant. The "thoughtful" gaze of the woman is contrasted with that of Vegeta (a famous character from the anime Dragon Ball Z), who appears to be looking directly at her (in the bottom right corner). Vegeta is well known for his grumpiness and sarcasm when he hears unfeasible ideas. Thus, it is possible to infer an implicit social criticism in response to the widespread dissemination of ineffective preventive measures against Covid-19 during the pandemic.

Two types of scientific knowledge are interrelated in the four memes. The first refers to actions, supported by scientific studies of measures to avoid Covid-19 contamination, particularly hygiene and social distancing. Understanding the message in terms of Covid-related knowledge requires multimodal reading with a combination of visual and verbal aspects. Martino and Grohmann [2017] point out that it is important for the message to be composed of a variety of images to which words are added to compose the message. This has given rise to the

representational narrative function, because memes represent actions aimed at avoiding contamination by Covid-19. The second item of scientific insight is implicit and consists of comparisons and contrasts aimed at eliciting a specific conceptual meaning for the reader. The reader's grasp of this conceptual dimension gives it an argumentative meaning, enabling him to conceptually justify the need for the specified actions. Thus emerges the conceptual representational function.

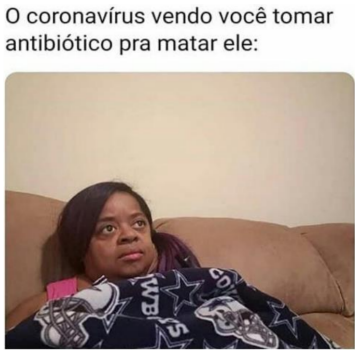
The above leads one to conclude that these memes have two functions, i.e., to communicate (narrate) science and to support its dissemination through conceptual elements. However, the lack of conceptual understanding also poses an obstacle to understanding the message conveyed by these memes. In the case of both representations, which are based on analogy, it is more likely that their conceptual dimension is not perceived outside of a particular group, since this requires a more in-depth analysis, which is not characteristic of social networks and communication through memes, based on the speed of their replication. As part of a mass digital culture, memes can remix and produce new meanings in public understanding and commitment to science [Gartley, 2022]. However, as Dynel [2021] cautions, memes are replicated on social media, so their original meanings may be lost or unintentionally distorted. As a consequence, memes that require critical thinking may be reproduced mindlessly [Ferreira & Vasconcelos, 2019]. This can be particularly worrisome, since social networks have been a vehicle for propagating fake news, creating strong counterpoints to trustworthy scientific news [Brotas et al., 2021; Massarani, Leal, Waltz & Medeiros, 2021].

Memes about Covid-19 "treatments"

The category of memes about Covid-19 "treatments" was the most representative, comprising seven items (Table 3). All these memes focus on the sociopolitical dispute generated by the supposedly preventive action of some medications. They all represent ironic expressions about the ignorance concerning the scientific principles that underlie the use of medicines, particularly hydroxychloroquine and antibiotics to combat the coronavirus, when in fact these are drugs used for other purposes, and there are no studies that prove their efficacy against Covid-19.

The Meme M5 depicts the skepticism of Mrs. Juicy (representing the Covid-19 virus) about its "treatment" with an antibiotic. The narrative function of the image is combined with the verbal message ("the coronavirus watching you take it"), and indicates a critique of the ineffectiveness of this action. The verbal message at the top of the image works as a title, "inviting" the reader to analyze the photograph, and refers to the temporality of the action. In terms of interaction, note that the representation of the virus in the image does not establish a direct relationship with the reader; instead, it is directed toward an internal dialogue, and does not require a response from the reader. However, the title (verbal message) is an invitation to enjoy the message of disbelief and irony. This type of contact is classified by the GDV as a contact offer, since the image and the verbal message do not interact directly with the reader through the participant's gaze, but offer an opportunity to reflect or ponder.

Table 3. Memes categorized as Covid-19 "treatments" and its descriptions.

Memes	*Description*
 The coronavirus is watching you take an antibiotic to kill it	*Meme M5*: the image shows a woman known as Ms. Juicy, a participant in an American reality show called "Little Women: Atlanta", who posted an image of herself on a couch watching TV and became well known when the user @sxturnsailor decided to add a screenshot of a video by @quenblackwell containing the photo posted by Ms. Juicy. At the top is the phrase: "The coronavirus is watching you take an antibiotic to kill it". This meme is used to communicate the feeling of incredulity about some fact. In this example, the figure of Ms. Juicy represents the Covid-19 virus and her disbelief in being affected by antibiotics, since they act against bacteria but not viruses.
	*Meme M6*: this meme represents a *manga* (a Japanese comic strip, which was later adapted to an anime and also originated the commercial game) called Yu-Gi-Oh! This is a card dueling game with two players, who choose cards based on their power to beat their opponent's choice. In this scene, note that two players engage in a duel. The player holding the "chloroquine" card is the fictional character Seto Kaiba, while the player holding the "Protozoan" card is Yugi Muto, the main character from Yu-Gi-Oh! In this duel, the stronger card defeats the weaker one; thus, the "protozoan" card won the "chloroquine" card, indicating that the drug chloroquine is effective in the treatment of diseases caused by protozoans but not by viruses.
	*Meme M7*: this meme portrays a dialogue between three people: "Dad, how did you survive the coronavirus?" "By taking chloroquine and ivermectin as preventive treatment and rejecting the vaccine." "Talking to yourself again, Jennifer?" The black and white scene and the dialogue suggest a disturbing atmosphere and a sarcastic climax.
	*Meme M8*: a prediction about the kind of bullying expected after the pandemic is made in the form of a joke. Bullying in the future: "What about your mom, who used to take medication for lice to avoid being contaminated with Covid-19!" Insulting jokes about mothers are made in social situations, which is why this type of bullying is portrayed. The image refers to the movie White Chicks, in which the characters use this type of joke to insult each other.

Continued on the next page.

Table 3. *Continued from the previous page.*

Memes	*Description*
	*Meme M9*: a man puts on clown makeup gradually to illustrate the dissemination of fake news in text format. The Covid-19 virus doesn't exist... Ivermectin cures Covid-19 in the early stage... Chloroquine helps in Covid-19 treatment... Nitazoxanide cures Covid-19. This time it's for real. LET'S GO FOR IT. In Portuguese, "to look like a clown" is idiomatic expression that means "to make a fool of yourself". The ironic remark indicates that someone who believes in such statements is a fool.
	*Meme M10*: the upper part of the meme shows an image of a Brazilian doctor, Nise Yamaguchi, when a reporter asks her: "What is a virus? What is a protozoan". The lower half shows her running away and the reporter insisting: "Madam, madam?" This led to repercussions after her participation in Brazil's parliamentary committee of inquiry (CPI) into ex-president Bolsonaro's Covid-19 response, when she defended the use of chloroquine to treat Covid-19. However, when asked if she could tell the difference between viruses and protozoans, she was unable to give a satisfactory answer. Chloroquine is a drug used to treat diseases produced by protozoans; hence, it is ineffective in the treatment of diseases produced by viruses such as Covid-19.
	*Meme M11*: this meme depicts a man in a stadium, whose posture and body language suggests someone ready to fight, and a sarcastic remark about the phase: "The dipyrone of SUS (Brazil's Unified Health System) is ready for the coronavirus". Keep in mind that dipyrone is ineffective against coronavirus. The ironical message is associated with the man's physical shape, not in concordance with a fighter.

The "characters" featured in the Meme M6 are participating in a duel typical of Yu-Gi-Oh! There is no centrality and the images occupy identical quadrants, indicating they are equally important. In this case, the scenes should be read sequentially, from left to right, following the idea of narrative temporality. With regard to the interactional category, the participants that appear in the four scenes of the meme appear in close-up in two scenes, prompting what GDV considers social proximity to foster intimacy with the reader. The "protozoan" card is enlarged and appears in the foreground, emphasizing this information. At the same time, the character's gaze is directed at the reader, in an attitude that highlights the "played" card.

In scientific terms, both M7 and M8 memes reveal narrative representations about the consequences of using ineffective drugs for Covid-19. Nevertheless, the reactional process of the participants differs considerably. Meme M7 shows a scene in which a father and his two children are talking to each other. The last sentence indicates that father is not really there, since he took hydroxychloroquine and ivermectin instead of taking the vaccine against coronavirus. The man is looking away, indicating that he is far from there (dead). The narrative representation is associated with the consequence (death). The image in black and white represents a "dark" and poignant atmosphere that should cause the reader to reflect. The subsequent meme (M8) underlines a joke also aimed at criticizing the use of ineffective drugs. Most of the image represents people laughing about the joke described in the text. The reactional process is less serious and invokes irony.

In meme M9, the texts on the left are followed by pictures on the right. The meme is divided into four steps representing the process of a person putting on clown makeup. The interactional characteristic is between the left side (information not supported by science) and the right side (person turning into a fool/clown). The narrative representation is predominant and displays an action process whereby the participant makes a fool of himself through his statements. The central meaning is to criticize distrust in science, thereby criticizing people who believe in such statements (and thus make fools of themselves) despite the proven scientific results and guidelines.

The centerpiece in meme M10 is the figure of Brazilian medical doctor Nise Yamaguchi being asked a question by a reported and then running away from her. During her testimony in Brazil's parliamentary committee of inquiry (CPI) into Covid-19, she failed to give an answer when asked to differentiate between viruses and protozoan. The analyzed image can be defined as a non-transactional action, i.e., one in which the participant reacts to a phenomenon not depicted in the image, to something undefined [Kress & van Leeuwen, 2006]. Thus, the action of running implies events outside the image. In addition to scientific knowledge, the situational awareness of historical moment of the CPI and its events is central to the production of meanings.

The intent of the last meme (M11) is expressed by the body language of the participant at the center of the image, and the verbal irony serves as a kind of title aimed at drawing attention to the image, similar to the first meme of this category. It should also be noted that the look on the faces of all the participants is of the contact offer type (when the participant does not look directly at the reader/observer), but is waiting for something external to the image (the viruses to be fought). As can be seen, this meme conveys both a sense of humor and a critical meaning. The humor lies in the physical appearance of the central participant, which is inconsistent with that of a well-prepared warrior. Its interpretation requires the articulation of semiotic and linguistic signs, as well as the exploration of concepts that go beyond the message, the image and the humor produced by it.

In all the memes, the better understanding of the message and, above all, of the ironic tone, requires scientific knowledge. The reader must be aware, for instance, of the fact that antibiotics are drugs used for the treatment of bacterial infections, and are therefore ineffective in fighting the coronavirus. Again, this denotes a hybrid between the narrative and conceptual functions. In this case, the conceptual

function is used as a basic foundation of argumentation for the interpretation of the actions, which adopt a sarcastic tone to criticize the use of drugs that are ineffective against Covid-19. Equally important is the social historical context, since to interpret the message requires the awareness of current situations or circumstances that prevailed in particular moments and contexts. In this way, the reader may feel encouraged to seek this knowledge in order to understand the underlying irony (this is a possibility of memes, including a teaching context, encouraging the expansion of knowledge triggered by the curiosity they arouse).

However, this category reveals another dimension that is difficult to overcome only in the face of scientific (dis)information. This is the anti-science or post-truth movement that has spread throughout social media, as described earlier by other authors [Albuquerque & Quinan, 2019; Casero-Ripollés, 2020]. In their specific investigation into the discourse about the use of hydroxychloroquine on Twitter posts, Ortiz, Brotas and Massarani [2020] reveal a basic lack of knowledge about science and its workings that leads to unfounded opinions, which are sometimes expressed using contemptuous and insulting language to disqualify the findings of scientific studies and recommendations based on them. The authors point out the political bias that was generated around the theme, disqualifying scientific arguments. Yeo, Cacciatore, Su, McKasy and O'Neill [2021] state that humor has been an effective means of reaching a wider audience, but the resulting effects depend on the knowledge of individuals.

Disinformation, due to a simple lack of access or political ideology, is an inevitable consequence of the contemporary world. When one thinks about the field of public science communication, one must keep in mind that memes express a socio-discursive approach that is usually implicit and based on critical argumentative (de)construction. Therefore, to enable the expansion of meanings about science, one must think about ways to instrumentalize the public so that it can analyze these posts, in view of their characteristics. According to Costa and Albuquerque [2021], analyzing aspects of irony, humor, comparing posts, and even encouraging the production of memes, which are strategies that convey a playful content, can help minimize this harmful phenomenon by circumventing a direct clash that stirs up ideological emotions and may be ineffective.

Meme about how the virus works

The only meme in this category portrays biological aspects of the virus, particularly its genetic mutation (Table 4). The meme comprises numerous images representing the virus composed of the face and expressions of the former Brazilian president Jair Bolsonaro, which confers human attributes to the Covid-19 virus. This resource is very common in memes, indicating the conscious intentionality of the agent of the action [Dynel, 2021; Costa & Albuquerque, 2021].

As for the conceptual representation, the meme imparts the idea of mutation metaphorically by demonstrating the changes in feelings through the various facial expressions, as well as the text at the bottom. The visual and verbal text associate the former president to the problems caused by the Covid-19 pandemic. In the interactional process, the contact is classified as a demand (when the participant addresses himself directly to the reader/observer). This plays a role in the

Table 4. Memes about virus's characteristics.

Memes	*Description*
	*Meme M12*: the image in this meme conveys humor through sarcasm and strong political criticism. The written message in this meme, "Beware of the new variants of the virus!!", clearly implies that Brazil's former president is a virus.

production of meanings, since scientific knowledge (about how mutation occurs and why) is not essential for the message, like in the memes analyzed above. The sarcastic and humorous tone prevails as a sociopolitical criticism about the actions, speeches and behaviors of the president that have been changed according to interests during the pandemic. Saint Laurent, Glăveanu and Literat [2021] highlight memes as intrinsic and partial narratives of a more complex story. In this case, the broader story was the role of the president in dealing with the pandemic. Particularly in Brazil, important political figures such as the former president and his allies, constantly expressed their disapproval of the guidelines of health organizations regarding the use of masks and social gatherings, not only through social networks but also through their behavior [Paes et al., 2022]. This has contributed to the alarming rise in science denial and the proliferation of fake news.

Final remarks

Monitoring posts on Instagram revealed the strong presence of the digital meme genre in the context of the Covid-19 pandemic. However, upon following accounts that posted memes almost exclusively for almost a year, it was found that only a small portion of them related Covid-19 to science. Only twelve memes out of a universe of 83 identified (14.5%) presented knowledge about science interdependently with meanings that could be produced. Although the twelve memes may be seen as a small data set for analysis, this indicates that despite the high circulation of memes as social or political criticism, as other studies have shown [Chagas et al., 2019; Gartley, 2022], science has played just a minor role in criticisms from memes in the pandemic context. This may suggest that it is difficult to use scientific information to produce the effects of ambiguity, humor and criticism characteristic of memes, given that the production and desired effects of this type of genre require reliable scientific knowledge.

One of the core aspects is the complexity of representations in memes about Covid-19, introducing the elements of humor, irony and sarcasm associated with social and political criticism through different multimodal interactions. These memes produce a variety of effects, including the recommendation of prophylactic measures (such as proper hand washing with soap and water, the use of face masks, alcohol gel and social distancing), criticism of arguments touting the use of ineffective medicines, the antiscience movement and social agglomeration. Given that memes are created based on social events, prior knowledge of these events is essential for the production of meanings about their message. In general, there is an implicit narrative within a more complex story, as also evidenced by Saint

Laurent et al. [2021], rendering the meanings produced interdependent between general knowledge about social events, more specific knowledge about science and multimodal analysis.

From the standpoint of scientific knowledge transferred through memes, it was found that this was achieved predominantly through figures of speech, particularly analogies and metaphors, particularly evident in conceptual representations. Such resources are probably related to the character of irony and humor that memetic language seeks to impart to the message. Furthermore, the findings indicated that memes with characteristics of conceptual representations require prior scientific knowledge to produce broader meanings (in the case of memes M1 to M6). As for memes whose narrative representation contains more evident scientific knowledge, the message does not depend solely on understanding science. This is an important finding concerning the understanding of science communication through memes, which may have consequences for educational practices. Later studies will be able to analyze the comments of users of social networks after reading these digital genres, as well as specific practices in a school setting. Expanding the sampling of memes for analysis is also important in order to obtain more comprehensive findings about their characteristics.

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