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Letter to The Editor

Accessibility of Astronomy Journal Papers

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Abstract

The Working Group on Accessibility and Disability (WGAD) of the American Astronomical Society published a list of accessibility recommendations for professional astronomy journals. Critical discourse analysis (CDA) tools were used to analyze a sample of 256 astronomy journal articles for discourse modes, including usage of linguistic indicators, digital architecture, and information display. Our analysis found that discourses in astronomical publications were typically constituted with the expectation of various shared commonalities between the author and the reader including: 1. sensorial modality of interaction; 2. experiential knowledge; 3. access to information; 4. linguistic knowledge; 5. cognitive strategies; 6. socioeconomic status and background. These findings may serve as a baseline for future studies on how inaccessible textual discourse, digital architecture, and digital display in STEM journals enhance professional inequalities. Examining how current standard journal standards impact the transition to different professional career stages could help to identify alternate discursive strategies for improved accessibility.

Keywords: Accessibility; Accessible Digital Interphases; Scientific Inclusion; Scientific Journals.

Introduction

This paper examines the presentation of knowledge within astronomy. The field represents an interesting case study given that it seeks to attract diverse audiences, while also employing a linearized perceptual discourse; meaning that there is a linear relationship between the perceptual discourse used to perform in astronomy and the perceptual methods used to present this field to the "diverse" audiences "sought". We need to ask whether it is acceptable if people express a fascination for astronomy, but then stay away because of the mathematics, the physics and its associated ways to convey the information. Astronomy is a child of physics; as such it rests heavily on mathematics. People interested in pursuing astronomy professionally must cope with the information in a uniform way. Being human allows us to have imperfect knowledge in many fields, including of course, in mathematics, physics, and their applications. During the preparation of this document, it came to our attention that the practices of information exchange in all aspects of STEM science, including academic preparation and especially in mathematics in higher education and the sciences in school classrooms, may prevent a majority of people from participating in the discourse on astronomy. Over the past 100 years, humanity has witnessed a change of overall mindset, toward the naturalization of the inherent human right to equal and egalitarian participation in the mainstream.

How did the self-presentation of astronomy become predominantly visual? A protracted literature search suggested that the lack of perception experiments (applied to astronomy data analysis), the development gap caused by the approaches to knowledge, performance, and production styles in the job market as machines were integrated into research, accompanied by the halted development of audio technologies (as compared to visual technologies) and its application to human factors, all contributed to a diminishment of forms associated with other types of sensory experience and the prevalence of uniform ways of conveying and analyzing astronomical information. Diaz-Mercedand Diaz-Merced, Schneps, and Pomplum[1] investigated whether visual modalities were better than other sensorial modalities for the exploration of astrophysics data through perception experiments and found that the use of sound increased the sensitivity of the expert astronomer to events in the data that by nature are blind and/or ambiguous to a human eye. Yet, before and after 2020, when the European Gravitational Observatory, under the direction of Dr. Stavros Katsanevas, pioneered the exploration of sonification, the use of sound has not evolved in the way that traditional visual displays have. By the same token, if funded, and even though there is no strong evidence regarding the effects of sonification for learning[2], funding agencies tend to support sonification for usage in education and outreach, but rarely for data analysis. There is no experimental evidence (for astronomical information) to support why the field ceased using other sensorial modalities for mainstreaming. This leads to the question: why have physics and astronomy continued to use the same, uniform, digital, human cognitive, expressive, reflexive transactions, and interactions? This may be due to lack of experimental evidence, the learning curve, the slow progress of audio resolution, or uniform learning methods (k-higher education), among others. However, it is certainly now clear that most sighted people use their eyes to make sense of their world, and that this is the prevalent human sensorial modality used to make conscious sense of astronomy knowledge during research tasks.

Regarding the core question of academic communication in journals, in 1989, the International Astronomical Union (IAU) published guidelines on how to prepare astronomy papers and reports[3]. The document crafted for "electric type written with carbon ribbon", and for camera ready documents, discourages the use of "footnotes, short, simple sentences and to avoid unusual words" among others. The document provides a list to review for errors in the camera-ready manuscripts. "Errors in numerical values…, errors in references…, errors and ambiguities in formulas as well as on designation of astronomical objects…or omission of the units…errors in grammar mistakes". Even though accuracy in mathematical proof is critically important for progress and credibility in physics and astronomy; grammar mistakes is the only error highlighted with consequences. It is important to note that a grammar mistake is the only error that may be addressed by editors and the only error that directly impacts peoples with certain types of impairments/disabilities, linguistic under represented individuals and economically disadvantaged astronomers trying to keep active in the field. Explore the quote:

"Errors in Spelling and Grammar: these may not appear to be important, but their presence is often indicative of a lack of care in the preparation of the report[3], and they may be taken to be indicative of a lack of thoroughness in the investigation to which the report refers" (p. S15). This quote was retrieved from the Rules, Guidelines and Instructions for Proceedings for authors and editors on October 19, 2019. Unfortunately, the document is an image which does not allow for the use of screen reader and audio access.

The majority of terms used in the science of astronomy and physics have no equivalent in contemporary American Sign Language. A major international effort, supported by the IAU and involving Deaf communities (in many countries) has begun studying the question at the Instituto de Tecnologías en Detección y Astropartículas (ITeDA), using CNEA, CONICET, and UNSAM, in Mendoza, to generate the first comparative list of astronomical terms in sign languages. Physicists and astronomers with reading and/or language impairments, who are visually impaired or blind or have other cognitive/physical and/or neurological impairments/functional diversities, may unknowingly commit grammar mistakes not related to their quality as researchers. In recent years, journals like the "American Astronomical Journal" have tended to show flexibility toward such errors by directing authors to companies that provide editing services.

This paper suggests a pragmatic approach to exploring whether there is any relationship between discourse configurations at scientific journals in astronomy and the presence of inequality in those fields focusing on peoples with disabilities. Our framework begins with the hypothesis that the aspects that shape inequalities in the classroom (higher education) are linked to the configurations of the discourse, which in turn may be linked, directly or indirectly, to the

inequalities that are existent in the professional sphere. This examination takes the form of a case study, with the science of astronomy as a child science of physics and staged on mathematics. We suggest that discourse analysis may be applied to reveal whether discourse configurations used in astronomy are supportive of diversity with disabilities and/or impairments in the field.

The structure of this paper is as follows. After the introduction, the reader will find a debrief of the World Wide Web accessibility guidelines (WCAG 3.0), following which the reader will find our methodological approach: Critical Discourse Analysis. We then explain our methodology and the materials employed. Subsequently, the reader will find the results of the linguistic analysis of astronomy papers. To contextualize, we present an analysis of the astronomy higher impact factors author guidelines. We then present our conclusions, possible next steps and the references.

Background: Web Content Accessibility Guidelines (WCAG) 3.0

According to the W3c webpage "The Silver Task Force / the W3C Silver Community Group / or taskforce (link at references) are performing the preliminary work for the successor to the Web Content Accessibility Guidelines (WCAG) 2. The guidelines will be named W3C Accessibility Guidelines (WCAG) 3.0 which reflects the anticipated broader scope beyond web content, but preserves the familiar acronym of WCAG." WC3[1] and W3C Silver[6].

The web accessibility guidelines collaborators have been working thoroughly to establish guidelines to meet the needs of peoples with disabilities at individual aspect/functional needs. On the WCAG 3.0 draft W3C Silver[6] WCAG has worked extensively to go beyond the yes-no success criteria commonly carried by developers. Still, WCAG discourse is subjective risking for its guidelines to be assumed as suggestions.

It is uncertain to find exactly the real number of countries listed online having laws for digital accessibility and if those laws may be realistically enforced. Many webpages list different numbers. 9, (Akinyemi 2022)[4]. 29 (France, Italy plus 27 countries in the European Union), according to the WCAG[4]and W3C[5] and 15 with laws or acts not based on WCAG W3C[5]. Of those countries the ones under the European Union (27), France and Canada may serve as example of explicitly detailing enforcement procedures (Level access 2022)[6]. The authors of this paper expect there are more. The authors of this paper underline strongly that we are not questioning WCAG as a legal mandate or assuming that it is a legal mandate. WCAG are just recommendations. The authors are pointing that the majority of countries reported on the WCAG page base their digital access laws (or acts) on WCAG. The combination of the subjective language of accessibility guidelines with a lack of high granularity metric of success and the chance of impossibilities for users to enforce realistically equal access to digitally displayed information may at some point hinder the voice of the person with disabilities producing more inequities. Critical discourse analysis offers a view to evaluate in an unbiased way the effects of those discursive approaches to participation of peoples with disabilities in the field of astronomy.

Experimental

Methodological approach: Critical Discourse Analysis

Discourse is not political or interpersonal alone. Intra-personal exchange, facilitated by the process of thought that directly links to identities and individual contexts, is crucial to power dynamics. Why should a discursive approach be taken to explore inequalities in astronomy as a case study? Relations and identities[7], together with the dynamics of power, are elicited in a field of practice that is unbalanced, crossed by relations of gender identity, ethnicity, disability, theology, sexual orientation, age, generation, and socio-economic status. We needed a methodology that would permit to explore over a very limited timeframe, whether a relationship exists between professional journal interactions and inequalities in astronomy as a field of practice. Critical discourse analysis (CDA) offers a flexible framework within which to relate aspects of textual discourse to the presence or absence of inequalities. We use CDA to build a framework and to possibly suggest mechanisms with which to test it and to use it in the field.

Constantly evolving external factors or social phenomena constantly influence human life[7,8]. For those with disabilities, these are not limited to the provision of assistive technologies. As Thomas Shakespeare says: "it is important to take into account the situations caused by the impairment and the barriers imposed by the discourse of the social organizations, and compensate for the limitations generated by both"[9]

On Critical Discourse Analysis and Digital Technologies

CDA focuses on the structure of the discourse to approach social inequalities. According to Tshelane *et. al.* 2022[10,11] it establishes an analysis for the identification of "structures, strategies, or other properties of text, talk, verbal interaction, or communicative events, playing a role in the

reproduction and challenge of dominance"[10]. It takes into consideration the social conditions that must be met to elicit the (re)production of social inequality in its societal and institutional aspects (among others).

Other forms of discourse analysis have been applied to the analysis of digital interphases. For example, Thurlow et.al, 2011[12], focus on digital discourse in terms of written expressions from a socio-linguistic perspective, addressing technologies such as "instant messaging, text messaging, blogging, photo-sharing, mobile phones, gaming, social network sites, and video sharing"[12]. Other forms of discourse analysis have been used in the medical sciences to explore effective communication between doctor and simulated patients.

The specific usage of critical discourse analysis techniques to explore access to digital interphases targeting digital accessibility and its possible extension to the existence of inequities hasn't been fully exploited yet (to the knowledge of the authors) and deserves deep consideration. Our paper innovates because it uses critical discourse analysis to focus on possible effects of discursive methods on disability. It departs from the position of awareness/concern/resistance expressed in the Working group for Accessibility and Disability paper.

Methodology

In 2016, the Working Group on Accessibility and Disability of the American Astronomical Society published an experience-based document calling for equal access to journal articles (WGAD 2022)[13]. This event was of critical importance for professional progress, as it would be in any science. The document expresses the voice of professional astronomers and graduate students, most of whom live with disabilities, asking for equal access in journal access. In the context of this paper, professionals are people who are paid to perform the mainstreaming of the science of astronomy. The participants asked for things such as: constancy in presentation, simplification of text, alternate ways to present mathematical formulas, and so on. All of these items are discursive strategies suggested to allow receivers to be able to consume information. The suggestions range from targeting architectural display to aspects directly affecting comprehension and evaluation of information. The document was supported by others who are part of other professional communities (disability specialists, those working in university disability services, and others).

This paper presents a categorical analysis of academic publications to determine those aspects that influence or do not influence access inequalities (i.e. is the effector an institutionalized mind frame or does the effector originate in the user?). We perform an exploratory, longitudinal approach to discover the factors in the publication of articles that may be linked to accessibility inequalities. This is done by grouping enabling and disabling strategies in astronomy papers into identified factors, and contrasting them to the emergent categories of the WGAD document.

The analysis is carried out using the IAU regional meetings proceedings. The proceedings of the IAU General Assembly are meant to reach audiences in diverse settings and that are potentially faced with limitations in access to information, even when performing professionally. At the time of the compilation of the sample papers, the authors of this paper found only two proceedings available.

The authors asked people with disabilities to check the digital and discursive accessibility of a small sample of these papers. The users with disabilities reported accessibility issues pertaining to the online access of PDF documents and access to PDF documents off-line that were synchronous. Note that, not all of the proceedings were reviewed, due to time limitations. The authors took two proceedings as a sample (APRIM 2014 and LARIM 2019; LARIM 2019 was discarded because it was not a scientific paper, but an eight-page report). The authors concluded that the samples available and that were analyzed between July, 2019, and November, 2019, were representative of the accessibility practices in the latest proceedings found in the IAU digital database.

The authors of the WGAD paper were professional astronomers and graduate students, who share a predisposition to the frame of mind of contemporary astronomy or are already involved in the field. The motto of the International Office of Astronomy for Outreach is "Astronomy for All" and, given the uneven and unbalanced access to information in high- and low-income countries, papers for the IAU General Assembly are written by undergraduate, graduate students, amateurs, specialists in education and outreach, and professional astronomers from all over the world. The authors established a stage of communication that targets this audience, but does not infantilize or oversimplify information. Instead, it renders it understandable by an undergraduate with limited access to information and vocabulary. We suggest that the stages be defined on a continuum from advanced beginner to competent scientist. For the purposes of this paper these are defined as follows:

1. Advanced beginner: a person that can begin to trouble-shoot problems and work on their own. An advanced beginner can identify differences between different contexts, move through layers of examples, and apply that information to approach knowledge or a problem. Individuals manage their way through the many plateaus and extended periods of practice that occur in the learning process (recognizing contextualized concepts and working through them to extend them to other contexts).

2. Competent person: can develop rules about what to apply and when. This kind of person has a better sense of what is relevant and what is not. He or she can recognize concepts from context without needing to invest the time to extend them to other concepts.

3. Expert: performs consistently at a higher complexity, tasks that can be administered to any subject[14].

Contradicting the IAU announcement and following 31 General Assemblies and more than 300 symposia held over the course of the history of the IAU, by the end of 2019, only two conference proceedings were available in the IAU repository when we prepared this article. Because it is cumbersome to access journal articles in PDF format online, this paper focuses on identifying scaffolding strategies, evolving from generalization to the specificity of content (provision of context before giving detail) to the novice and competent performance aspects defined earlier. A total of 256 papers were analyzed: 187 papers (the entire proceedings) from the Asia regional meeting APRIM 2014,(Proceedings Korean Astronomical Society 2015)[15] and 69 papers (the entire proceedings) of the proceeding of the Latin-American meeting (LARIM 2005) [16]as these were the only ones available.

Exploring the different strategies in which the objects (the themes, ideas) are constructed and contrasting these with the emergent categories of the WGAD document, we may be able to consider how and whether the professional discourse in scientific journals is exclusionary. This should be done because this may help to trace implications (i.e., possibly hindering progress from the advanced beginner or competent phase to expertise). Using categorical coding, we extract factors from the construction of those objects and their digital display. These factors can help us research the origins of any possibly identified effect.

An interdisciplinary team of science high-school educators, linguists, and professional astronomers took part as raters. Through discussion, the raters agreed on a scale. Individually, each rater evaluated the content and digital display of the articles (see a description of the scaffolding below). The categories emerged by classifying the scaled content and expectations into categories targeting or not targeting a certain type of audience or forcing people to meet certain expectations in order to be able to understand or write articles. We analyzed the recommendations contained in the document written by the WGAD to identify emergent categories describing problematic situations when accessing the articles: "procedural recommendations, navigation, content, layout and style, multi-modal access, graphs and charts"[7]; from those recommendations, we identified which of the strategies in the proceeding papers addressed the emergent categories. Finally, and to begin to track the origin of any effect identified, we classified the author recommendations for journal access in the WGAD publication, and the higher-impact-factor astronomy journals (relating discursive practices identified in the WGAD paper to discursive activities carried out by journals).

Materials

The examined documents were as follows:

A.1 Annual Review of Astronomy and Astrophysics (University of Harvard), impact factor of 33.069

A.2 Living Reviews in Solar Physics (Springer), impact factor of 5.2

A.3 Astronomy and Astrophysics review (Springer), impact factor of 15.143

A.4 Author guidelines for submission to the International Astronomical Union

A.5 Proceedings of Regional Meetings (LARIM 2005, APRIM 2014)

We examined 256 articles from the Proceedings of Regional Meetings. Of those 256, we discarded those for EPO. We studied 2005 and 2014 because these years were the only ones available at the IAU repository at the time of this analysis. These documents also fit the following inclusion criteria:

- Cost-effective access to proceedings, if the person accessing them has access to digital technology and the internet. Only two sets of proceedings were available.
- Proceedings are unedited, providing us access to natural written discourse. As these articles are submitted to meetings as abstracts and reviewed by a scientific committee, and the proceedings are paid for by the IAU, any effect identified may be extrapolated to the funding organization.

- Observe whether any strategies have evolved over time inside and across divisions (as the articles do not provide biometric information this was impossible to assess).
- If the previous point is possible to pursue, then associate any possible strategy to the existence of initiatives at national or international level.
- International representation of global astronomy practices.

Tools for linguistic Analysis

The Executive Committee for Women in Astronomy was established in 2003 and the WGAD was established in 2012, and this discursive action may be associated with changes in the discursive methods of journals. As a result, we expected to find a relatively large number of articles that reflected not only differences by gender (more articles by female authors and greater gender neutrality in writing and redaction) but impacting people with disabilities. Here, we do not analyze in detail; rather, we consider the expectations reflected by the scaffolding structure of the science conveyed and displayed.

We used the linguistic attributes that have been identified to support readability[17, 18] in semantically complex information presented in the sciences. According to Lu et al. [19], semantic and lexical complexity is expected from scientific authors who are seeking to publish papers. In our case, the lexical complexity is directly related to the semantic complexity, and meaning is built from experiential interactions. For this reason, we considered the assumptions and expectations reflected by the semantic complexity present in the reviewed articles.

The NVivo software[20] was used to identify the linguistic attributes of the 256 papers, using the Van Dijk classification to separate them as indicators that may point to the linguistic strategies commonly used in science writing to expand and support a bottom-up, top-down, combined-scaffolding approach. Semantic complexity and the scaffolding of lexical complexity were also examined, using examples of bottom-up, top-down and combination of bottom-up-top-down scaffolding conveyed through argumentation, structural representation and semantic content. The indicators suggested by Hardy and Phillips[21] were used to identify strategies to build concepts using bottom-up or a combination of bottom-up and top-down approaches to create concepts or knowledge communicated in the papers. A metric was used to scale whether the indicator supports meaning in a top-down approach, whether it supports meaning by combining top-down and bottom-up methods or whether the indicator does not support meaning (assuming linearized knowledge of meaning). The examples were evaluated in terms of contextualization, the expansion of the definitions, and the expansion of content inside the aspects of expertise targeted in this paper and the use of linguistic strategies outlined below.

The reader should recall that papers are required to convey innovative findings and, for instance, new knowledge. Additionally, we used the NVivo software to search for the words identified in the discursive analysis of Van Dijk as evidence of those indicators and sought for linguistic subordinating and the superlative and negative strategies attached to those indicators.

Once the linguistic indicators where identified, we went to the articles, and one by one (word by word), we verified the context, root, and pedagogical use of each of the words linked by the NVivo program to indicators of grammatical and semantical content in sentences and paragraphs.

In Table 1, we provided linguistic indicators to identify words associated to these indicators; according to Van Dijk, these are:

- Comparisons discourse
- Contrast discourse
- Invitational discourse
- Example discourse

Two independent raters evaluated the papers. A scale was defined and tested for validity and reliability after inter-rater reliability was established. The two teams of raters are described below:

- Rater 1: Astronomy PhD and high school educator. Screening criteria: Astronomer with more than six mainstream astronomy research papers published after finishing PhD and performing as a high-school educator. It was required for the educator to be licensed in the teaching subject and for the licensing to require the completion of a pedagogical preparation module.
- Rater 2: Linguist, employed in higher education with more than six mainstream postdoctoral papers published on discourse; the PhD was complete.

The raters only met once, using Zoom software, and performed the evaluation independently.

Table 1. Linguistic indicators

Comparison	Contrast	Invitational	Example
Like	In contrast to	Participation	For example
Likewise		Invite	Probably
Same as		Get in touch	Viable
As well as		Suggestions	We estimate
Also		The support of	
Too		The help of	
In contrast		Point of view	
As opposed to	As opposed to	Available	
Different from	Different from	We estimate	
Whereas	Where as		
Unlike	Unlike		

In the following, the scale used to identify the use of linguistic indicators is provided, as created by the multidisciplinary team of raters. The scale is a 3-point scale beginning at 0.

- 2: Supports meaning with a top-down approach, i.e. it expands the use of examples flowing from general examples to particular ones and comparisons (relative to the aspect of expertise targeted in the document).
- 1: Supports meaning with top-down and bottom-up methods, i.e., its language expands, making use of example-flow from general examples to particular examples and comparisons, sensorial expressions, and the gradual removal of the scaffold (relative to the aspect of expertise targeted in this document).
- 0: Does not support meaning scaffolding (it assumes linearized knowledge of meaning, of specific words, and of untranslatable words).

Results and Discussion: Astronomy paper evaluation results

Using the scale, raters found that 100% of the articles did not use top-down methods. Bottom-up methods were present in .05% of the articles, in the form of definitions. Invitational linguistic strategies were present in 0% of the articles, and comparisons were not identified. Example attributes were identified in 100% of the papers. Of those, 0% were employed in top-down or a combination of top-down and bottom-up approaches for the scaffolding of the presented innovation. The examples were evaluated in terms of contextualization, the expansion of the definitions, and the expansion of content inside the aspects of expertise targeted in this paper and the use of linguistic strategies defined in subsection 5.1.

We analyzed the semantic constructions of the definitions resulting in a 100% lexical complexity. Lexical complexity is measured in terms of familiarity (frequency of exposition to a word under circumstances of uneven digital and book access) and etymology (word origins and historical formations may contribute to complexity, as meaning may be inferred from common roots). Thus, raters estimated that example indicators did not exist in the articles reviewed. These lead to 0 existence of 0% of presence of multi-modal linguistic strategies and contextual linguistic strategies (Table 2).

The Cohen-Kappa reliability, adjusted for chance, was 87.3. This is considered a good agreement between the raters[22].

In a second step of the analysis, based on previous findings, the raters examined how each paper constituted its themes. Raters found that this was done according to the following expectations:

1. Same sensorial modality of interaction as the authors,
2. Same experiential knowledge as the authors,
3. Same access to information as the authors,
4. Same linguistic knowledge as the authors,
5. Same cognitive strategies to build knowledge as the authors, and
6. Same socioeconomic status and background as the authors.

The categories emerged from classifying scaled content and expectations into categories targeting one kind of audience or forcing people to meet certain expectations before being able to understand or write articles.

As a third step, even though categorization is based on possible author expectations, we evaluated the digital presentation and support of the content. In the articles examined, 100% contained examples (see above), 100% contained

footnotes, 0% contained generalizations (relative to the aspect of expertise targeted in this paper), 0% contained data for presented charts, and 89% contained definitions not attached to examples (relative to the aspect of expertise targeted in this paper). Of the latter,0% were employed for top-down or a

Table 2. Linguistic strategies in astronomical papers

Papers read 256	Top-down	Bottom-up	Example indicators	Top-down and bottom-up (combined)	Example attributes	Multimodal linguistic strategies
Rater 1	0	1	0	0	0	0
Rater 2	0	1	0	0	0	0
Total	0	2	0	0	0	0
%	0	.05	0	0	0	0

combination of top-down/bottom-up strategies for the expert scaffolding of the presented innovation. The scaffolding was evaluated in terms of contextualized definitions and usage of terms. We analyzed the semantic constructions of the definitions resulting in a 100% lexical complex of definitions. Lexical complexity is determined by many factors and is very difficult to study.

For example: frequency, length, morphology, etymology, ambiguity. In our case, we paid attention to how often the reader would encounter a word and the cognitive load required to understand a word in context. For that reason,

we estimated that example indicators were generally not present in the articles reviewed. Sensory motor representations were absent textually and as an online support in 100% of the articles. The translatability/transportability of words, referring to equivalent textual methods, judged according to accessibility for the stages of expertise of this paper, were absent in 100% of the articles evaluated.

The display architecture was constant across all documents in terms of header positions: title, abstract methodology, discussion, results, acknowledgments, and references. In all, 100% of the documents failed to include the elements identified in Table 1 as indicators of constancy of display, accessibility to screen readers (i.e. tagging, description of formulas and charts, navigation through different parts of the article, and orientation), voice interaction, color-blind options, dyslexia-oriented fonts and sizes, multisensorial display, and so on.

The science was displayed as unimodal, mono-sensorial, uniform, and linear-functional. The linguistic strategies found in LARIM (2006) and APRIM (2014) were uniform, with a total of 256 articles being constituted as being opposed to multimodal inclusive discursive strategies, as indicated by the WGAD article. Finally, to track the origin of any effect identified, we classified the
recommendations for journal access included in the WGAD publication, the Astrophysical Journal,

the Royal Astronomical Society and the IAU guidelines for proceedings.

Analysis of Guidelines

We categorized the recommendations provided in the WGAD document for journal accessibility and compared them with the guidelines of the Annual Review of Astronomy and Astrophysics (University of Harvard), impact factor 33.069; Living Reviews in Solar Physics (Springer), impact factor 5.2; and Astronomy and Astrophysics Review (Springer), impact factor 15.143. These journals have the first-, second-, and third-highest rankings, respectively, according to the Scimago Journal and country Rank (2022)[23].

It should be recalled that the WGAD recommendations were written by professional astronomers and students in higher education. We classified the strategies recommended by WGAD to the inaccessibility challenges faced by readers as follows:

a. Digital display
b. Contextualization
c. Cognitive access to content and digital display
d. Information display
e. Digital constancy
f. Semantic content
g. Inaccessibility to information architecture
h. Sensorial representation contextualization

Following these points and the results given above, the guidelines for each major journal were carefully examined. As a result of this consideration, we established the following.

The Harvard recommendations for authors;

a. Do not offer editorial support, whether in the form of links to sister companies for editing or on the page.
b. Do not require disability access features for any of the aspects mentioned by WGAD.
c. Do not mention any requirement for data to support charts in multimodal sensorial display of information.
d. Do not offer recommendations for digital, content access.

d.1. In terms of content.
d.2. In terms of disability access.

e. List as optional the submission of:

e.1. Multimedia.
e.2 "Terms and definitions lists, defined as providing definitions for as many as 20 of the most important abbreviations or key terms, limited to 20 words maximum".[24]
e.3 Summary points lists: highlighting the central points of the review.
e.4 Future issues lists: noting where research may be headed.
e.5 Related resources list of materials not listed elsewhere in the paper.

The Springer recommendations for authors;

a. Do not mention recommendations for disability access features.
b. Do not require multimedia content.
c. Do not mention a requirement to provide data to support the charts in the multimodal sensorial display of information.
d. Urge authors to ask colleagues who are native English speakers to review the manuscript for clarity.
e. Assume the author has peer support.

The Springer (Springer 2022)[25] "English-language tutorial given, covers common mistakes when writing in English"[25]. The tutorial offers useful advice for the positioning of verbs, topics, comparisons, usage of articles, proper nouns, and others.

"Using a professional language editing service where editors will improve the English to ensure that your meaning is clear and identify problems that require your review."[26] The latter assumes that the author has institutional support and/or means to fund this. Springer suggests Nature Research Editing Service and American Journal Experts. Although Springer assumes that the author has institutional support and/or the means to pay for such services, this is the only concrete support offered to linguistic minorities.

Conclusions

The analysis performed in this paper underlines the need for professional astronomers and astronomy students with disabilities to obtain access to the same amount and quality of information as those peers with no disabilities. The analyses performed here suggest that access to journal information that is linked to mainstreaming science may be compromised. More user-centered studies are needed to assess this from the perspective of the individual functionality of the users. By using proceedings as representations of astronomical discourse, we were able to identify a possible effect of discursive practices and extend the existence of discursive practices to the existence of diversity in the field.

Our analysis allows us to consider the relationship between discourse and discursive activity within the particular institutional field. It also allows us to identify where the possible effect emerges. The reader perhaps may want to keep in mind that inequalities are not only produced by the discourse within a system of journals, but by a much broader discourse that does not allow for contextualized action in information display.

The preliminary results given in this paper indicate a 0% presence of multimodal linguistic strategies, contextual linguistic strategies and simplified text. Text Simplification is a petition found inside the WGAD document. At present, technology makes it possible to display information in multiple ways and in multiple forms (visual, auditory, tactile, and multi-language) and even test for text grammar complexity. Online free lexical-complexity estimators for the English language are available, for example, the Lexical Complexity Analyser.[27]

To make scientific contributions accessible to all and establish accessibility as the only permitted practice for paper publication will benefit everyone in the field at all aspects and stages of performance. The editorial staff of astronomy journals should unite to end practices that label and instead move toward an inclusive, equal, and equitable practice.

The field of astronomy was taken as a case study, and it will be very interesting to extend this investigation to other natural sciences. In addition, the maintenance and development of tools (such as a user-centered sonification software) to ensure user-centered multimodal

access to information and databases is a crucial topic.

Assessment of the strategies used by scientists with congenital and late-onset disabilities to access information and produce investigations and research will make it possible to produce recommendations that are not limited to the baseline of WGAD and ISO, which the authors understand only mark a minimum of accessibility, even at its own maximum levels.

Next steps

As astronomic science is an old professional field, it seems to be time to take action to enforce disability access to the mainstream. In this sense:

1. To establish the possible origins of the effects identified in this paper.
2. If effectors are identified, to extend the evaluation to accessibility to data analysis software.
3. To establish an interdisciplinary group of sociologists, disability-studies specialists and scientists with congenital or late-onset disabilities, to assess whether possible inaccessibility to papers in this scientific field leads to a skill-development gap that is preventing the ability of people to work in the field of astronomy and to participate in society.
4. To track the causes of the effects identified in this paper.
5. To assess if the effects identified in this paper exist in other sciences.

Future observations of classroom practices or professional interviews regarding higher education, comparisons across sciences, and access to basic biometric information on anonymous authors, will improve this proposal and enable inclusion to be not just a word, but a reality.

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Conflict of interest

The authors declare that there are no conflicts of interest to the present work.

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