# Improving Accessibility of Astronomical Publications

Recommendations from the Working Group on Accessibility and Disability

Each individual copes, searches, thinks, performs, perceives, and interacts differently. Interaction implies a response to physical, cognitive, emotional, and other stimuli that have been processed by an individual. In the interest of disseminating knowledge to the community in a fully inclusive way, we would ideally accommodate the coping and cognitive needs of every single human being. Well-designed user-centered interfaces take into consideration characteristics of the target audience to create a Human-Computer Experience that will not prevent access, frustrate, or serve to disengage the user. For the field of astronomy, where thousands of publications are generated each year, the number of articles published by a scientist is highly weighted in performance and productivity metrics. To publish and stay up-to-date on the latest research is mandatory to find the next job. However, the pervasive dependence on language and expressions that fit only one perceptual style suggests that our field has limited itself to the participation of only this perceptual style. This dependence forces people with other learning styles to learn or memorize using this particular style. To unwittingly deny people with disabilities the same amount and quality of information that is available to a traditional visual learning astronomer has the exclusionary effect of severing our links with the field and society.

We recommend that journal staff consult User Centered, Universal Design specialists among other information access professionals rather than relying on a checklist for developers to follow to achieve “accessibility,” as the latter will lead to more complications than solutions. User Centered design considers all of the perceptual strategies of humans to design systems that will not disengage the user. This strategy lends itself to widen the participation of a large diversity of people by enabling their participation in tasks that have traditionally excluded non-visual learners. Astronomy and physics are very visual fields that often force people that do not fit that learning style out of the field.

Information Access (IA) technology (Assistive Technology, hereafter AT) is very expensive, which in itself excludes most people from efficient, effective and useful IA. Common assistive technologies used by people with disabilities are alternative keyboards, pointing devices, eye-tracking equipment, voice-recognition software and screen scanning options. Software in general is overcrowded and updates frequently change the way things are done whenever new features are added. Changes in software may frustrate users who are accustomed to a certain interface. This is a major challenge for people with disabilities. On top of that, we note that accessibility is not a

priority for our culture: for example, journal display typically prioritizes use of PDF generators that save space over ones that make it easy for people with cognitive, attention, and focus challenges. Technology used to improve accessibility should be compatible with freely available accessibility software; for example, the NVDA (NonVisual Desktop Access) screen reader is compatible with the Mathematical Markup Language (MathML). A culture where the use of words does not disempower people is mandatory if science is to become truly representative. Moreover, accessibility should be performed automatically and not as an exception.

Deaf and hard of hearing people are often assumed to not face difficulties when reading or navigating webpages. That assumption is far from reality, and excludes many individuals. Words commonly used in astrophysics often lack direct equivalents in sign language and so must be painstakingly spelled out letter by letter. Ideally every word used in a journal article should have a translation to sign language. The Office of Astronomy for Development (OAD) and the Office of Astronomy for Outreach (OAO) are coordinating efforts to address the lack of sign language for astrophysical words at the professional level, and as needed to develop international signs. We advise the journal staff to seek their advice.

Below, the reader will find recommendations for improving the accessibility of astronomical journals. It is important to highlight that no user centered testing or focus group has been performed to gather the suggestions below. These suggestions should serve as a guide and motivation for the reader to perform a user centered study and deepen the research on how best to use technology to bring different learning styles on board. We mentioned previously that a list of steps for developers to follow is not the solution, even though our suggestions below may look like a list. Lists limit creativity, limit possible new solutions, and may be unintentionally taken as absolute, thereby leaving out the very important phase of continuous focus groups and usability testing. Good back-end and front-end design is guided by continuous usability evaluations. We hope that readers will gather help from experts on user centered design, human computer interaction, and disability in astronomy to enrich the field at all levels.

On the same token, there are many learning styles and disabilities, and we are not specialists[1] in all these learning styles. It is not our intention to leave any disability out, but if we did then please reach out to us with your suggestions. These suggestions were gathered from astronomers whose experiences are informed by our own disabilities.

---

[1] The reader may write to access-astronomy@googlegroups.com or to the chairs of the American Astronomical Society Working Group on Accessibility and Disability.

In order to meet the needs of all readers with disabilities, we recommend that journals conduct focus groups with different users from the target audience (students and astronomers with disabilities). This will require approval of an Institutional Review Board. Studies with astronomers with disabilities have already been done while respecting their anonymity: the journals may also begin with the target audience doing a high granularity usability evaluation of the journal interface as it is, together with remote login to monitor the navigation and text-to-speech interface. This approach lends itself to widening diversity, identifying deeper situations affecting the target audience, and prioritization. It is important to develop new methods that will lead us to create robust and enduring interventions. The work to be done also comprises the design of a template where the article will be inserted; that may require additional unique expertise.

## Procedural Recommendations

- **Form a committee to evaluate and improve the accessibility of astronomical publications.** This could be done in partnership with the Working Group on Accessibility and Disability (WGAD), the Office of Astronomy for Development (OAD), and the Office of Astronomy Outreach (OAO). The knowledge gained should be shared openly with other journals and publishers.
- **Perform user-centered studies** to deepen the research on how to best use technology to make astronomical publications accessible to people with different learning styles and disabilities.
- **Perform usability evaluations** regularly to make sure that articles are compatible with accessibility software. However, assistive technology compatibility does not necessarily mean that information may be accessed by the reader.
- **Seek feedback from the astronomical community about the accessibility of journals**, especially from students and astronomers with disabilities.
- **Provide space in astronomical publications for articles on accessibility, equity & inclusion, astronomy education research** (possibly as a supplemental journal article or letter series).
- **Provide authors with guidelines on accessibility.**
- **Ask referees to comment on the accessibility of manuscripts.** Provide specific criteria for referees to comment upon such as the accessibility of graphics and captions, and the understandability of the manuscript. A side benefit is that referees will learn better strategies for accessibility that they may use in their next publication.
- **Provide accessibility trainings for journal staff.**

## Navigation

- **Organization of the articles, browser, and content should follow a consistent/standard format.**
- **Use tags and links within documents to improve ease of navigation.** For example, a table of contents with links to the different sections should improve screen reader compatibility. Use usability evaluations to refine how tags are used to fit the cognition and thinking styles of the target audience.
- **Ensure that people using screen readers and other assistive technologies are able to get the gist of an article, and can go back and forth between different sections at will.** For example, imagine someone who only wants to hear the methodology section and has no need to hear the introduction, but the screen reader goes through it anyway. Readers should be able to easily jump between the text, table of contents, footnotes, and references. Documents should have a defined safe spot in case a reader loses orientation.
- **Speech recognition software** may ultimately be a good option for navigating journal articles. However, speech recognition software presents its own problems (Hwang et al. 2003; Wobbrock & Gajos 2008) such as difficulty distinguishing between similarly sounding words.
- **Find and use resources such as MathML and/or Mathspeak that are compatible with free screen readers and other assistive technologies.** It is important not only to read the variables and operators one by one in an equation (which is the equivalent to reading a sentence by spelling it letter by letter), but to know what the equation means and how it is being used (e.g., what graphemic symbol in the equation changed and how) to tackle the whatever situation the author is considering. The user should be able to recognize the equation and not to be forced into a memory overload.
- The **spotlight technique** proposed by Lee and Oulasvirta (2015) brings important information to the foreground and may be used in PDF readers to accommodate people with attention challenges. A very useful resource is the Americans With Dissability Act Network, Great Lakes Training Center library training session on
  "How do I know my PDF is accessible" http://www.accessibilityonline.org/ada-tech/archives/110440
- Journals should provide users with accessible, time-effective, efficient, and useful ways to **choose the settings** to engage with the content. This should be possible without having to perform complicated movements with the mouse. Shortcut keys could be used, for example, to hear the spelling of a word or navigate within the document.

- To **aid users with motor impairments**, avoid small clickable elements, mouse-dependent actions (Cannon 1987), and keyboard traps.

## Content

- **Provide articles with a logical and clear structure.**
- **Research articles should be as understandable as possible for students and early career astronomers.**
- The written content should **use richer (sensorial, verb, etc.) descriptors and expressions**. Non-visual learners require **more descriptive text**. Publications should **provide visual content to accompany text** when possible for deaf and hard of hearing individuals.
- Journal articles are notoriously dense and use many words that are beyond the everyday experience of some users with perceptual disabilities. **Sensorial information** (visual, hearing, touch, taste) is involved in the dissemination of knowledge through construction of analogy and development of relatable explanations. The sensorial information linked to linguistics and the creation of knowledge has been extensively studied. Journal managers should consult with professionals in linguistics and phonology, and note that OAO or OAD are performing research on the subject. For a specific example, the recent LIGO gravitational wave detection news heavily circulated the analogy of “hearing” them for the first time; this is a fraught and technically incorrect description that misleads the general public and can be alienating or insulting to persons with disabilities (e.g., “we were deaf but now can hear”).

## Layout and Style

- **Prioritize accessibility over other criteria in the design and layout of astronomical publications.** Redesign format with accessibility in mind.
- **The display should be simple** and accommodate the search and coping strategies of the diversity of possible readers.
- Websites should **allow users to easily change display settings related to accessibility**. Provide high contrast and high visibility options, mouse-over text, and descriptive image captions. Allow the fonts and font size to be changed.
- **Maximize accessibility for people with dyslexia.** Use dyslexic accessible fonts (including but not limited to Helvetica, Verdana, and OpenDyslexic) at a reasonably large font size (12 pt) with sufficient space between lines. Avoid

crowding,[2] and follow best practices related to the length and arrangement of sentences that are displayed.[3] Many potential astronomy students have dyslexia (Schneps 2006), and some people with disabilities excluded because they feel incompetent when the situation is mostly related to access to information.

## Multimodal Access

- **Provide multiple modes of access to the information contained in journal articles.** Possibilities include podcasts, presentation slides, and videos to complement research articles. Options should be made available for embedding varied media formats (audio, video).
- **The format of articles should allow Braille embossing.**

## Graphics and Charts

- **Use colorblind intuitive palettes** for graphics.
- **Provide sufficiently descriptive captions for graphics**. The description should be enough for
- **Descriptions of charts should follow a standard form and use richer descriptors and expressions.** Research should be done to create guidelines on best practices. For example, if a person or screen reader describes graphemic symbols one by one to a blind person, this overwhelms their memory and makes it difficult to recognize meaning. This situation is similar for many others with perceptual and reading challenges.
- Data from plots and charts should be made available for **sonification and/or audio descriptions**. An example tool is xSonify.

In conclusion, we hope that astronomical publishers and journal staff find the information useful in the important task of making astrophysics accessible to all. WGAD is here to help in this process, and we appreciate your time and efforts. We are glad to be part of a community that values inclusion and access.

With our best regards, the coordinating committee members of the AAS WGAD:

---

[2] **Crowding** is a perceptual phenomenon where the recognition of objects (or graphemes) presented away from the fovea is impaired by the presence of other neighbouring objects (sometimes called "flankers").

[3] Schneps, M.H., Thomson, J.M., Sonnert, G., Pomplun, M., Chen, C., & Heffner-Wong, A. (2013). Shorter Lines Facilitate Reading in Those Who Struggle (link) (see research of laboratory of visual learning for people with reading challenges (ex. dyslexia) (article on crowding and vertical display on scientific American: Using Technology to break the Speed Barrier of Reading posted at researchGate)

Wanda Díaz-Merced (Co-chair)
Nicholas Murphy (Co-chair)
Alicia Aarnio
Jacqueline Monkiewicz
Jason Nordhaus
Sarah Tuttle

## References


Cannon, W.B.. The james-lange theory of emotions: A critical examination and an alternative theory. The American journal of psychology, pp 567–586, 1987.

*A New era: Deaf Participation and Collaboration*. (2016). Retrieved 2016, from World Federation of the Deaf: https://wfdeaf.org/databank/information-about-deaf-issues/a-new-era-deaf-participation-and-collaboration

Deaf, W. F. (2016, may). *World Federation of the Deaf*. Retrieved 2016, from World Federation of the Deaf: https://wfdeaf.org/databank/wfd-and-other-publications

Hwang, F., Keates, S., Langdon, P. and Clarkson, J. Mouse movements of motion-impaired users: a submovement analysis. SIGACCESS Access. Comput. 77-78, 102-109.2003. DOI=10.1145/1029014.1028649 http://doi.acm.org/10.1145/1029014.1028649

Lee, B., Oulasvirta, A. Spotlights: Facilitating Skim Reading with Attention-Optimized Highlights. UIST '15 Adjunct: Adjunct Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology, 2015.

Wobbrock, J.O,. Gajos, K, Z. Goal Crossing with Mice and Trackballs for People with Motor Impairments: Performance, Submovements, and Design Directions, ACM Transactions on Accessible Computing (TACCESS), v.1 n.1, p.1-37, 2008 [doi>10.1145/1361203.1361207]