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Emotions and Science Communication

ARTICLE

Wonder and disappointment observing the sky: how emotions shape astronomy communication interactions

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Abstract

Emotions are key features of observations of the sky, yet studies exploring the characteristics of emotions in these activities remain scarce. In this article we analyse the emotions present in a video corpus of 13 hours of sky observations. These observations were recorded and analysed using a naturalistic approach that provides evidence about their structure and the role of emotions as they happen, in context. Although common throughout our data, emotions are complex and varied. We characterize their form, placement, evocation and role in the interaction. Moreover, findings highlight the collaborative nature and centrality of the sharing of emotions in the interaction and the presence of expressions of intimacy, authenticity, contemplation, reflection, and curiosity in these emotional moments. The identification of diverse emotional interactions and the discussion of their importance to astronomy communication contributes to the literature on emotions, the training of guides, and the evaluation of these activities.

Keywords

Popularization of science and technology; Informal learning; Public engagement with science and technology

Additional Keywords

Observations of the sky; Astronomy communication; Ethnomethodology and Conversation Analysis (EMCA)

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1 ▪ Introduction

Astronomy is known for evoking emotions such as wonder and awe [Kessler, 2012], especially when it comes to observations of the sky [Marques et al., 2024], which are very popular astronomy communication activities that reach thousands of people all over the world. Armed with their lasers and telescopes, guides (professional and amateur astronomers, educators and science communicators) show the sky to all types of audiences. Observations of the sky are complex practices that involve different dimensions [Marques & Retrê, 2023], and present unique interactional characteristics and embodied practices [Azevedo & Mann, 2018; Marques et al., 2020]. They can have an impact on the audience and are permeated with expressions of emotions. Moreover, these activities are often the first contact the public has with astronomy and with the astronomy community. Emotions are important in the engagement and interest of the public [Davies, 2019] and there is increasing attention given to science communication's affective dimension [Bellocchi et al., 2017; Davies et al., 2019]. Even so, studies about this topic in astronomy communication, and particularly in observations of the sky, remain scarce. In response, we describe and map the emotional moments produced in observations of the sky in Portugal focusing on their interactional characteristics. To realize this, we adopted a naturalistic approach rooted in Ethnomethodology and Conversation Analysis (EMCA) that allows us to observe and specify people's expressions of emotion *in situ*. EMCA is sensitive to the interactional practices that occur in sky observation sessions, which facilitates the study of the details of these events as they are produced in sequentially organised interactions. It suggests not only that emotions are intrinsic to observations of the sky, but also explicates *how* emotions are organised and enveloped within these activities. At a granular level, addressing *how* people's activities are conducted within interactions themselves not only furthers our understanding of the role of emotions in observations of the sky, but also provides broader features for future research and ramifications for training.

2 ▪ Emotions in astronomy communication and observations of the sky

Astronomy is seen as a gateway science [Barragan & Meltzoff, 2024; Madsen & West, 2003] that is naturally awe-inspiring [Christensen, 2007; Kessler, 2012; Salimpour et al., 2024], catches the attention of a wide range of people, and may act "as a powerful vehicle for improving the public awareness and understanding of science." [Madsen & West, 2003, p. 3]. Astronomers and astronomy educators and communicators acknowledge the importance and centrality of emotions in astronomy communication activities, and a body of literature explores the awe-inspiring nature of astronomy.

Some of those studies focus on the use of images in astronomy communication, and show that astronomical images impact astronomers and the public and are produced to inspire and elicit awe. Images of the cosmos, ubiquitous nowadays, shape the ways astronomers think [Galison, 2002] and the ways non-astronomers imagine the universe [Kessler, 2012]. Moreover, interviewing the astronomers that made the images of the Hubble Space Telescope, Kessler [2012] found that these astronomers want to show and communicate to the public the awe they experience themselves when observing the universe. In another study, Smith et al. [2010] analysed how experts and non-experts understand the science behind astronomical pictures. They found that the non-experts show what can be perceived

as wonder or awe when observing images of the universe and that, in addition, after the expressions of awe, non-experts move to an inquisitive mode. They ask questions about the images, about how they were generated and about the science behind the objects portrayed in the images. Moreover, they also questioned the perspective of the scientists looking at those same images [Smith et al., 2010]. Also focusing on emotions and astronomical imagery, VanDyke and Yeo [2024] studied how media content on James Webb Space Telescope can inspire audiences and motivate reflection, curiosity and awe. Findings suggest that visual communication "may induce awe from viewing, which may lead to reflective thought, and ultimately, feelings of inspiration" [VanDyke & Yeo, 2024, p. 11].

All these studies highlight the presence, intentional from science communicators and astronomers and spontaneous from the public, of emotions related to awe and wonder in astronomy communication. Moreover, research also seems to point to a relation between these emotions and an increase in interest in astronomy [Barragan & Meltzoff, 2024].

These emotions are also central in the broader field of science communication. Wonder and curiosity have a role in the production of science [Davies, 2019] and in how science is depicted. The desire of science communicators to inspire and trigger emotions such as awe, enthusiasm, interest or curiosity in their audiences is also reported in several studies (e.g. [Davies et al., 2019]). These science communicators and mediators are important in the emotional experience of the public. For instance, Massarani et al. [2023] found that mediated visits to science exhibitions occasioned more emotional expressions than visits made without mediation. Research shows that awe and related emotions can play different roles and functions in science communication [Luna & Bering, 2020], and suggests that other emotions also present in these practices should be studied further [Luna & Bering, 2022]. Some recent studies already focus on other emotions, such as hope and fear [Bilandzic et al., 2020; Nabi et al., 2018], and there is also research showing that, despite the expectations and focus on positive emotions such as awe and enthusiasm, sometimes what is felt by the audience is frustration and confusion [Davies, 2019] or doubt and disagreement [Massarani et al., 2023].

In the specific case of observations of the sky, which is the focus of this study, it is apparent that emotions such as awe and wonder are present [Barragan & Meltzoff, 2024; Marques et al., 2024]. Similar to the broader field of science communication, astronomers, amateur astronomers and science communicators want to create and share their enthusiasm with the public [Bossema et al., 2018; Toyib et al., 2024]. In this context, a group of related studies starts to emerge, driven by the dark skies movement[1] and the genuine concerns of astronomers and lay public with light pollution and its impacts. Bjelajac et al. [2021] review the literature on the topic and highlight the inspirational aspect of the night sky and its influence on well-being. Derrien and Stokowski [2020] analysed narratives of night sky experiences in a U.S. national park and discuss the uniqueness of each interaction that occurs in observation experiences. In a recent large-scale survey on the impact of light pollution in the U.S., Barragan and Meltzoff [2024] found that there is a correlation between the inability to observe the night skies in states with more light pollution and lower interest in astronomical topics, and "*positive association at the state level between low light pollution and feelings of wonder about the universe*" [Barragan & Meltzoff, 2024, p. 2].

1. See for instance https://darksky.org/.

These studies, however, only indicate that there are emotions involved. There is a lack of research exploring *how* these emotions are actually produced — how these are "accomplished" [Garfinkel, 1967] and displayed in context by the participants — as well as the characteristics of these emotions in the interactions. Acknowledging this need to further understand emotions in observations of the sky, we ask:

1. What are the main contextual and interactional characteristics of the emotions expressed in observations of the sky with the public?
2. What do these expressions of emotion tell us about the activity of observing the sky?

To answer these questions we conducted a naturalistic study of these activities, which is described below.

3 ▪ An ethnomethodological approach to the study of emotions

Our research adopts a naturalistic approach based on Ethnomethodology and Conversation Analysis (EMCA; e.g. [Garfinkel, 1967; Sacks, 1992]). As a data-driven approach to the study of social practices, EMCA concentrates on taken-for-granted methodic properties of action and interaction explicating their details through fine-grained analysis of audio and video recordings, as data of real events. It is through the detailed study of such naturally occurring data that the technicalities of ordinary and specialized activities are observed, unpacking how science is actually communicated, enacted and understood, moment-by-moment in the interaction among participants.

EMCA argues that emotions are publicly available, shared phenomena that are amenable to rigorous, objective study [Wowk, 1989, 1995]. This approach accords no special status to "emotions" preferring instead to analyse expressions of emotions and other conduct as linguistic phenomena, produced in the context of the interaction. Emotions expressed are interactionally organized practices [Marques et al., 2024]. Focusing on language practices enables analyses that preserve the unique characteristics of emotion: what is regarded as emotive, the expression of emotion, and the recognition and treatment of emotion by others. Following Wittgenstein [1969], we use terms as awe, amazement, wonder or, in other cases, astonishment or disbelief, with almost the same meaning. We use synonymous ordinary language words to better characterize — rather than "reduce" for the sake of "generality" [1969, p. 18] — those interactions taking place and the emotions expressed within these.

By adopting EMCA, our focus is not on the absolute characteristics of emotions, or distinguishing and unequivocally defining them (as attempted by Ekman and Cordaro [2011]), nor on social and cultural factors that influence them or the impact of emotional interactions. The focus is on the importance of these emotions for members in the interaction and how these are treated by others who are also party to that interaction [Wowk, 1995]. Context is not defined by analysts but is co-produced by participants of observation sessions through their interaction. Our study of emotions in observations of the sky continues the methodological policy of remaining tied to interactions themselves, without "losing the phenomenon" [Garfinkel, 2022, p. 29] by "decontextualizing" emotions — instead, preserving emotion expression *in situ*.

4 ▪ Method

The naturalistic approach of EMCA relies on naturally occurring data; in our case, naturally occurring data of observations of the sky. Data are preserved as video recordings, that afford the inspection of language practices *in situ* [Sacks, 1984]. These videos are available to repeated visualizations and increasingly detailed analysis, among other methodological advantages (see e.g. [Carlin et al., 2021a]). As part of the analytical process, transcripts of the data are also prepared. These transcripts of the interactions allow for the visualisation and presentation of phenomena captured on video. A key methodological principle of studying expressions of emotions from a social/interactional perspective is the attempt to "anchor [it] in the interactional matrix in which the expression occurs: its form, its placement, its response and the organizational and interactional origins of its accountability" [Whalen & Zimmerman, 1998, p. 158]. The analysis is conducted through "the examination of data with a view to determining which kinds of "elements" it is made up from, the ways in which those "elements" are related, and the kinds of things we can usefully say about the organisation of their relationship." [Sharrock & Anderson, 1979, p. 83]. Breaking interactions down to the sequential organization or turn-by-turn vocalizations by public and guides allows us to show how emotions are organized in their contextual variety.

Using this approach, the validity of findings is ensured by the availability of our data for inspection in order to follow our argument and analysis. Since real events are preserved using video, interactions and their detailed transcripts are available for detailed and repeatable inspection. Moreover, it is important for a research team to have competences in the EMCA research approach and in the skills demonstrated by practitioners in these events, as is the case with this current study. In addition, an unmotivated inspection of what the actual events contain ensures that scientific criteria such as generalisability, reliability, and validity are met [Marques et al., 2022; Peräkylä, 1997].

In the next sections we will detail how, in accordance with this naturalistic approach and the aim of our study, a group of diverse naturally occurring observations of the night sky were recorded and analysed.

4.1 ▪ *Participants and settings*

The recordings took place in Portugal, in different settings and locations. The dataset is composed by a total of 19 observations, representing around 13 hours of data and more than 800 people observing through the telescopes (adults, young people, families with children, etc.). A total of 22 guides/astronomers with different levels of experience conducted the observations and operated the telescopes. A variety of celestial objects were observed. The main characteristics of the observations recorded, the participants, and the settings can be consulted in Table 1.

Table 1. Characteristics of the equipment, settings, objects, guides and pubic of the observations recorded.

Observ. ID	General Description	Objects Observed	Type of Celestial Object	Equipment	Duration (min)	Guide ID	Gender	Experience	Public	# Pax
1	Public observation at Observatory (Asteroid Day)	Ceres asteroid	asteroid	Celestron 14” Edge HD	39	G3	M	high	adults and families	57
2	Public observation at Observatory	Double star; Jupiter; Saturn	stars, planets	Celestron CPC 1100 GPS (XLT)	98	G8	M	medium	adults and families	108
3	Public observation in the city	Jupiter; Saturn	planets	Reflector, 10”, Dobson	120	G1, G9	M, M	high, low	adults and families with children	144
4	Star Party at Science Center	M57	nebulae	Meade, Catadioptric, 10”, Schmidt-Cassegrain	26	G10	M	high	adults and families with children	22
5	Star Party at Science Center	Jupiter; M13; M8; Saturn	planets, clusters, nebulae	Meade 8” f/4 LX85	83	G12	M	high	adults and families with children	75
6	Star Party at Science Center	Jupiter	planets	Meade 8” f/4 LX85	18	G12	M	high	adults and families with children	15
7	Star Party at Science Center	Saturn; Jupiter; Moon	planets; moon	Meade, Catadioptric, 10”, Schmidt-Cassegrain	54	G5	M	high	adults and families with children	41
8	Star Party at Science Center	Andromeda; Moon	galaxy, moon	Celestron Nexstar Evolution 8”	17.5	G13, G14	M, F	low	adults and families with children	23
9	Star Party at Science Center	Moon	moon	Refractor, 5”	21	G16	M	high	adults and families with children	27
10	Star Party at Science Center	Saturn	planets	Sky-Watcher N 250/1200 PDS Explorer	42	G12	M	high	adults and families with children	26
11	Star Party at Science Center	NGC 457	cluster	Reflector, 8”	9	G18	F	medium	adults and families with children	9
12	Star Party at Science Center	M10; Moon	cluster; moon	Reflector, 40”, Ritchey-Chrétien	14.5	G10	M	high	adults and families with children	11
13	Booked observation at Observatory	Moon; Jupiter; Pleiades; M42	moon, planets, cluster, nebulae	Celestron 14” Edge HD	66	G4	F	medium	group of children and teen Scouts	88
14	Star Party organized by Amateur Astronomers	M13	cluster	Reflector, 10” and Reflector, 24”, Dobson	18	G24	M	high	adults and families	15
15	Star Party organized by Amateur Astronomers	M83; M57	galaxy, nebulae	Catadioptric, 8”, Schmidt-Cassegrain	18	G25	M	high	adults and families	15
16	Star Party organized by Amateur Astronomers	M57, M51	nebulae, galaxy	Reflector, 8”, Dobson	13	G25	M	high	adults and families	15
17	Star Party organized by Amateur Astronomers	M81, M3	galaxy, cluster	Celestron Nexstar Evolution 8”	32.5	G23	M	high	adults and families	15
18	Star Party organized by Amateur Astronomers	M13, M82, M81, M57	cluster, nebulae, galaxy	Catadioptric, 10”, Schmidt-Cassegrain	26	G26, G27	F, F	high	adults and families	15
19	Public Observation at the beach	Moon	moon	Skywalker 8”, Dobson	52	G26, G27	F, F	high	adults and families with children	19

4.2 ▪ *Data collection*

These data were recorded using visible and infrared cameras to capture the interactions in the low light environment of observations of the sky. The stationary recording equipment was positioned at a certain distance from the telescope, in a location where the guide, telescope eyepiece, the visitor who was observing, and people surrounding the telescope could be captured without disturbing or interfering with the observation. In some cases, more than one camera was used. The analyst recording the activities had minimum contact with the public or guides during the observations recorded. Depending on the distance of the camera to the telescopes, extra infrared lamps were also used to better illuminate the scene. Microphones were placed near the telescope to capture the conversations at the eyepiece with precision. The videos and audio of the different events were later cut, merged and synchronised in order to obtain a final record for each event. A dataset with all the final recordings was established and transcripts were prepared. Participants consented to have their image used in academic research contexts and we followed the ethical guidelines of our institutions in regards to confidentiality, secure data storage and retention.

4.3 ▪ *Data analysis*

The analysis was conducted through multiple visualizations of the recordings and their transcriptions. Transcriptions were prepared using a recognized notation system ([Jefferson, 2004] — see Supplementary Material) that accounts for the particularities of the talk (pauses and silences, repetition, overlapping utterances, rapidity of talk, intonation, etc.). Transcription afforded detailed analysis of the interactions and the identification of the excerpts that show expressions of emotions to build the corpus. Excerpts were selected by identifying all the parts of the interaction where by talk, silences or gestures, participants visibly described or embodied emotions (e.g. saying something is amazing, vocalizing a wow, smiling, raised their voice, complaining, observing for a long time). This triage process was conducted by both researchers through several rounds until a final set of data was reached. Each excerpt was then described in terms of the specificity of emotion and the way it was expressed in the interaction.

The selected perspicuous instances of expressions of emotion from the transcripts and recordings produced a final corpus of 174 excerpts. The individual analysis of each of these excerpts was conducted with reference to the original videos and corresponding transcriptions. The analysis focused on the details of the interaction and its sequential aspects, attempting to preserve the contextual nature of the emotional expressions within the larger context of the observation session. This form of analysis allowed for the identification of a set of common features that characterize these emotional expressions: how are they expressed? where are they expressed within the interaction? what evokes them? what is their role in the interaction? In each of the 174 excerpts these features were described and analysed, and then the diversity encountered was systematically mapped. In the next section we will describe our findings, analysing the emotional expressions in observations of the sky and their characteristics in the interactions.

5 ▪ Findings

5.1 ▪ *Characterization of emotional moments in observations of the sky*

In this section we present the main findings related to the interactional characteristics of the expression of emotions in observations of the sky. Expressions of emotions are common in the data, occurring multiple times in each of the 19 activities recorded. The large majority of the emotions identified are positive, but negative emotions were also expressed. Although expressions of negative emotions occur to a lesser degree, the number of negative emotions does not diminish the importance and attention that should be given to these (see [Davies, 2019]).

An example of the expression of positive emotions at the telescope can be found in Figure 1.

Figure 1. Excerpt 63. Awe and joy observing the Hercules Cluster.[2]

The woman observing is already smiling when she approaches the telescope (Figure 1, screenshot a), showing enthusiasm in the activity even before observing. As she starts observing, she has an almost immediate reaction of wow (what we call a "wow moment") as she sees the celestial object through the eyepiece. Within her turn at the telescope, her observation through the eyepiece is of 16 seconds duration, which is a long time for a visitor to look through the eyepiece, always smiling in what we can described as delight and joy. We note that the guide responds to the visitor's "*wow*" with what we call an upgraded confirmation term: "*great*" (screenshot b). The guide's confirmation works to suggest that that is exactly what she should be seeing (something similar to "that's it") and, in colloquial terms, to "validate" what she is experiencing. This shows that, to this guide, experiencing "wow moments" is part of the purpose of showing the sky. After her long smiling observation, the woman moves away from the eyepiece, sharing with her companion (next in line) that it is "*nice*", evaluating the experience and reflecting on it. She then keeps smiling whilst looking at the telescope in a contemplative way (screenshot e).

We see in this example that different emotions are produced during the activity in the interaction. Each emotional moment is unique in its sequence of details and interactional context, but in the broad frame of observations of the sky we found that these emotional moments share a group of features that allow for their characterization, namely related to their placement, form, evocation and role in the interaction. These characteristics are summarized in Figure 2 and will be described next.

2. All the detailed transcripts of the examples presented in this article are available as supplementary material.

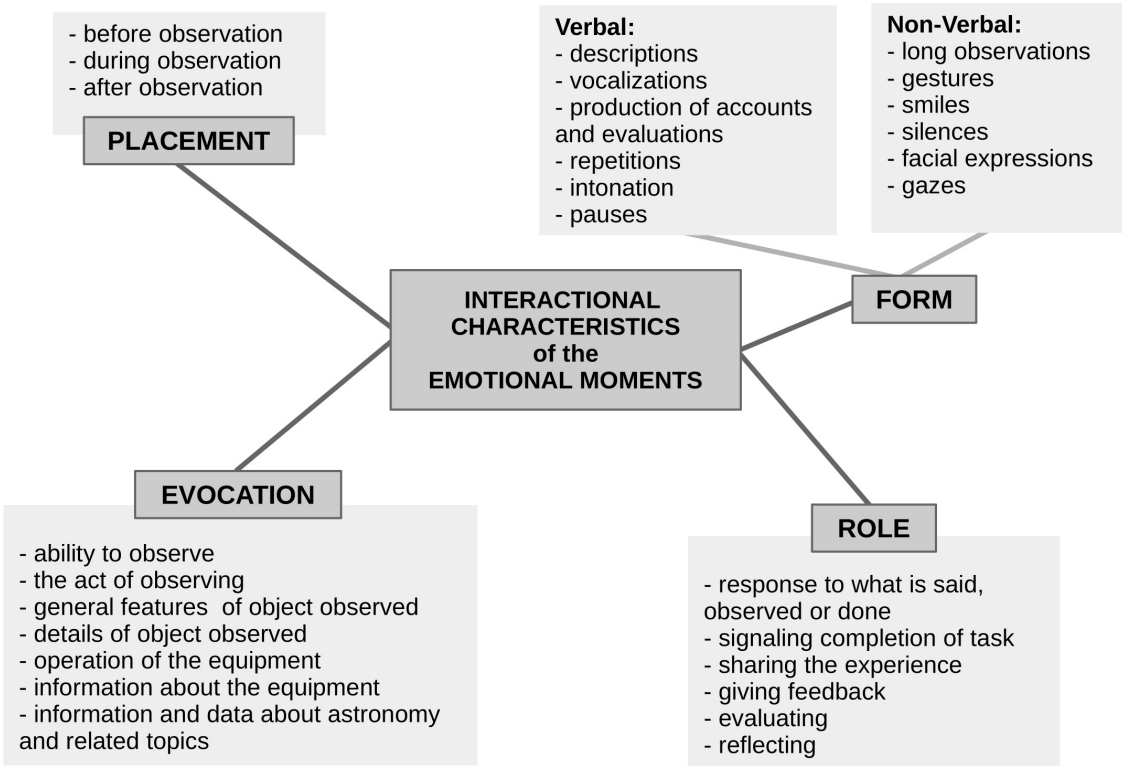

Figure 2. Summary of the interactional characteristics of the emotional moments in observations of the sky.

5.1.1 ▪ *Placement*

Emotions are not just reactions to what is seen through the eyepiece and, therefore, can be locatable in different moments of the interaction. In the example above (Figure 1), the expression of emotions is located before, during and after the observation. This placement in the interaction varies and gives information to the guide, whether about expectations, the success of the observation or the elements that are evoking emotions.

5.1.2 ▪ *Form*

Emotions are produced in sequences of interaction in a complex manner and in a variety of forms. They are expressed via intertwined verbal and non-verbal aspects, the main features of which are summarized in Figure 2. In the example of Figure 1 we can identify a group of these verbal and non-verbal aspects (talk, vocalizations, smiles, looks and prolonged observation) that both index and help others to recognize the emotional moment, in this case a “wow moment” of the visitor, that is validated by the guide.

5.1.3 ▪ *Evocation*

Observing can occasion emotional expressions, both negative and positive; and these can be evoked by different aspects of the observation. Concerning the expression of negative

emotions, such as frustration and disappointment, our findings show that these occur in relation to the characteristics of the images observed (small size, low definition, lack of detail) and difficulties in properly observing through the eyepiece. For instance, people struggle to distinguish the rings of Saturn, hope to see details and colour in nebulae and galaxies or, most frequently, get disappointed with the size of what they observe. On the other hand, positive emotions can be evoked through a broader set of aspects in the interaction. Often it is the "getting to see a celestial object through the eyepiece" that elicits emotion, as illustrated in Figure 1, but the quality and definition of what is being observed can also be related to positive emotions. This occurs in many interactions, and "seeing clearly" may involve seeing some specific details, be it the craters of the Moon, the round shape of a nebula or Jupiter's stripes and moons. Often these details are not obvious to the untrained eye and guides direct the look of the visitors and help them see them [Marques et al., 2020]. The achievement of "getting to see" these details as well as actually seeing them evoke emotional responses. In addition, data show that it is not just what is observed at the eyepiece that can occasion emotional moments. These other factors that evoke the expression of emotions found in the data are summarized in Figure 2.

5.1.4 ▪ *Role*

The emotions expressed can be immediate and spontaneous while others are cumulative, realized gradually, involving descriptions, questions and comments. They serve different roles in the interaction, both to the public and the guides. In most cases, they are a reaction or response to what was seen, said, or done, be it the observation of a celestial object, the talk about the dimensions of the universe or the ability to focus the image. They help the public and the guide to structure the activity. In some cases, as seen in Figure 1, these emotional moments commence before the observation; such emotions seem to be a response to the setting or an anticipation of the observation activity, giving clues about the expectations of the public. The expression of an emotion can also provide the guide with information about the completion of a particular task, signaling that the observer at the telescope is seeing what they should be seeing (or not, in the case of a negative emotion), operates the telescope well enough, or understands/follows explanations. These expressions in the interactions also serve to share the experience with others, give feedback to the guide, evaluate the experience and/or reflect upon it. Figure 1, above, exemplifies this, when the woman observing moves away from the eyepiece and says "*nice*", sharing the experience, giving feedback and evaluating it.

5.2 ▪ *What emotional moments tell us about observations of the sky with public*

The detailed analysis of the emotional moments in observations of the sky also revealed a group of other results that, in addition to characterizing the emotional moments, contribute to reflection on why observations of the sky are emotional activities. We found that emotional interactions at the telescope are collaborative and shared, intimate and authentic experiences. Moreover, emotions foster curiosity and engagement, and invite further reflection and contemplation. Each one of these aspects will be explored in this section, with examples evidenced in the data.

5.2.1 ▪ *Shared emotions as a collaborative activity*

One important finding is that emotions are shared. In interaction after interaction, we see people sharing their emotions about what they saw, calling others to see and feel it too, and producing accounts about what made them feel that way and why. As such, emotional moments prompt the sharing of the experience and sense of connection. This happens both with the guides and among audience members. For instance, in Figure 1 (above) the positive emotion is shared immediately after the observation. In the example in Figure 3 (below), we observe the sharing, sense of connection and collaboration between a group of friends.

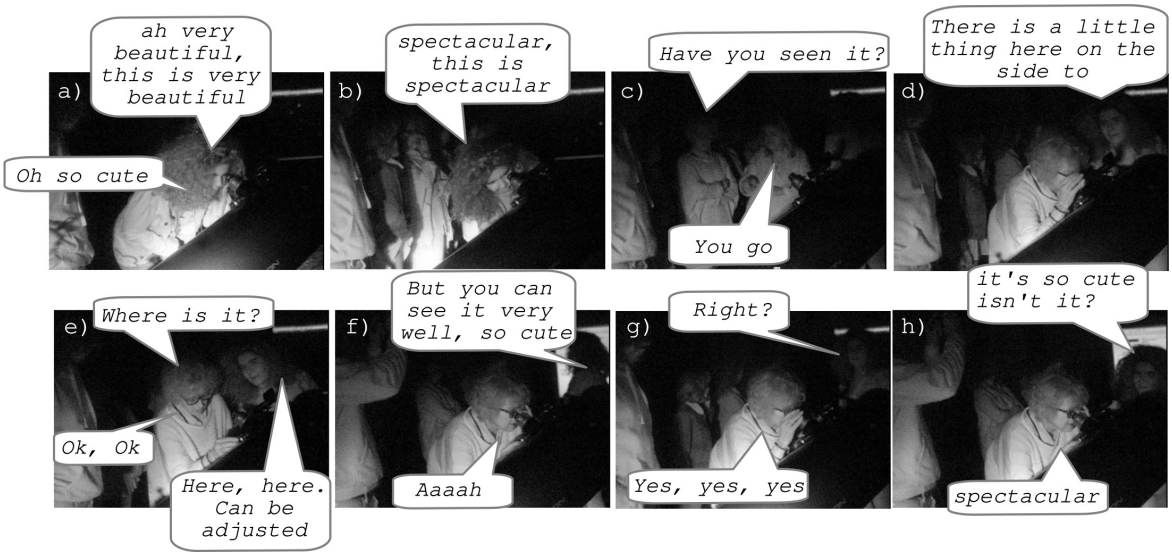

Figure 3. Excerpt 53. Collaboration and sharing emotions.

The woman with curly hair (here called V2) is the first in her group of friends to observe through the telescope. In screenshot a) (Figure 3) she looks delighted with the sight of Saturn, characterizing what she sees as "*cute*", "*very beautiful*", and later "*spectacular*". Her serial upgrading of positive comments primes overhearing visitors that they will also see something "spectacular" (see [Sacks, 1986]). She observes for some seconds and then moves away from the eyepiece giving space for others to observe. V3, the woman in glasses, is selected to go next (screenshot c) and she approaches the eyepiece starting to observe. V2 stays nearby and helps V3 to focus (screenshots d) and e), while sharing her accounts about the sight of Saturn and its rings (screenshot f). She shares this while walking away, encouraging her friend and preparing her. After some time (seven seconds) trying to observe, V3 finally sees it, "*aaaah*" (screenshot f). V2 immediately comes closer to share the emotion and the sighting of Saturn and its rings (screenshot g). She picks up on the statement she made earlier (screenshot f) and asks for its confirmation "*right?*" (screenshot g). When V3 confirms "*yes, yes, yes, yes*" (screenshot g), V2 goes further — not just you can see it clearly, but also "*it is so cute, isn't it?*" (screenshot h). Her friend agrees, "*spectacular*" (screenshot h). V2 seemed eager to share her delight, as something she had discovered and wanted her friend to discover too. Here we can see a clear example of collaboration and sharing. V2 had an emotional moment at the eyepiece and then prepares the way for her friend's observation by helping with the focus and technicalities, reporting to her friend what she thinks about it and how it looks; then waiting until her friend finally sees it, returning and sharing the "discovery" and what impacted her — the quality and beauty of the sight.

There are many other examples in the data corpus, such as "*Oh so cuuuute. You come and see it now. Look.*" (excerpt 41), or "*Wow, it is incredible, come see it*" (excerpt 206). In these two examples, observers don't just share their enjoyment, but invite their friends/families to observe. This invitation is another sign of a successful observation. People observe, enjoy, think that it is worth seeing and turn to their companions expressing their feelings, inviting them to experience it too, connecting through that emotional experience of observing a celestial object. In this way, emotional moments are closely related to the sharing of the experience.

5.2.2 ▪ *Experience of intimacy and authenticity*

Intimacy and authenticity are other characteristics of observations with telescopes that we found are iterated as emotional moments, which relate to magnification and a perceived proximity of the objects being viewed. This is visible in the interactions when, for instance, people interrupt their observation to look at the celestial object with the naked eye and then look again through the telescope. This is also sometimes highlighted by the guides, reminding visitors that "*You're really looking at it*" (excerpt 31) or by visitors who, in disbelief and wanting to confirm the authenticity of their experience, ask the guide if he/she is playing a trick: "*It cannot be, it seems that you glued a picture there. Is this real, what I am seeing?*" (excerpt 149).

This authenticity, and the one-to-one experience at the telescope, also create a sense of intimacy that some people formulate during their viewing. For instance, analysing Figure 4, we see a father observing through the telescope, sharing the experience with his son and stating that "*Saturn is right there*". He goes even further and makes a joke, personifying the planet and asking the son if he wants him to call Saturn to meet him where they are.

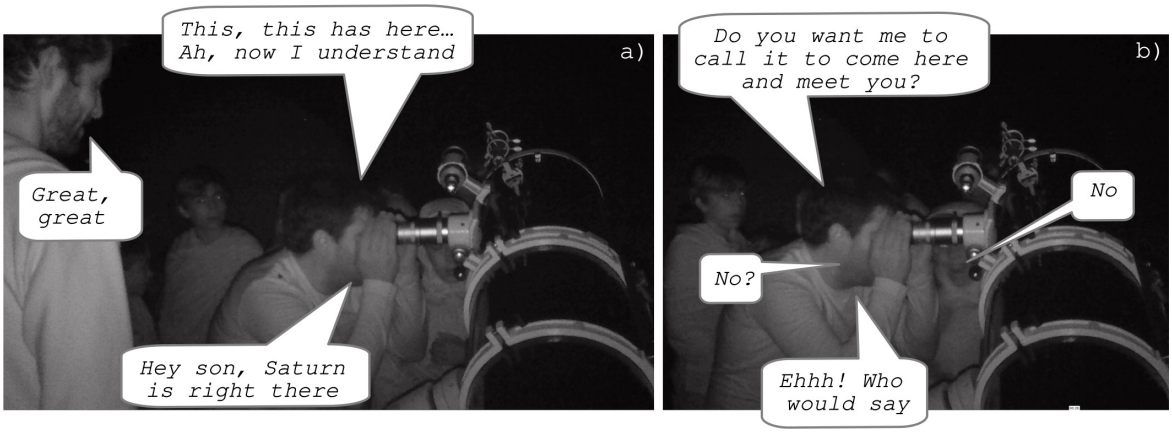

Figure 4. Excerpt 152. An intimate connection with Saturn.

In another example (Figure 5), a man observes the Moon and is amazed by its beauty and by the details of the craters, repeatedly exclaiming throughout his observation how beautiful the Moon is and how well he can see the craters. Like many others, this observation also has a feeling of intimacy. The interaction shown in Figure 5 is one of the multitude of viewings in which people observe through the eyepiece for a long time, sometimes more than 30 seconds, sometimes returning for a second view, contemplating the celestial object in a

one-to-one experience. Similar to the father in Figure 4, this visitor also comments in astonishment to a friend, "*as if it was here!*" (screenshot d), as if he was close to the Moon.

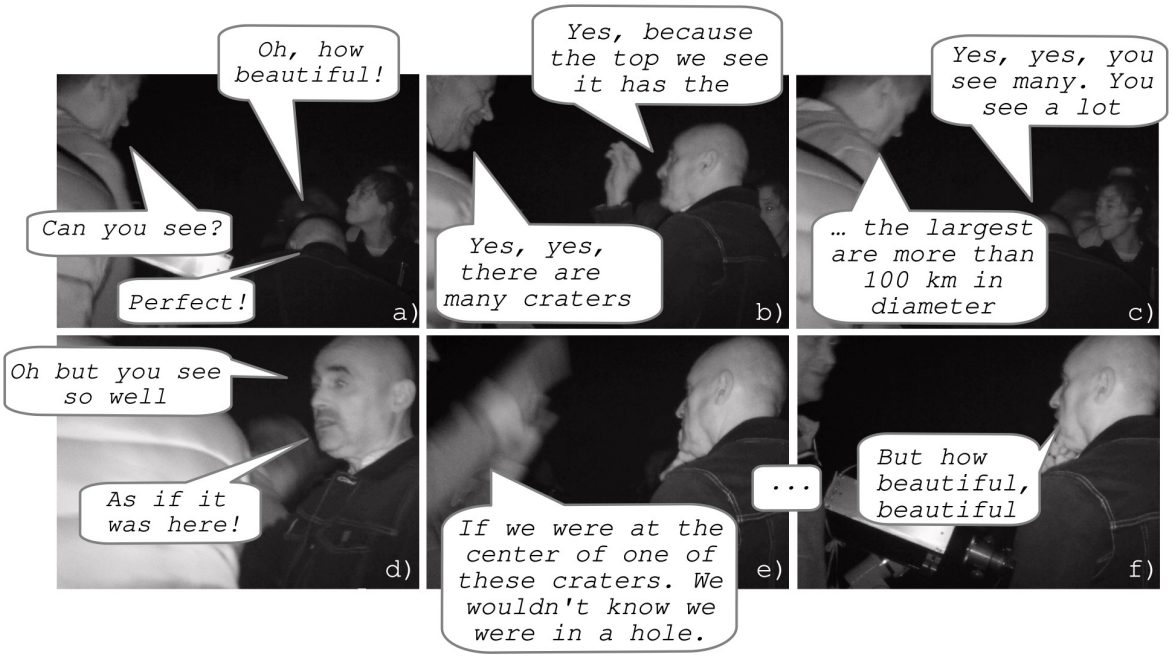

Figure 5. Excerpt 130. The Moon right here.

5.2.3 ▪ *Fostering curiosity and engagement*

In the specific case of Figure 5, the craters of the Moon attract the observer's attention. He seems enthusiastic and seeing these details clearly sparks curiosity and desire to understand what is being observed. In screenshot b), by starting to describe the image, he asks the guide to confirm that what he is seeing are craters. This curiosity, present in his comment, is seen by the guide as an opportunity to provide further information, occasioning an explanation about the characteristics of Moon craters (screenshot c).

In other pieces of data, we see similar interactions, where the emotional expression is followed by engagement, in the form of questions and conversations contoured with emotion. Throughout the data we found that emotional observations may trigger curiosity and, in most cases, availability to learn, to discuss facts and curiosities about astronomy and related subjects. It is common to see people ask about characteristics of planets and their locations in the sky, constellations, distance to galaxies, but also telescopes, satellites and other topics. Those questions are frequently tied to the objects being observed. Whilst attendance at this kind of activity may be motivated by some prior interest in these topics, our corpus of data indicates that emotional interactions often relate to ensuing talk about science topics, as in the example of Figure 5, above.

5.2.4 ▪ *Opportunity for reflection and contemplation*

Looking closely at the interactions presented so far, there is another component that accompanies emotional observations — a lasting reflection, as if people are taking time to

"absorb" the experience. We see it when the young lady in Figure 1 keeps smiling and looking at the telescope (screenshot e), we see it also with V2 in Figure 3, observing and repeating to herself expressions such as "*spectacular, this is spectacular*" or "*ah very beautiful, this is very beautiful*". Whether with gestures, silences or praise repetitions, people allow the experience to sink in, prolonging and reflecting upon it. In the data there are also instances of silent contemplation, while others produce repetitions of accounts, or more articulated reflections, as in the example of Figure 6.

Figure 6. Excerpt 124. Looking outside the galaxy.

When the young man in Figure 6 commences observing the Andromeda Galaxy, he is not very effusive but acknowledges that he is able to see clearly (screenshot b). He keeps observing in silence for some seconds and, while still observing, starts reflecting on what he is seeing, contemplating that distant object outside our galaxy. With the emphasis in his utterance "*spectacular!*" (screenshot d) and his questioning of the guide in subsequent turns at talk, it is clear that what he feels is spectacular is not just Andromeda and the good quality of the image (as he states in screenshot b), but the act of observing it. "*Maybe they are also looking back at us?*" (screenshot e), he asks after a pause. Andromeda catches his interest and he stays at the eyepiece for almost half a minute. He reflects on the act of observing and on the possibility of existence of other life, also capable of observing the Universe. As we cannot read people's minds, we don't know whether his musings are similar to what the young woman in Figure 1 is thinking while observing the Hercules Cluster. Yet our extensive analysis of the data suggests that visitors do experience contemplative and reflective moments and these are visible through silent, extended observations and expressive articulations.

6 ▪ Discussion

In observations of the sky groups of people with different experience, knowledge and curiosity about observations and astronomy gather together, looking at the sky with

telescopes. It is a complex setting for visitors. In dark, unfamiliar environments people have to understand where the telescopes (and queues) are, how and where to position in order to observe, what and when to look, how to look and what to see. In these activities different emotions are expressed. Taking an EMCA approach, we analysed the interactional details of expressions of emotions in 19 different observations of the sky with telescopes. Our research questions sought to identify and map the main contextual and interactional characteristics of the emotions expressed, and to investigate the implications of these expressions for the activity of observing the sky. Our findings show that emotional moments have distinct forms and placement in the interaction, are evoked by specific features of the activity and can play a role in each interaction. It is because we found that emotional expressions were intrinsic to interactions at and surrounding the telescope that we suggest that emotional moments are *fundamental* for explaining observations of the sky.

Emotions are expressed and defined in the interaction for the participants and by the participants. We suggest that emotional expressions index visitors' seeing and recognition of the phenomenon or object that is the purpose of the session and the guides' descriptions. Emotional expressions are culminations of the work that goes into the viewing, as well as appreciating the experience and object that is intended to be viewed. For a visitor to see anything at all through a telescope can be an achievement in itself — it is a trial-and-error process that may be immediate or take a number of seconds. Whilst observations of the sky are necessarily "equipmentally mediated" activities [Carlin et al., 2021b, 2024], in this paper we add that they are also "emotionally charged", in the sense that the presence of emotions is important in the production of these activities and that the feeling of positive emotions related to awe and inspiration is a part of the perceived purpose of these activities [Bossema et al., 2018; Davies et al., 2019; VanDyke & Yeo, 2024]. Recognizing that viewing celestial objects may comprise various simultaneous actions it is not necessarily the case that any metric of "emotion" attends only to facial expression or "Wow"-type utterances. If a visitor takes an extended turn at the eyepiece then this may also be an indicator of an emotional moment. Moreover, a long observation alone, mentioned earlier as a possible indicator of a positive emotional moment can, in other cases, be a sign of a struggle to observe properly. Our findings show that there is great variation and complexity in the way emotions are expressed in the interactions and that each occurrence relates to a unique set of verbal and non-verbal elements (known as "indexical expressions") in context. Every interaction is unique and should be looked at in the totality of its elements. Only by taking into account all the elements in the sequence of the interaction can meaning be established. Our study sought to contribute to this, by outlining the different aspects that need to be considered.

Emotions are not fixed, but can evolve and change during the interaction. For instance, the sight of the telescope can be a reason for joy and awe, but then getting to focus and look through the eyepiece can be a reason for frustration. Finally seeing successfully after the initial difficulties in focusing can again trigger joy and a sense of accomplishment, and this can become amazement as the observer appreciates what is being observed. This can all happen in 10 seconds as someone gets his/her turn at the telescope. This complexity was not explored in this article but is present in many of the interactions. Moreover, the role of the guide in guiding the observer through the interaction, whether helping a visitor to see [Carlin et al., 2021b; Marques et al., 2020] or managing the emotions expressed, is important in the interaction and deserves further attention.

We further contribute to the literature by highlighting the collaborative nature and the centrality of the sharing of the emotions in the interaction. Despite the observation ultimately being an individual experience of "getting to see the celestial object through the eyepiece", our results show that people share their emotional experience of observation, work collaboratively in order to help others to have that experience as well, and encourage them while they are attempting to see what evoked an emotional moment. In previous literature, sharing emotions, especially positive ones, was shown to facilitate social bonding, coalition and trust [Peters & Kashima, 2007]. It was also observed that people are more likely to share content that they find surprising and interesting [Milkman & Berger, 2014], which indicates that the sharing of the experience at the telescope relates to a positive experience and evaluation. Future research is required to confirm this in the context of observations of the sky.

Another interesting characteristic of the observation and a constituent of emotional moments is the expression of intimacy, of being "close" to the celestial object. This intimacy experience is an encounter between the observer and the celestial object, a connection mediated by the telescope. This intimacy has the potential to "*deliver powerful experiences*" [Ryding et al., 2021] and should be further explored in future research as a dimension of observations of the sky. Closely related to this dimension of intimacy is the feeling of authenticity, which relates to amazement, and sometimes even disbelief, of looking at the real object through the eyepiece.

Authenticity, which was observed in several excerpts, generates emotional responses produced in the interaction and is sometimes questioned. The topic of authenticity (and authentication) has been discussed for a long time in art, archaeology and heritage, and is not seen as "*an absolute and constant quality inherent in an object or an experience; it is constructed in the process of research*" [Fless et al., 2016]. The process of attributing authenticity to the observed celestial object may involve different dimensions that could be analysed in future research. In addition, the view of authentic celestial objects through the telescope can also evoke emotions of disappointment, if they are compared with astronomical images that proliferate in the media, as discussed by Carlin et al. [2024]. Nevertheless, the encounter with the real object is impactful and emotional, and consequently central to the experience of observing the sky, which is exactly an opportunity for the public to have contact with the astronomical objects, the equipment, and the observational practices. In science education, the concept of authenticity has been used with different meanings [Anker-Hansen & Andreé, 2019], such as "authentic" science education experiences are experiences comparable with practices of professional scientists and, in other cases, practices of non-professional citizens. Understanding how observations of the sky relate to professional and amateur practices may help better understand this authenticity dimension, and the consequent emotional moments that occur in these settings of informal learning, which provides another opportunity for future research.

Other emotional experiences identified are moments of contemplation and reflection prompted by the observation of celestial objects. Research shows that this contemplation and reflection are associated with expressions of awe and wonder [Darbor et al., 2015]. It is also associated with experiences in nature, where we can include observation of the sky, experiences that evoke emotions and feelings of the sublime [Bethelmy & Corraliza, 2019]. This contemplation and reflection can be about our place in the universe, its vastness and the existence of life in the universe, as seen in our data. These topics catch the public's attention

and interest. Future research is required to further understand the connection between observation of the sky, emotions and reflections about these philosophical questions.

Finally, we highlight that emotional observations may trigger curiosity and interest and, in many cases, willingness to learn, to discuss facts and curiosities about astronomy and related subjects. This connection between awe and curiosity was also found by Smith et al. [2010] in relation to the viewing of astronomy images; by Barragan and Meltzoff [2024] in relation to the access to the starry night sky; and by Sawada and Nomura [2024], who designed several experiments to show the relation between awe and curiosity related to the same awe-evoking subjects. Nevertheless, studying a science festival, Davies [2019] found, that "curiosity does not necessarily emerge naturally" [2019, p. 1], and that visitors report challenges in understanding what to do in the setting. These struggles are also present in our data. By mapping the characteristics of the expression of emotion, we contribute to the understanding of what prevents a positive emotional experience and what elements constitute a positive experience. In addition to those characteristics, our findings further indicate that authenticity, intimacy, contemplation, sharing and curiosity play important roles in the emotional experiences that need to be better understood. Investigating these aspects further may help guides to improve design and conduct observations of the sky in line with their intention of these being awe-inspiring [Kessler, 2012; VanDyke & Yeo, 2024].

7 ▪ Practical implications

Emotions are central in observations of the sky. The act of looking at distant celestial objects, observing and learning about them, attracts people of all ages and is often an emotional experience. Our findings show that these emotions are complex and have different roles and triggers within interactions, and identify the interactional characteristics of the emotional moments. This contributes to the study of emotions in observations of the sky as astronomy communication activities, and to the characterization and definition of these settings. From a theoretical perspective, our study contributes to the literature on observations of the sky and on emotions in astronomy communication by highlighting the collaborative nature and the centrality of the sharing of the emotions in the interaction, and by discussing expressions of intimacy, authenticity, contemplation and reflection, and curiosity. In doing so, our study helps to guide future research and contributes to the definition of observations of the sky with the public, as activities of science education and communication.

The accounts and other interactional aspects that we have identified are available as sources of knowledge that guides can use to read the observation, to understand the emotions displayed, and to manage these accordingly. In that sense, the results of this study, which make activities that people engage in at the telescope visible, also have implications for the training of guides and for the evaluation of observational activities.

Guides influence the outcomes of the observation. This may occur in a negative way, for instance if guides fail to help the public to observe; or in a positive way through interaction, as observed in the examples in Figures 5 and 6. Additionally, guides should recognize that the emotions expressed are co-produced by them and their audiences and that understanding how they are expressed, their complexity, and the different elements involved, may help to manage those emotions, improve the observation activities and the experience of the audiences.

Our characterization of the emotional interactions and the identification of the central elements involved in those interactions can therefore be used in the training of guides and assist in the reflection about their practices. For instance, acknowledging the importance of the shared experience, moments of sharing should be fostered throughout the observation activity. On the other hand, time should be granted to the observers in order not to be rushed to observe and having the opportunity to enjoy the intimate and contemplative experience. This should be encouraged, and many guides do it, however it may be that more effective strategies can be put into practice.

Our results can also be used to evaluate observations of the sky. The interactional characteristics of the emotional moments give us information about different aspects that can be used to evaluate the success of the observation. For instance the overall display of emotions (both positive and negative); the understanding of expectations and whether they are met or not; or the different interactional clues that point to the success of the observation, such as expression of positive emotion, display of curiosity, willingness to share the experience with others, indicators of reflection and contemplation, among others. All these are observable in the events that we studied. We are confident that these concrete aspects observed in the interaction can be used as indices for evaluation of the overall success of the activity in practice.

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