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Connecting with the Outside World: Psychosocially Supportive Aspects of Operational Communication Between Isolated Crews in Space and Mission Control on the Ground

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Abstract

Radio-based communication between crew members in space and mission control centers on the ground has the operational purpose of supporting the safe and effective execution of missions in space. Space-to-ground communication also, however, constitutes one of the relatively few interpersonal relationships astronauts have during missions and in addition to its operational purpose, this communication can support astronauts' wellbeing. The purpose of this paper is to identify psychosocially supportive aspects of operational space-to-ground communication between astronauts in space and spacecraft communicators on the ground. Through qualitative analysis of authentic mission communication, this paper identifies two supportive aspects and develops a terminology for describing these. *Operational kindness* describes operational messages that are considerate, show understanding of others, and include implicitly expressed enjoyment of associating with others. *Operational wit* describes operational messages in which not only content and clarity, but also the style with which a message is conveyed is given attention, by including a subtle wit or charm. Both are illustrated with excerpts from data and are discussed in relation to existing research.

Keywords: space-to-ground communication, psychosocial support, human space flight, mission control, interpersonal relationships, astronaut

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1. Introduction1[1]

Calls between astronauts onboard the International Space Station (ISS) and spacecraft communicators in mission control centers (MCCs) on the ground using space-to-ground (S/G) radio systems usually have a specific operational purpose. For instance, a ground-operated experiment could require someone to physically press a button onboard the station, equipment could be malfunctioning, or astronauts could have questions about a written procedure they are following. In the technical and complex working environment of the ISS (and any other spacecraft), it is of particular importance to know exactly which button to press or what specifically is unclear in a certain step of a procedure. To effectively and safely accomplish this, it is an ideal for S/G communication to be operationally relevant, concise, and clear (Fortunato & Lamborelle, 2012). Receiving correct and specific information from the ground is, however, not the only need astronauts have in the isolated, confined, and extreme (ICE) environment of space. They are physically isolated from Earth and confined by the boundaries of their spacecraft for typically 6 months at a time with the current missions to ISS. Although not the only support available, the day-to-day contact with spacecraft communicators on the ground is a connection to the outside world that has the potential to support astronauts in terms of both helping with operations and being psychologically and socially supportive (Kanas & Caldwell, 2000). The aim of this paper is to identify psychosocially supportive aspects of authentic operational S/G communication. Two aspects are identified and

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[1] **Abbreviations**: International Space Station (ISS); mission control centre (MCC); space-to-ground communication (S/G communication); isolated, confined, and extreme environment (ICE). The term astronaut is used throughout this paper to refer to crew flying and working in space, regardless of their nationality.

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termed *operational wit* and *operational kindness*. These are both aspects of S/G communication that coexist with the operational value of a given message rather than taking the place of or reducing this value. The perspective taken is that S/G communication can strike a balance where it has both a conciseness and clarity that make it useful and helpful on an operational level (thus, *operational*), and at the same time has qualities described as *kindness* and *wit*, which can be psychosocially supportive for astronauts (and in some cases also for ground crew), thereby supporting good working relationships between crew in space and MCC personnel on the ground.

1.1 Existing Research

As a backdrop for understanding the conditions under which S/G communication and its potentially supportive functions take place, the review first describes how real-time coordination and information flow is structured between teams of experts on the ground and astronauts in space. Secondly, some of the challenges of working in space and the need for psychosocial support are introduced. This second part draws heavily, but not exclusively, on the excellent astronaut diary study of Stuster (2016) and on insights from Bartone et al. (2019). The review also briefly lists other support measures available to astronauts and finally introduces findings from existing studies of S/G communication.

1.1.1 Structure of real-time coordination and information flow between mission controllers and astronauts

In order to support daily operations on the ISS a number of experts referred to as *flight controllers* are placed in MCCs on the ground with the job of remotely monitoring the many systems on the ISS that do everything from controlling experiments, removing CO_2 from the air, providing power and connectivity, and ensuring a suitable temperature for humans and equipment to mention a few. Some of these flight controllers are placed in a main room, and for some areas there are additional experts placed in backrooms.

The remote monitoring of on-board systems done by flight controllers is combined with a multichannel voice-communication system, that enables distributed supervisory coordination between flight controllers on the ground. This is an approach to real-time coordination that prioritizes quick information alignment where any problem or question from an astronaut can immediately be heard by all flight controllers on the ground, so that the one(s) with relevant expertise can quickly offer solutions or advice without the need for a gatekeeper to first delegate the information to the relevant persons (Caldwell, 2005).

At the same time, however, not everything said by any one person is heard by everyone else. The information flow is asymmetrically differentiated into three different types of voice loops as illustrated in Figure 1. While all flight controllers can hear what the astronauts are saying on the S/G loop, under normal circumstances only the spacecraft communicator in mission control talks with the astronauts on the S/G loop. The flight director in mission control has final decision-making power in ongoing flight operations, and decides what will be sent back up to the astronauts based on input from the flight controllers (Caldwell, 2008). A typical sequence of events is shown in Table 1, but the initiative can also come from the

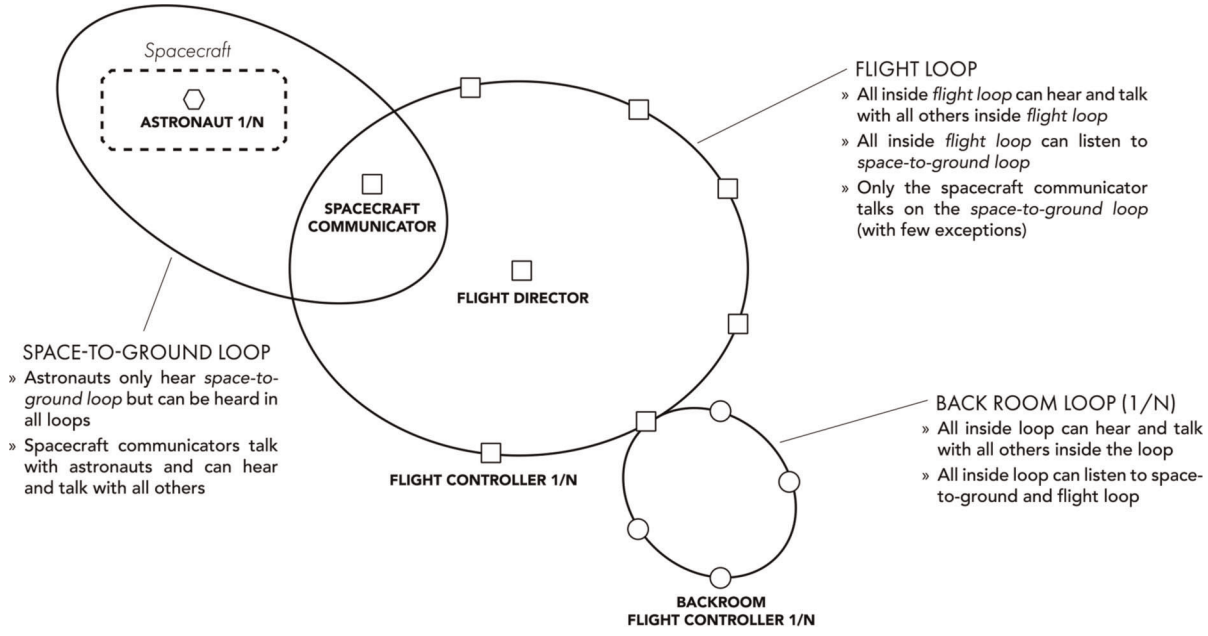

Figure 1. Configuration of communication loops involving MCCs and astronauts in space. 1/n denotes that a number of these persons or positions exist, so there a number of different flight controllers and astronauts and there are a number of different backrooms. Model based on Caldwell (2008).

Table 1
Typical sequence of events in S/G communication across loops.

Action	Heard
1: An astronaut asks a question on the S/G loop	In all loops
2: A flight controller (possibly in a backroom) with relevant knowledge offers an answer to the question	In flight and backroom loops, but not by the astronaut in the S/G loop
3: The flight director reviews the given answer(s), decides what should be done, and asks the spacecraft communicator to answer the astronaut	By all in the flight and backroom loops, but not by the astronaut in the S/G loop
4: The spacecraft communicator answers the astronaut	The astronaut in the S/G loop and all in the flight and backroom loops

ground, if flight controllers for instance identify a problem through their remote monitoring of onboard systems and ask an astronaut to help fix the problem.

The analysis in this paper is of the communication happening in the S/G loop between astronauts in space and spacecraft communicators in mission control on the ground. One of the working conditions for spacecraft communicators is that they are often not the ones with the expertise needed to answer questions (other flight controllers have this) nor can they decide fully on their own what to answer (the flight director has final say in this).

1.1.2 Conditions for working in space: challenges from environmental factors

There are several environmental factors that can be challenging to astronauts. Working on a spacecraft in microgravity makes even simple tasks complex and time-consuming. This was explained by one astronaut as similar to having to sort a bag of M&Ms into separate colors and put each color into a different bag. Without gravity assisting, the M&Ms cannot simply be poured into in a bowl for easy access, but would float around in the air, as would the bags they were to be sorted into. Other factors include high CO_2 levels in the air on board, which can cause frequent headaches. The written procedures describing how to solve tasks can be unclear or even incorrect and equipment will malfunction (Stuster, 2016). There are also the physical dangers of being in space, which can be a near-constant source of stress for astronauts. These include the risk of radiation exposure, the loss of bone and muscle mass from extended periods in microgravity, and being fully reliant on supplies and a range of technical equipment on board to work (Bartone et al., 2019).

Finally, the prolonged stay in confinement with a small group of people who have not chosen each other for company can be difficult. The physical and social isolation from people on Earth, in particular the family and home of the astronaut, can also cause psychosocial stress (Sasahara et al., 2020) as the fellow crew are not the same people that make up a crew member's normal support system. In other words, although "you are with other people, they are not *your* people" (Bartone et al., 2019, p. 6).

1.1.3 Conditions for working in space: challenges from organizational and interpersonal factors

Astronauts sometimes (perhaps half-jokingly) describe themselves as *glorified lab technicians* (Slavens, 2018), *glorified maintenance personnel* (NASA, 2012), or *glorified construction workers* (Space Channel, 2020) and the reality behind this joke can be traced back to several factors. Firstly, that although *astronaut* is arguably a prestigious job title, life in space involves a lot of the same mundane tasks we find in jobs on Earth, such as cleaning and maintenance, just as things also break in space and need repairing. Secondly, the ISS is an extremely complicated machine consisting of numerous systems that require specific expertise to develop, maintain, and repair, and for this reason, there are specialists on the ground who diagnose problems and develop instructions for the astronauts, who are not allowed to independently take action before checking with mission control. Thirdly, when not maintaining the station, astronauts spend most of their working hours conducting experiments designed by principal investigators on the ground, and here again, most of the development and planning take place on Earth and only the execution of specific tasks is performed by astronauts in space (Uhlig et al., 2015). This separation of planning and execution can lead to astronauts feeling distrusted by ground-based personnel, for example when they are not allowed to make what they consider small decisions or judgements themselves but have to check with the ground first. Some astronauts have described how they will try to avoid asking the ground questions about a procedure they do not immediately understand, as they do not want to appear incompetent (Stuster, 2016).

Astronauts also experience time pressure to complete tasks that have been planned and allotted a certain amount of time to finish on Earth, but that often take longer to do in practice in space. There is a *continuous battle with time* as one astronaut described it, worsened by the aforementioned environmental factors (Section 1.1.2) that make it challenging to work in space. There can be a disconnect between how complex the planners on the ground think a task is, and thus how long it will take, and the actual hands-on experience in space, where things can take longer than anticipated, leading astronauts to experience time pressure (Bartone et al., 2019; Stuster, 2016).

1.1.4 Conditions for working in space: psychological support measures

In this challenging working environment, there are a number of psychological and social support measures available to astronauts. Although the day-to-day S/G communication in this paper is argued to potentially play an important role in being supportive, it is by no means the only contact astronauts have with the ground.

There are people on the ground tasked with supporting the wellbeing of the astronauts as best as possible, e.g., through the arrangement of special private events with celebrities on Earth. Astronauts can also audio and video call their families at certain times. Some astronauts describe broadcasting to the public through social media and public events as beneficial to them, as they get a sense of encouragement and positive feedback on their work (Bartone et al., 2019; Stuster, 2016).

Outside of their contact with the ground, the beauty and wonderment of actually being in space and being able to observe Earth from the outside have also been reported as awe-inspiring and beneficial (Yaden et al., 2016).

1.1.5 Existing studies of S/G communication

The Russian Federal Space Agency has been using S/G communication to monitor the status and wellbeing of their crew in space since the 1970s. Based on content analysis through categorizations of the statements made (coding) and quantitative measures such as the POMS scale, diagnostic methods have been developed and used (Kanas et al., 2008). For instance, studies have found that a drop in the frequency or duration of calls could be a sign of the crew distancing themselves from the perceived interference of mission control or of diminished wellbeing among the crew. Content analysis of statements in S/G communication has also found themes similar to those of interest to the present study. Some statements were categorized as expressions of encouragement, such as compliments, gratitude, humor, and jokes (which were noted to help relieve tension), and others as warm-hearted humor and phatic expressions (i.e., expressions that serve to establish and maintain contact). Analysis has also distinguished between work and non-work conversations and found that one communicative strategy from crews in space is to engage in non-work conversations and to use humor, phatic communication, and criticism when trying to avoid additional workload from mission control on the ground (Gushin et al., 2016; Yusupova et al., 2019).

In another coding-based study of astronaut interviews and other documents, Brcic et al. (2018) found that among astronauts humor is used to support cohesiveness in interpersonal relationships (termed "affiliative humor"), as a form of individual self-care when, e.g., upset or unhappy (self-enhancing humor), and as a tool for handling problems and stressful events (humor as coping). The authors note that since astronauts are comfortable using humor in stressful situations, their ground-based space agencies can also use jokes and humor to relieve stress and reframe problems to something less troublesome. This paper picks up on this recommendation by demonstrating how this is done in practice with examples of ground crews using humor in their interactions with astronauts.

1.1.6 Supportive forms of communication: the risk of praise inflation

A particular aspect of S/G communication that is of special interest to the present study is praise inflation. This is a practice where both spacecraft communicators in MCCs and crew in space will give numerous compliments and encouragements to each other, even when not deserved. Praise inflation is done with the purpose of maintaining strong interpersonal relationships that foster effectiveness in problem solving and task completion. The phenomenon also includes avoiding conflicts and confrontation, e.g., by not mentioning problems and deficiencies. However, a known problem with giving this amount of praise is that if everything a person does is answered with praise, it becomes perceived as unauthentic and consequently loses its value to the recipient (Stuster, 2016). Along similar lines, Gushin et al. (2016) refer to an *agreement* communication style in S/G communication, which supports emotional stability, reduces the number of conflicts, and lowers stress among crew, but runs the risk of hiding real problems of stress, onboard tensions, and diminished wellbeing caused by isolation and confinement. Praise inflation is what intended psychosocially supportive S/G communication risks turning into, and one focus in the analysis in this paper will be how this can be balanced.

1.2 Contribution

The aim of the present study is to contribute to knowledge on S/G communication in two areas. The first is methodologically by doing microlevel analysis of transcripts demonstrating in detail the mechanics and relational dimensions of S/G communication on authentic mission data. Existing research has focused more on coding-based categorizations of this communication and this paper seeks to contribute with an in-depth more contextualized perspective. Although supportive elements and, e.g., the use of humor have also been identified in existing research, this paper seeks to demonstrate how these are closely intertwined with otherwise operational messages. Existing research has made an either/or distinction between work and non-work conversations. Very little non-work conversation took place in the observation period of the present study, so while non-work conversations could also be psychologically and socially supportive, this paper exclusively addresses how work conversations, referred to as "operational communication," can serve that dual purpose. Secondly, this paper also aims to contribute

to developing a terminology for effectively describing the supportive aspects of S/G communication identified herein, which can serve as a useful terminology in training spacecraft communicators, other mission controllers, and astronauts.

2. Material and Methods

2.1 Material

The data analyzed in this study covers 189 hours of observation of S/G communication between mission control on Earth and astronauts on the ISS. NASA livestreams the publicly available channels of this radio communication to the internet, from which the data were accessed. In the observation period, 310 minutes of English-language S/G communication took place, and these conversations were transcribed to enable analysis. For privacy reasons, the names of all persons have been changed and Russian language S/G communication had to be excluded due to researcher language limitations.

2.2 Methods

The analysis is a case study that seeks in-depth understanding of the phenomenon under study by focusing on a limited amount of data. Case studies accept a trade-off where increased depth of understanding through contextualized explanation is achieved at the cost of width and quantitative generalizability (Thomas, 2011).

Parts of the 310-minute dataset were selected for further analysis by reading the transcripts a number of times and then performing an abductive selection process (Bryman, 2016, p. 394). Interactions found to potentially be more than purely operational were selected and analyzed in more detail, sometimes to be excluded if no supportive communicative aspects could be identified, and otherwise to be included and analyzed further.

The qualitative microlevel analysis of the selected data was based on pragmatics and speech act theory (Alrø et al., 2016; Mey, 2001), which focuses on how language is used in practice—how it is given meaning by the people participating in the conversation. This method of analysis explores the space between what people say and which intentions they, sometimes quite indirectly, express through these said words in a conversation. Analytical interpretations were made through a process starting with identifying observable or close-to-observable characteristics, and then progressively moving towards less observable interpretations of the indirectly expressed meanings and intentions of the persons involved in the conversations. Each time an interpretation was made, its validity was critically reassessed against the data and other possible interpretations that could be better fits. Interpretations were also crosschecked by two senior experts in the field of communication analysis. Finally, transparency in the interpretations was ensured by including both the raw data and the interpretations in the analysis in Section 4.

The interpretations were qualified using existing theory, as presented in Section 3. As an example, a frequent use of metaphors was identified, and this led to consulting Jakobson's (1960) theory on the poetic function of language, which then further informed the analysis.

The terminology developed in this paper (operational wit and operational kindness) grew out of an analytical dialogue between interpretations of the data, theoretical ways of understanding these, and the researchers' desire to choose illustrative terms that would make sense in the context of training practitioners in the human spaceflight industry.

For brevity reasons, the findings are presented in the paper using illustrative data excerpts, rather than the full extent of the data analyzed.

3. Theory

The development of the two concepts of operational wit and operational kindness was informed by existing theories coupled with the analysis of the data. These concepts are introduced and defined in this section and subsequently demonstrated through analysis in Section 4.

3.1 Theoretical Foundations of Operational Wit

3.1.1 The poetic function of language

Besides referring to something in the world (words are words about *something*), there are other functions of language. Jakobson (1960) argues that there are aspects of communication in which the focus is on the message for its own sake, in the sense that the same message could be expressed in quite different ways, and these different ways are the focus of what he calls the poetic function of language. For example, the content of the famous victory message attributed to Julius Caesar *veni, vidi, vici* ("I came, I saw, I conquered") could also have been expressed by saying *I moved to a location with my army, observed what was there, and then won a battle against the enemy's army*. While the content of the two messages is similar, the form differs, with the former showing some creativity in composition, as *veni, vidi, vici* has a certain rhythm and rhyme, being three words all of the same length, starting with v, and ending with i (Jakobson, 1960).

Nerlich and Clarke (2001) argue that the use of creative expressions and metaphors (i.e., the poetic function of language) can make conversations more interesting and engaging for the conversation partners because of the added novelty and wit. Consequently, if operational messages in S/G communication were rigidly kept as short and specific as possible (the operational ideal previously introduced in Section1), they would risk becoming stale and sterile forms

of human interaction, and they would lose the potential for creating the intimacy and social bonds that using the poetic function of language can bring.

3.1.2 The use of humor in professional contexts

Along similar lines, it is well documented that humor and laughter can have both physiological and psychological benefits for humans also in professional work contexts (Elliot, 2013). Although making jokes could be nonprofessional behavior or could be categorized as a nonwork activity (though it might still take place on the job), joking and humor can also be used by professionals, for example, to cope with difficult or frustrating situations in their jobs, thus making it a more integrated part of their work (Brcic et al., 2018; Richards, 2010).

3.1.3 Definition: operational wit

The term *wit* was chosen for its reference to: "the ability to use words or ideas in an amusing, clever, and imaginative way" ("Wit Definition and Meaning," 2022) and based on Jakobson's (1960) poetic function of language and Elliot's (2013) descriptions of the use of humor in the workplace, this paper defines operational wit as a form of creative language use in which operational messages in S/G communication are conveyed in a subtly humorous, metaphorical, or otherwise imaginative way. Operational wit entails that not only the content of a given message, but also the form or style of the message in itself is given attention in S/G communication.

3.2 Theoretical Foundations of Operational Kindness

3.2.1 Sociability

Simmel (1911/1949) introduced the concept of *sociability*, which describes an inherent satisfaction arising from being associated with others and the human impulse that drives us towards this form of interpersonal relationship. It can be found in contacts and encounters which are initiated and driven by another purpose but which at the same time enable the parties involved to simply enjoy associating with each other. Although there are exceptions, the argument is that in many of the contacts humans have with each other, while we are brought together by purposes other than just associating, we also experience some joy in having gone from solitariness to a form of togetherness; this joy is what sociability describes. This joy is not necessarily expressed directly in conversations but can still exist between conversation partners as they enjoy interacting, for example while solving a task together. The task that is solved—or in S/G communication, the operational purpose of a conversation—can be understood as a *carrier wave* of sociability, as something conversation partners do together and that also enables them to enjoy each other's company (Frederiksen, 2018).

3.2.2 Congruence, empathy, and confirmation

Rogers (1962) argues that in the professional work that takes place in helping relationships (e.g., counseling or teaching), the most important predictor of effectiveness in helping others is the quality of the relationship itself. The techniques and skills learned, such as asking good questions in counseling or providing effective instruction in teaching, are only secondary, as the success of these techniques and skills relies on the quality of the relationship between counselor and client or teacher and student. Rogers outlines three relational qualities in helping relationships. These are congruence, empathy, and positive regard and, as will be discussed below, these have been adapted by Kristiansen and Bloch-Poulsen (2005) to work contexts other than helping relationships. If we apply Rogers' line of thinking to S/G communication, the best response to an astronaut in need of help from MCC is one that is conveyed through an interpersonal relationship between the spacecraft communicator and the astronaut that has certain qualities.

The term "organizational congruence" describes a state in which the feelings that conversation partners experience are available to them. In other words, they are not trying to ignore or suppress inner thoughts or feelings, but rather they recognize and are able to authentically live these feelings in interactions and communicate them to conversation partners when relevant. Being congruent is a form of authenticity. It is the opposite of playing a role or saying things one does not feel, and Rogers (1962) argues that people who are congruent, i.e., who are not trying to work from behind a mask, will build trust in their interpersonal relationships with others. Organizational empathy, meanwhile, is the ability to understand other people's ways of thinking and acting in their jobs and the conditions they are under, which can differ between people, professions, departments, and job roles. Organizational confirmation means being considerate, accepting of others, and offering positive feedback and confirmation in interpersonal relationships when relevant (Kristiansen & Bloch-Poulsen, 2005; Rogers, 1962).

3.2.3 Definition: operational kindness

The term *kindness* was chosen for its reference to a "helpful or considerate act" and to "the quality of being gentle, caring, and helpful" ("Kindness Definition and Meaning," 2022). Based on Rogers' (1962) description of the qualities of interpersonal relationships and Simmel's (1911/1949) concept of sociability describing an inherent value found in associating with others, this paper defines operational kindness as authentic but often indirect and subtle expressions of enjoyment found in socializing during operational communication and acts of helpfulness and showing understanding of the other person's perspectives and working conditions. Operational kindness can involve verbal gestures and pleasantries included in operational S/G communication.

4. Analysis and results[2]

4.1 Operational Wit in Procedure Descriptions and Operational Kindness Through the Expression of Appreciation of Each Other at the End of a Conversation

In this first data excerpt, some operational wit was evidently employed in a written task list, and this spills over into the S/G conversation. Astronaut Lauren has been talking with spacecraft communicator Jim at MCC about a couple of other things and finishes the conversation with the following:

(1)	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Lauren (ISS)	And lastly there's the ***scoochie scooch*** activity for the SSC on the task list. I just did that one as well and I wasn't able to get six inches I think given the current config. So let's have them check out the temperature and see if it is improved. I definitely did improve the situation somewhat, but we can re-evaluate the config if we still need to. Right now, I just try to leave them relatively in the same config that they are in, but just giving them more space. But we can further evaluate as needed.
	16 17	Jim (MCC)	Okay copy let us look at the temperature for a while.
	18 19	Lauren (ISS)	***Okay*** thank you Jim. Have a great day. [lighter tone of voice than 1-15]
	20	Jim (MCC)	Thank ***YOUU.***

An SSC is a laptop computer and the activity discussed seems to involve moving the mentioned computer away from something else to prevent too high a temperature building up. Astronaut Lauren first lets spacecraft communicator Jim know that she will now be talking about an activity that she sees on the task list (lines 1–3), a list that is digitally available to both her on the ISS and Jim at MCC. This activity has a peculiar name in that it is called "the ***scoochie scooch*** activity" (1–2) and Lauren signifies this peculiarity by slightly changing her tone of voice when pronouncing its name. The term "scooch" can be used in the phrase *scooch over*, which is a way to ask someone to make a bit of room, e.g., on a bench, in order to also sit down on it ("Definition of SCOOCH," 2022). Calling the activity something with "scooch" draws on that meaning of making room, and the "scoochie" in front adds another layer to this playful way of describing the mundane task of moving something six inches, thereby making it an example of operational wit, where a subtle bit of humor is worked into otherwise operational content. A more strictly operational name for the same activity could have been *the SSC repositioning task*, for example, but instead we see that some attention has been paid to the style and form of the message.

Later in the conversation, Lauren reports to the ground that she has moved the laptop and how far she was able to move it (3-5). She then gives her assessment that she "definitely did improve the situation somewhat" (8-9), and that she has tried to keep things in the same place as they are now (11–14), but is open to moving things around more if an evaluation shows this is needed (9–11, 14–15). Jim acknowledges he has understood and accepts Lauren's suggestion that they evaluate by saying that MCC will "look at the temperature for a while" (16–17). Having finished this operationally necessary exchange of information, Lauren changes to a lighter tone, thanks Jim, calling him by his first name, and wishes him a great day (18–19). Jim also answers in a different tone of voice, saying "***thank YOUU***" (20), drawing out the last syllable slightly, again adding a subtle change of style to the form, distinguishing it from a more formally polite thank you, which could have been spoken in the same tone of voice as the rest of the conversation. This last very short exchange is an example of operational kindness, in which Jim and Lauren share a more informal tone and express appreciation towards each other.

4.2 Operational Wit When Dealing with a Reoccurring Problem

In the excerpt below, astronaut Lauren introduces a problem with another laptop to MCC, and after having detailed the troubleshooting already done, operational wit is employed at the end of their exchange on this topic.

(2)	1 2	Lauren (ISS)	Houston, station on 2 for SSC 22 and task list
	3 4	Jim (MCC)	Go ahead for SSC 22
	5 6 7 8 9 10 11 12 13 14 15 16	Lauren (ISS)	Yeah good morning Jim. It's Lauren. Couple of things. First of all for SSC 22 it was working normally this morning but then Joey went to launch a DCT software and that seems to hang it up. So we did already two hard reboots including removing power and the battery and now it will reboot, you can log in, but it doesn't seem to be loading everyth; it's not loading the home page or any

[2] In the transcripts, bold and italics mark emphasis through, e.g., change of tone or volume. Words in square brackets are descriptions of actions taken by the speaker, that are not words, e.g. laughter.

17 18 19 20 21		product. And I checked the connections. I didn't see anything obvious. So if you guys could come aboard and take a look at that.
22	Jim (MCC)	Okay. Copy.
		[1 min 12 sec conversation about another task, before the conversation returns to SSC22]
23 24 25	Jim (MCC)	… And say again, if you would please, the software that you were trying to get to on SSC 22.
26 27 28 29 30 31 32	Lauren (ISS)	Yeah I wasn't actually trying to. Joey was trying to open a data collection tool and that seems to be what caused the problem. And now it's just not really connecting to anything in terms of explorer. The computer did reboot though.
33 34 35 36	Jim (MCC)	Okay copy. I've fought many a wars with the data collection tools so copy that one [slight laughter]. We will see what we can do.
37 38	Lauren (ISS)	Yeah, we weren't that overly surprised. Exactly.

Astronaut Lauren calls MCC, letting them know that her inquiry is about computer "SSC 22" and "task list" (lines 1–2). Spacecraft communicator Jim lets Lauren know he heard the call and is ready to answer about SSC 22 (3). Lauren says good morning and uses Jim's first name, without him having introduced himself beforehand, meaning she must have recognized him from his voice alone (5–6) making this an operationally kind gesture, through which she shows that she knows who Jim is. She goes on explain that there is a problem with computer SSC 22 that started after astronaut Joey launched a DCT (data collection tool) software package (6–11). She details the troubleshooting steps they have already gone through (11–18) and finishes by asking MCC ("you guys") to "come aboard and take a look at that," i.e., asking MCC to remote access the computer and troubleshoot (19–21). Jim accepts (22), and they talk about another question Lauren had before returning to the question of which software they were trying to access on the computer (23–25). Lauren repeats that it was a data collection tool that seems to have caused the problem (26–32). Jim answers that he understood ("Okay copy"), thereby indicating that he, for the operational purpose of troubleshooting the problem, now has the information he needs (31). After a slight pause, he adds something that shows operational wit, saying "I've fought many a wars with the data collection tools, so copy that one," and laughs a bit afterwards (33–35). "Many a war" is a fixed expression that can be found in English literature dating to the early 1800s (*Many a War*, 2022) and Jim is drawing on this old expression (almost as something a fictional character might say) to express metaphorically that he himself has had numerous problems relating to DCT software. This, together with "so copy that one" (35), indicates that he finds it both unsurprising and, with the laughter, a bit amusing that such a problem is occurring again—or at least that this is an experience one can only deal with by trying to laugh a bit about the continuously troublesome software (the alternative could have been to express frustration) ("Definition of Have to Laugh," 2022). Lauren replies with agreement, "yeah" (35), followed by saying that they "weren't that overly surprised" (37–38). By saying they were the opposite of very surprised, she is indirectly emphasizing that they on ISS are also familiar with problems caused by data collection software, and finally underlining how she recognizes Jim's fight with the tools "exactly" (38).

Rather than expressing frustration or discontent with a malfunctioning system, the way they communicatively deal with this tool repeatedly causing problems is, first by Jim to employ operational wit by talking in a stylistically playful way about how this tool can be troublesome, and that this can be laughed about. His aim is perhaps to offer a subtle expression of sympathy, or to let the ISS crew know that he understands the situation of having problems with the tool. Secondly by Lauren as he responds by expressing how they, on the ISS, share his experience with the tool.

4.3 Operational Wit When Dealing with Prolonged Troubleshooting

(3)	1 2	Madilyn (ISS)	Houston station on two for CrewNet
	3	Jim (MCC)	Good morning
	4 5 6 7 8 9 10	Madilyn (ISS)	Good morning Jim. Great to be with you today. I believe Joey left a note about us not being able to connect to CrewNet and we're up now and I was wondering if there are any actions we could take.
	11	Jim (MCC)	***Okay*** stand by, just one
	12 13 14 15	Madilyn (ISS)	***Thank you.*** And also any info you guys have on the Astros won or not. We haven't been able to check.

16	Jim (MCC)	Astros 4 to 1 over the Nats
17 18	Madilyn (ISS)	***Go 'stros.*** That's great (smiling voice)

[other conversation followed by 12 min silence]

19 20	Jim	Station Houston on two for Madilyn
21	Joey	Go ahead Jim
22 23 24	Jim	So we're still working on the CrewNet piece of the equation. Couple of questions for you (…)

[2 hrs 52 min]

25 26	Jim	Station, Houston on two for CrewNet.
27	Chris	Go ahead Jim
28 29 30 31	Jim	Okay. We had one ***missing T*** that wasn't crossed. Can you to check see if your CrewNet is working now.
32 33 34 35 36 37	Chris	I'll give it a try right now. (13 sec pause) And Royce, with my attempt I got unable to join network ISS CrewNet 2.4 gigahertz. I'll have somebody else give it a try.
38 39 40 41 42 43	Jim	OK very good. I think eh I think we're still going to have to find the I that's not dotted and I'm going to turn it over to Allison's ***capable hands*** and she'll get it all squared away hereafter.
44 45 46 47	Chris	Okay copy. We'll still have someone else give it a try on a different iPad (…) We'll let you know if we do get joy

[1 hr 3 min]

48	Madilyn	Houston station on two for CrewNet
49	Allison	Go on two
50 51 52 53	Madilyn	So it looks like that wasn't the magic bullet either, but thanks for letting us give it a try. [slight laughter]
54 55 56	Allison	All right. [smiling voice] Copy, we are going to continue troubleshooting on the ground.

This data excerpt is from a Saturday on which the first call heard in the S/G loop starts at around 10:00 in the time zone followed on the ISS, when astronaut Madilyn calls MCC Houston concerning "CrewNet" (lines 1–2), referring to the system that gives astronauts internet access on the ISS. Spacecraft communicator Jim answers by greeting her "Good morning" (3). Madilyn says "Good morning" back and includes the name of the spacecraft communicator, "Jim," which she must have recognized by his voice alone, as he has not identified himself. She adds another operationally kind pleasantry, "great to be with you today" (4–5). She then explains that she thinks another crew member, Joey, left a note for the people in MCC about how the crew on the ISS are unable to connect to CrewNet and she would now like to know if there was something the crew could do to fix this problem (5–10). Jim acknowledges and asks them to stand by "just one" (11). Madilyn emphasizes a "***Thank you***" and asks about the result of a baseball game, as they have not been able to check themselves on the ISS (12–15) due to CrewNet not being available. Jim answers right away that the Astros won (16) and Madilyn expresses excitement about this (17–18).

Over the following 7 hours, MCC attempts to locate and fix the problem with CrewNet and makes contact with ISS on six separate occasions: three when they think they have solved the problem remotely from the ground and ask the crew to check, but the problem remains, and three which require the crew's active involvement in power cycling (switching off and then on again) systems on the ISS as part of troubleshooting. Some of these instances of S/G communication have been omitted here for brevity. What is of interest to this paper is the way they communicate when working on this problem, where operational wit, through the use of metaphors, is repeatedly used.

This starts with Jim calling the station again 12 minutes after having been introduced to the problem with CrewNet and asking for Madilyn (18–19). Astronaut Joey answers in Madilyn's place and Jim explains that he is calling about troubleshooting the CrewNet access problem, "So we're still working on the CrewNet piece of the equation" (22–23), metaphorically meaning that just as equations can be solved when all pieces have been found, there is still something missing for them to be able to fix CrewNet.

Almost three hours later, Jim calls the station again (19–20) and astronaut Chris answers this time (21). Jim says "Okay. We had one ***missing T*** that wasn't crossed. Can you to check see if your CrewNet is working now" (28–31). He here uses another metaphor to express how there was something missing for CrewNet to work. This metaphor comes from the expression to "dot the I's and cross the T's," which means doing something very meticulously and paying attention to detail, especially when completing a task ("Dot the I's and Cross the T's,"

2022). Jim is expressing that they have found one final detail in their troubleshooting that they think was the problem, and now asks the astronauts to check. Chris checks right away and is unable to access CrewNet, but says he will ask another crew member to check as well (32–37). Jim acknowledges "OK very good" (38) and seems to think the other crew member will probably also not be able to access CrewNet, as he continues by using a variant of the metaphor he introduced in (28–29) by saying: "I think eh I think we're still going to have to find the I that's not dotted" (38–40), thereby expressing that in addition to the metaphorical last line missing over the *T*, they now have to look for some other small detail missing somewhere, as one does when looking over a page for an *I* that is missing a dot. Jim is metaphorically talking about the problem as something that just needs one final detail to be solved. Then, his shift must be ending as he uses another fixed expression: "I'm going to turn it over to Allison's ***capable hands*** and she'll get it all squared away hereafter" (40–43). To get something "squared away" means to complete all necessary arrangements ("Square Something/Someone Away," 2022), and so he is saying that he is sure Allison, with her ***capable hands***, will find a solution to the problem when she takes over as spacecraft communicator. Chris answers that even though Jim concluded there was likely still a problem, he will still have someone else from the ISS crew check (44–47).

Around 45 minutes later, Allison from MCC calls back saying the ground crew have tried something else, but the astronauts report back that this still has not fixed the problem. The astronauts offer to power cycle a unit and MCC accepts (this interaction is further analyzed in Section 4.5).

Fifteen minutes after this, astronaut Madilyn calls the ground, informing them that this also did not work, and she does this using a new fixed expression: "So it looks like that wasn't the magic bullet either, but thanks for letting us give it a try [slight laughter]" (50–53). Allison in MCC answers by matching Madilyn's slight laughter and by acknowledging that she understands (54). A "magic bullet" is a very effective solution to a problem ("Magic Bullet," 2022), so Madilyn is saying that what they are looking for is a very effective solution, but that they still have not found such a solution with this attempt.

The incorporation of these metaphors into the operational messages connected with troubleshooting CrewNet shows operational wit being employed by both spacecraft communicators and astronauts. This same operational content could have been expressed without any use of metaphors. For example, instead of referring to the desired solution as a piece of an equation, the crossing of a T, the dotting of an I, or a magic bullet, the message from MCC could have been *we now believe CrewNet has been fixed, please check to see if this is the case, at your convenience*; the crew could likewise have responded *we are still unable to connect to CrewNet.*

One interpretation is that the employed operational wit functions as an indirect apology for taking so long to fix the problem, and as a way to express that it is a small thing that is causing the problem, which will be easy to fix once that small issue is located. As the astronaut first describes the problem, when Jim is in need of more information, he describes the problem as a piece of an equation. After that, he continues to talk about the solution as something small, or as a last thing that needs doing. When informing the astronauts that another spacecraft communicator is taking over, he refers to her having capable hands, i.e., as someone who is skilled, and promises on her behalf that she will help fix the problem. These instances show a subtle imaginative use of language in a potentially frustrating situation, which could help defuse the frustration connected with a systems malfunction that, in this case, has left the crew without internet access.

4.4 Operational Kindness When Giving a Troubleshooting Update

(4)			
	1	Chris (ISS)	Houston station on two for SSC 22.
	2	Allison (MCC)	Go for SSC 22.
	3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	Chris (ISS)	Good morning, Allison, or good afternoon, er, good morning. I know that you guys have probably got handover from the last shift that we were having issues with SSC 22, and since then we've done a reboot and a reboot with a battery removal and a reboot with a battery removal and a hard drive removal. And I have logged back in. It's still giving us the same issues (…) I just want to give you the update that we have done those additional steps. You're welcome to come on board at any time. I know that PLUTO is working on a lot of things this morning.
	20 21 22 23 24	Allison (MCC)	Thanks Chris, it's good to talk to you. We appreciate the update. And PLUTO is definitely working on a lot of things and has put that on their to do list.
	25 26 27	Chris (ISS)	Okay copy. I just wanted to let them know that we've done those additional steps of the different, all

28		the reboots that we're capable of
29		doing, so just wanted to add that.
30		So ***take the time***. We appreciate all
31		the hard work on the weekend.
32		
33	Allison	And we appreciate your
34	(MCC)	troubleshooting as well. Thanks
35		Chris.

Astronaut Chris calls the ground about laptop SSC 22 (1), and spacecraft communicator Allison responds (2). Chris starts with "good morning, Allison," then corrects himself by saying "or good afternoon," but then with a slight pause ("er") goes back to "good morning" (3–4). He is making this call in the afternoon on the UTC time zone observed on the ISS (at 14:38), and likely knows that mission control in Houston is 5 hours behind this and wants to greet Allison (whom he also calls by her first name, without her having identified herself) with the little gesture or pleasantry of knowing what the time is at her location—an example of subtle operational kindness as he is demonstrating an understanding of an aspect of Allison's situation. Along similar lines, Chris demonstrates that he understands how mission control does handovers, and refers to a problem they likely are aware of already, i.e., the issue with laptop SCC 22 (5–8). He details several troubleshooting steps the ISS crew have now taken that the former shift in MCC was not informed about (8–12), but reports that they are still experiencing the same problem (12–14). He meta-communicates about why he is detailing what they have done, "I just want to give you the update that we have done those additional steps" (14–16), and invites the ground crew to "come on board at any time" (16–18), referring to their ability to remotely access the computer and try to fix the problem from the ground at a time suitable to them. He finishes with another piece of meta-communication that also demonstrates an understanding of the working conditions of the people in mission control: "I know that PLUTO is working on a lot of things this morning" (18–19). This shows that he understands that this may take a while as PLUTO, the mission control position in charge of laptops, is also working on the CrewNet problem. He is perhaps also showing that he is not trying to be pushy, but just wants to offer information so that it is available when the PLUTO staff has time for it. Allison responds by greeting Chris using his first name and adding the pleasantry "it's good to talk to you" and saying that they "appreciate the update" (20–21). She confirms and underlines that PLUTO "definitely" has a lot of work (22–23) and says she has put the task of handling this new information from Chris "on their to-do list" (23–24). With more meta-communication, Chris reiterates that he just wants to add this extra information (25–30) and then shows again his understanding of their working conditions and his appreciation for their efforts "So ***take the time***. We appreciate all the hard work on the weekend" (30–32). Allison reciprocates by answering that they in Mission Control also appreciate how Chris has done these additional troubleshooting steps and finishes with "Thanks Chris" (33–35).

This is operational kindness demonstrated from both parties. Astronaut Chris shows it by incorporating the subtle gesture of remembering Allison's time zone into his opening greeting, by showing a somewhat detailed understanding of the working conditions of mission control personnel on the ground, and by meta-communicating to make sure they understand that he is not trying to express impatience but just wants to be helpful. Spacecraft communicator Allison shows operational kindness by using pleasantries like expressing that it is good to talk with Chris, and by showing appreciation for his update and his troubleshooting efforts.

4.5 Operational Kindness Through Thinking of the Needs of Others

Later, after another unsuccessful attempt has been made to fix the problem with CrewNet, the conversation below occurs after astronaut Madilyn has reported the outcome of this attempt to MCC.

(5)	1	Allison	Okay. Copy that. I think we're
	2	(MCC)	going to start looking at the
	3		wireless networks next. Erhm as
	4		we're going to continue
	5		troubleshooting the rest of today.
	6		We wanted to ask you, to make
	7		sure that (.) we can continue
	8		coordinating with you guys and
	9		bother you to see if CrewNet is
	10		working, or we can leave you be.
	11		We wanted to see what your
	12		preference was, as we continue
	13		troubleshooting.
	14	Madilyn	Copy that, yeah. Thanks for
	15	(ISS)	taking the temperature, we are ***all***
	16		for you guys getting in touch with
	17		us as soon as you can on that. We
	18		definitely enjoy CrewNet on the
	19		weekend so appreciate that. But
	20		feel free to call up at anytime.
	21		Wanted to offer first something
	22		out there, recycling the power on
	23		the VAPs is low hanging fruit for
	24		us. It's something we've done
	25		before. We can take care of it, and
	26		you know, the 30 seconds it

27 28 29 30 31		requires for the switch for us. So if that was something that you guys thought any chance of helping out, let us know.
32 33 34 35	Allison (MCC)	And awesome Madilyn. Thanks for the offer and we'll actually take the cycling of the VAPs, now, if you don't mind.
36 37	Madilyn (ISS)	Copy that, I'll put it to work and let you know.
38	Allison (MCC)	Okay, perfect.

As Madilyn has just reported crew net still does not work, Allison starts with acknowledging she understands, points to the next step they will be taking in troubleshooting (1–3), and starts meta-communicating about how they should continue working on this problem. They, in MCC, wanted "to make sure" (6–7) that it is okay for them to be continuing to "bother you to see if CrewNet is working, or we can leave you be" (9–10). MCC has been working on fixing CrewNet for four hours at this point, and has asked the ISS crew to check four times, but there has been no direct statement or indirect sign in the S/G loop that the crew has felt bothered by being asked to repeatedly check CrewNet. Hence, this is an example of MCC trying to be considerate by showing an operationally kind understanding of the situation or possible needs of the crew on the ISS, without the astronauts having expressed them out loud. MCC is both seeking to be one step ahead of the needs on ISS, and at the same time, making sure they do not just assume what other parties in the conversation would like, instead actively asking by meta-communicating. It is also worth noting that it is MCC that introduces the term "bother" into the conversation, perhaps making it easier for the ISS crew to express, directly or indirectly, whether they are in fact bothered by the repeated calling. Allison finishes her statement by reiterating that they "wanted to see what your preference was" (11–12). In her answer, Madilyn acknowledges this (14) and uses the metaphor "Thanks for taking the temperature" (14–15) to express gratitude for MCC having checked what the crew would prefer in this situation. She also underlines how they would very much like to be asked again—"we are ***all*** for you guys getting in touch with us"—and that they are interested in having a solution as quickly as possible: "as soon as you can on that" (17–18). She elaborates why this is the case, saying, "We definitely enjoy CrewNet on the weekend so appreciate that" (18–19), reiterating how they will appreciate being asked again as soon as there is something new.

Returning the consideration shown by MCC in thinking ahead regarding the possible needs of the ISS crew, Madilyn goes on the offer that the ISS crew could power cycle the VAPs (virtual access points). This, using another metaphor, is described as "low hanging fruit for us," i.e., something that is easy to do to obtain a positive outcome ("Low-Hanging Fruit," 2022), because it is a procedure they are familiar with (24–25) that will be very quick to perform (26–28) if MCC thinks it could have "any chance of helping out" (30–31). Madilyn uses four different expressions to strengthen this offer to MCC by underlining how it would be easy for the crew and, possibly more indirectly, how important getting CrewNet access is to them, and their resulting willingness to help out with troubleshooting. Allison recognizes the gesture with the informal use of "awesome" in her answer, "And awesome Madilyn. Thanks for the offer" (32–33). She accepts the offer on behalf of MCC, and Madilyn puts it into effect (36–37); Allison then thanks her for that with an "Okay, perfect" (38).

Operational kindness is demonstrated here by MCC's unprompted effort to put themselves into the situation of the astronauts and to consider the astronauts' possible needs. This kindness is reciprocated by the astronauts offering to help with troubleshooting and underlining how it is a very easy thing for them to do, and thus is no bother to them.

5. Discussion

The purpose of this paper has been to identify qualities in operational S/G communication that could be psychosocially supportive for astronauts while they are in space. Two such qualities were identified through analysis and were named *operational kindness* and *operational wit*. Existing research (see Section 1.1) has demonstrated environmental, organizational, and interpersonal factors that can make space a challenging context to work in, and the supportive aspects of communication identified in this paper are ways in which astronauts and ground crew can support each other and their working relationships, while working under these conditions.

Operational wit and operational kindness are supportive aspects *of* operational communication. That is, the qualities identified in this paper are not nonwork conversations, in which the primary purpose could be to share jokes or exchange pleasantries; at the same time, their content is also not directly related to the formal purpose of the call (e.g., troubleshooting a malfunctioning system). The characteristic that makes them aspects of operational communication is that they are closely intertwined with, run parallel to, and are in close proximity to operational communication. Occurrences of these qualities were demonstrated through microlevel analysis in Section 4, and in this section the limits of these concepts are discussed, as well as the practical implications.

5.1 The Limits of Operational Kindness and Operational Wit

Operational kindness is delimited by, on the one side, strictly operational communication solely focused on solving problems and the clear transmission of information. When signs of helpfulness, enjoyment of social interaction, and understanding of others' perspectives enter conversations, they can become expressions of operational kindness. On the other side, operational kindness is delimited by the risk of turning into praise inflation, where so much kindness is expressed that it becomes unauthentic and loses its value to the recipient (Stuster, 2016). For example, when astronaut Chris went out of his way to greet spacecraft communicator Allison with the correct greeting for her time zone, if he had made this gesture an overt subject of their conversation, he may have prompted her to acknowledge his gesture. In other words, the conversation could have deviated from its operational purpose if the conversation partners felt socially obligated to acknowledge each other's kindness.

Operational wit, meanwhile, is delimited by a form of conversation wherein a focus on the style of the message and humor becomes a guiding principle for communication to the extent that the conversation loses its operational value and becomes a nonprofessional, nonwork conversation instead of a helpful tool to handle operational matters in a supportive way.

5.2 The Importance of Subtlety and Authenticity (Congruence)

In the case of both operational wit and operational kindness, on an interpersonal level, the subtle nature of these qualities as they were identified in the analyses seems crucial to maintaining their supportive value as nonoperational qualities intertwined with operational messages. Making expressions of kindness subtle minimizes the risk of praise inflation, while making expressions of wit subtle minimizes the risk of the conversation losing operational value.

On an intrapersonal level (i.e., the level of the thoughts and feelings inside each individual), a certain degree of authenticity or, in Rogers' (1962) terminology, congruence seems important. To avoid praise inflation, a guiding principle could be to say *thank you*, when one is thankful, and to express praise not when one feels it is expected or required as a spacecraft communicator but when something genuinely feels praiseworthy to you. The same is the case with the demonstrated instances of operational wit by, for example, using metaphors, where these should not be construed as a tool, where the use of metaphors is in itself a good way to be psychosocially supportive, unless there is some authenticity to one's expression of them as the spacecraft communicator.

In conclusion, the qualities identified in this paper demonstrate how S/G communication can be conducted in a way that is engaging and interesting to the conversation partners, supports them socially and psychologically, and can do so without losing its operational value.

5.3 Limitations and Future Research

The current study is limited to analysis of the S/G communication that took place during the 189 hours observed and the characteristics of this. While this is a condition of any empirical study, it has particular implications for this type of study, regarding how far the findings can be extended in the field of human space flight and other work in ICE environments.

Two characteristics of these data in which operational wit and kindness were identified were the following. (1) There was a low degree of urgency, meaning that solving the problems arising was not talked about as particularly time-critical outside of the overarching time pressure experienced by astronauts. (2) There was also a low degree of task complexity on the side of the astronauts, so although reestablishing CrewNet access (Section 4.3) seemed to be a complex task for flight controllers on the ground, the steps sent up to the astronauts did not require extensive explanation or follow-up questions from astronauts, before they were able to follow them. Considering this, one obvious avenue for further research would be to expand the focus on supportive aspects of S/G communication to more critical parts of a mission. What happens when the task becomes more complex and thus more demanding to the astronaut? What about planned higher-risk situations where procedures are more rehearsed and scripted as for instance with EVAs (space walks) or spacecraft liftoff and landing? Communication could be more focused on its instrumental value in these cases, so if supportive aspects could be found, it might be expressed in different ways.

Finally, the internal communication in the flight loop and the backroom loops in mission control could be studied further. As illustrated in Figure 1, only the S/G loop is studied in this paper, but the internal voice communication between flight controllers on the ground also warrants further study. For instance: How does the spacecraft communicator convey the answers, which are given by other flight controllers and by the flight director, and where do the supportive aspects of the communication emerge? Are the supportive aspects added by the spacecraft communicator, with the flight loop being kept more concisely operational? Or can their origins be traced back to individual flight controllers? More contextualized microlevel communication research is needed in these areas.

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