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The Use of Narrative and Metaphor in Intercultural Science Communication: An Analysis of Spoken Discourse in Japanese Science Q&A Programs

Kaoru Amino

Institute of Humanities, ShanghaiTech University

Abstract – In Japan, as in many other countries, scientists whose work is publicly funded must communicate their results to the taxpayer. However, for many, this task is more difficult than speaking at conferences or writing journal articles. The present article demystifies the communication of science to non-specialist audiences by describing how experts on a Japanese radio program for elementary school students explained their research using communicative strategies linked to storytelling and metaphor. Several key storytelling strategies tailored to different audiences were observed, including chronological "hardship anecdotes" delivered by speakers, eliciting relevant experiential narratives from audiences, and the use of onomatopoeia to visualize scenes. Moreover, speakers used metaphors, examined the knowledge of questioners, and taught scientific approaches rather than knowledge. The results indicated the overall effectiveness of a communicative approach that personalizes and humanizes scientific knowledge into more familiar frames of reference. These strategies contextualized complex knowledge more immediately for non-experts, reducing the epistemic gap between them and the scientists. In terms of intercultural communication, the results show that overcoming epistemic differences via personalized, in-depth storytelling that focuses on hardship, analogy, and epistemic inquiry may also help novices readjust their communicative practices and thus adapt to the demands of new and unfamiliar cultures.

Keywords – Science communication, analogy, storytelling, epistemic status, high and low context culture.

I. Background

The meaning of the term "science communication" varies between contexts and stakeholders, but involves either educating the public or gaining their acceptance by discussing innovative technologies. The stakeholders in scientific communication include governments, public relations experts, university and research institutions, and journalists [1], all of whom can be seen as professionals working at the interface of science and the public.

In Western contexts, the concept of science communication began in the 17th century as the need to "translate" scientific knowledge to citizens or "popularize" it among a generally less knowledgeable public [2]. In that era, a lot of research was conveyed by scientists working outside academia, whose labor was supported by prosperous patrons. By contrast, in contemporary Japan, only 2.6% of total research funding is privately sourced [3] underlining an obligation to communicate advances to the taxpaying public. The view that scientific communication consists of interaction between communities that are highly specialized (i.e., scientists) and non-specialized (i.e., the public) to fill an epistemic gap is known as the *deficit model* [4]. The deficit model has been criticized as unidirectional, asymmetrical, and focusing on persuasion, in contrast to the interactive model that emphasizes mutual understanding and negotiated, constructive solutions [5]. In the 1990s, the interactive model gained attention in Japan as the social environment shifted and accidents such as the sodium leak at the *Monju* fast-breeder reactor or the HIV-tainted blood scandal became a matter of public debate.

Although alternatives to the deficit model exist, the core element of science communication remains the transmission of culturally specific knowledge to another culture that lacks this knowledge: the key issue is how such transmissions occur, in terms of communicational strategies. One useful approach for understanding this is the theory of language socialization, which has been defined as the process by which novices are socialized into local theories and preferences for acting, feeling, and knowing [6]. From this perspective, one important idea is that of *epistemic stance,* a person's knowledge or belief, including sources of knowledge and degrees of commitment to the truth and certainty of propositions [7, 8]. In these terms, science communication involves language socialization and implicates epistemic stance as one's degree of commitment to specific knowledge. Heritage suggested another category related to stance: *epistemic status*, which stands for the shifting knowledgeability and experience of a speaker relative to their conversational partner(s) in terms of the domain under discussion [9].

The concept of high- and low-context communication offers a useful framework for the current study [10]. High-context (HC) communication occurs when most of the information is either in the physical context or internalized in the person, with very little information in the coded, explicitly transmitted part of the message. These conditions are reversed in low-context (LC) communication. Thus, conferences involving expert members of the same scientific society or journal contributors would correspond to HC communication, although logical clarity would be required and not all parts of messages would be coded. However, on the deficit model, the transmission of messages between scientists and citizens involving the popularization or education of science is a form of LC communication. Here, information is depersonalized, and messages should be conveyed explicitly by those with higher epistemic status.

HC and LC communication were terms originally used to explain different, culturally specific modes of interaction embodying different social norms, but "culture" can also denote a community with a certain epistemic specialism in which linguistic or national distinctions are irrelevant. In this sense, the domain of science communication overlaps with that of *intercultural communication*, where individuals try to transmit their message across social norms and rituals in communication and knowledge.

Accordingly, this study disregards the sense of the "deficit model" as outdated or implying the need for communicative improvements but understands science communication as exemplifying the way that culturally distinctive groups gain understanding despite differences in their assumptions around acting, feeling, and knowing. While approaches to health or risk communication are fundamentally similar in their aim of explaining specific areas to non-specialists, they are rarely critiqued for proceeding in a unidirectional or top-down manner [4]. To ensure that knowledge is not conveyed in directive or asymmetrical ways, dialogic or active learning methods can be deployed.

Similar to the West, science communication in Japan aims, in part, to secure public acceptance. For instance, since 2006, the "Science Agora" annual symposium has been organized by the Japanese Science and Technology Agency (JST). This scientific event emphasizes cooperation and interaction between stakeholders and citizens with multiple disciplines and backgrounds. In fact, the JST functions primarily as a centrally funded agency and must therefore explain to citizens how their tax revenues were utilized. Thus, the Science Agora seeks public acceptance of publicly funded scientific achievements.

While the events held at the Science Agora aim to persuade the public, they also highlight address the risks inherent to intercultural communication. For example, scientists may need to modify their usage of specialized terminology to make their message understandable to citizens or to adjust it in line with their expectations of the public's knowledge of an area, compared to a particular disciplinary community. However, many scientists struggle to ascertain the degree to which they should modify their academic levels or may simply regard this "dumbing down" as a kind of betrayal of their identity as academics. Yet modifications to content are usually required because a non-specialist audience would simply fail to grasp complex information or provide meaningful responses, thereby undermining the entire purpose of the event: gaining public support for scientific activities.

To avoid the possibility of public misunderstandings of scientific research and practices, communicative strategies such as storytelling and metaphor have been widely used in Western contexts. Storytelling is a long-lived, universal tradition used to entertain, transfer knowledge between generations, maintain cultural heritage, or warn others of danger [11]. Its purpose has always been to instruct based on cases, narratives, scenarios, and problems [12].

There are opposing axes involved in science communication, wherein the theoretical, factual, and logical concerns of science confront its audibility or readability for citizens [13]. Scientists focus on established academic formats, consisting of hypotheses, approaches, and statistical results. However, these primary elements do not attract and engage public audiences as much as a narrative presentation of science. In contrast to the statistics and evidence required in academic discourse, narrative science communications may contain "plot" detail and the subjectivity of "characters," which converge on the ending of a story. However, this audience appeal may come at the expense of facts, to a greater or lesser degree.

This process of familiarizing audiences with science by describing details from the subjective viewpoint of a particular character resembles Goffman's account of how carers come to understand the patient's standpoint by assuming the role of "the wise"—one who has come to understand the patient's current state via their close familiarity with the trajectory of his or her condition [14]. Moreover, the process of familiarizing an audience with science is an act of intercultural communication in which the Other's perspective is obtained, freed from one's subjective viewpoint. The effect of the printing press made it possible to share the thoughts of others, with the mid–late 19^{th}-century epistolary novel enabling people to share the responses, emotional states, and thought processes of others through the narration of protagonists [15]. Thus, tracking the narratives of Others enables their perspectives to be entered into and brings various epistemic frames into contact.

One strategy aligned with appealing storytelling in science communication is *metaphor*. Using the example of evolutionary theory, Miller suggests that storytelling that centers on a researcher's personal struggle or metaphor could popularize scientific knowledge or logic among citizens and contribute to public acceptance of their discovery [16].

In the Japanese context, metaphor has traditionally been discussed as a rhetorical, expressive strategy in creative writing, such as novels or poems. In Western discourse, the study of metaphor has extended to nonfiction texts. Rhetoric consists of argumentation and figurative meaning (i.e., metaphor and metonymy) and has been defined as "transferring the meaning of another word to signify the meaning of an intended word" [17, p 53]. In turn, this definition coincides with Lakoff and Johnson's description of rhetoric as substituting a more remote image of a certain agent for a closer one, or an activity that associates known information with that of the unknown [18]. Metaphor understood as substituting an unfamiliar with a familiar concept is linked closely to its use in science communication.

In Japanese discourse, Haru explores the significance of metaphor focusing particularly on the subcategory of *analogy*, which refers to categorization based on species and variations. In this sense, analogy functions as a cognitive mechanism [19] allowing relevant similarities to be recognized through the use of metaphor as an active mechanism for generating new concepts based on existing meanings. The author demonstrates this via several formulae, as follows: if relationship α denotes a link between a and b, it is described as formula 1 ($a : b = \alpha$). Formula 2 ($a : b = c : d$) is then introduced. If this correlation α also applies to that between c and x in formula 3 ($a : b = c : x$), x can be expected to correspond to d ($x = d$), as shown in Figure 1.

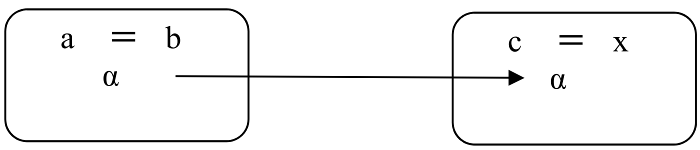

Figure 1: Mechanism of analogy to guess a given value of *x*

In brief, analogy consists of "source" and "target" domains, with some regularities and concepts in the source domain also reflected by reasoning in the target domain. In the previous example, the regularity "α," which exists in formula 1 as the source domain, will be compatible with the regularity and concept that governs the correlation between c and x, whose value is thus successfully calculated as "d".

Analogies have been utilized in scientific discoveries. In Kepler's law, the relationship between the brightness of a planet and the sun's distance to a planetary sphere was used to calculate the swiftness of that sphere's orbit around the sun [20]. Using this analogy, Kepler guessed the orbital speed of each planet, by adopting α as the brightness of the source domain to calculate its physical power in the target domain. Analogy is closely compatible with Lakoff and Johnson's understanding of rhetoric as a process of correlating known with unknown information or substituting a closer image with a more remote one.

Scientists should modify their language when communicating their work to the public. The reasons for doing so include the need for public acceptance of their labor, the obligation to explain how public money was spent, and the wish to show how their achievements might contribute to society. However, in the Japanese context, little is known about which verbal science communication strategies are the most effective. In fact, even accounts of Western science communication lack detailed analysis of metaphor, analogy, or functional storytelling from the perspectives of communication, discourse, or linguistic behavior. Moreover, in Japan, science communication emphasizes interaction and collaboration with citizens. Although this dialogic understanding transcends the deficit model, it is currently not defined and remains conceptually vague. Clarifying the linguistic tools used may assist young professionals who, having acquired the norms of academic communication, may suddenly need to master a set of quite different communicative practices to transmit their achievements to the public.

In line with the above considerations, this study set out to investigate the strategies used by specialists to achieve successful scientific communication. The first aim was to clarify science communication strategies in detail by explaining how scientists convey systematic knowledge in interesting ways to a public that knows little about academic culture. The second aim was to generate a novel perspective on intercultural communication between groups with different epistemic statuses, and the third, to determine whether the intent behind these strategies were to secure the patronage of citizens, to educate people, or simply improve communication with the public.

II. MATERIAL AND METHODS

2.1 Methods

This qualitative study deductively analyzed conversational sequences to identify examples of storytelling and metaphor as novel science communication strategies using sequential analysis. By tracing the sequential flows in interactions between individuals, sociologists can reconstruct the underlying structures of meaning [21]. This process, based on recorded natural conversation, can identify regularities in constructing meaning and is usually conveyed line-by-line, enabling the cumulative development of hypotheses. Quantitative methods were also used to analyze the chronological sequences of conversations and pinpoint strategies that enabled functional science communication.

2.2 Materials

The study data were obtained from the scripts of a radio program whose target audience consisted of elementary school pupils. In the program, entitled "*NHK kodomo Kagaku denwa soudan*" (NHK Telephone Consultation on scientific issues for kids), scientists affiliated with various universities, institutes, and museums replied to scientific questions asked by elementary school pupils.

This program was a prototypical example of science communication, in which specialists communicate with non-specialists whose epistemic status and ability to contextualize differ markedly from their own. To communicate successfully, scientists need to bridge the epistemic status gap to groups whose access to scientific contexts is limited. The data below were purposively sampled to observe the scientists' communicative strategies. The program topics included meteorology, mineralogy, astronomy, botany, biology, chemistry, technology, and psychology, as shown in Table 1.

Table 1: Data from "NHK *Kodomo Kagaku Denwa Soudan*" (NHK Telephone Consultation on Scientific Issues for Kids)

Data #	Title	Date of broadcast	Field
1	Why are human beings afraid of insects even though we're far bigger than them?	12/28/2020	Biology
2	Why are burs called "adhesive insects" even though they're not insects?	02/07/21	Biology
3	It happened that boiled water froze faster than water. Why?	02/07/21	Chemistry
4	Why do insects exist in this world? (I think flies, at least, are unnecessary).	02/07/21	Biology
5	What kind of things has the Hubble Space Telescope been doing?	01/31/21	Astronomy

6	What is a computer virus? What happens if we are infected?	01/24/21	Technology
7	How can we make our brains more active?	01/24/21	Brain science
8	Did Tyrannosaurus carry their babies like alligators do today?	01/24/21	Paleontology
9	Are there any clouds bigger than Japan?	01/17/21	Meteorology
10	Why do human beings make big groups and then tease people who don't belong to their group?	01/10/21	Psychology
11	Why do couplings change, depending on the type of train?	12/29/20	Technology
12	Who decides the name of constellations?	12/27/20	Astronomy
13	Why are Durians so stinky?	12/13/20	Biology
14	If a Hayabusa (a robot aircraft) could land on earth slowly, would it manage to avoid burning up?	12/13/20	Astronomy
15	Steel becomes rusty due to a chemical reaction, but can any rocks cause chemical reactions?	12/28/20	Mineralogy

From these questions, the frequency and sequences of linguistic strategies and formulae associated with storytelling and metaphor were extracted and analyzed to identify persuasive science communication strategies beyond the deficit model.

III. Results

Table 2 summarizes the analysis based on the framework provided in the previous section. The storytelling strategies designed to involve and engage audiences included the following: (1) telling anecdotal "hardship" narratives based on the speaker's own experiences, (2) encouraging the audience to narrate their own experiences of an issue, (3) narrating the events in each story chronologically, (4) visualizing some scenes from the stories, and (5) anthropomorphizing animal or inanimate participants in the narratives by giving them the same thoughts and motivation as human beings. The first four strategies above were realized by the following linguistic features, respectively: 1) 1st-person pronouns for the anecdotes, (2) nominating expressions to encourage the audience to narrate their own experiences, (3) conjunctive expressions using either the *te* form to show the temporal link between two clauses [22] or conditionals to connect occurrences in sequential order, and (4) the use of onomatopoeia. This "storytelling" data contained numerous examples of analogy as metaphor.

Interactive linguistic strategies to address differences in epistemic status included the actions of examining and checking audience understanding and eliciting requests for clarification. Additional science communication strategies consisted of explanations of scientific approaches (rather than the knowledge/content itself), explanations of scientific progress covering previous and current research, and support for citizens' efforts to clarify scientific issues. Information about the number and frequency of the data containing these strategies is displayed in Table 2, below.

Table 2: Linguistic strategies and features used in science communication

Strategies	Linguistic feature	Sample #	Frequency *
1. Storytelling		**All except 2, 7, 9, 14**	**73.3%** *2
(1) Self-narrative ("Hardship" anecdotes)	1st personal pronoun	1, 5, 6, 15	26.7%

(2) Eliciting self-narrative	Nomination	6, 12	13.3%
(3) Description in chronological sequence	Conjunctive expressions (*te* form, conditional forms)	3, 4, 8, 10, 11, 15	40%
(4) Anthropomorphism of animate or inanimate objects	Agents of transitive verbs	11, 13	13.3%
	Citation	13	6.7%
(5) Visualization	Onomatopoeia	11, 13	13.3%
2. Expanding adaptation of metaphor (analogy)		**1, 2, 5, 6, 8, 10, 13, 15**	**53.3%**
3. Examining the degree of knowledge		**1, 3–5, 7–9**	**46.7%**
(1) Epistemic examination	N/A (no specific linguistic feature was used to convey this strategy).	1, 3–5, 7–9	46.7%
(2) Requests for clarification and checking understanding		3, 4, 7, 8	26.7%
4. Explanation of scientific approach rather than content		**1, 3, 8, 15**	**26.7%**

* Refers to the percentage of samples featuring each strategy/formula. ** Each value was rounded to one decimal place.

Table 2 shows that storytelling and metaphor were observed in more than half of the data. Where different epistemic statuses came into play, the term "epistemic examination," (3.1 in Table 2) was used to denote occasions when a questioner's topic knowledge was examined, and terminology was explained. This expression was seen in almost half of the data while requests for clarification or strategies to check understanding were found in almost a quarter of the data.

The last category (4) was not related to the transmission of knowledge itself, but to the process of explaining relevant scientific approaches. Some experts declined to express confidence in current science, electing instead to explain approaches by which further scientific progress would be made. The strategies and the linguistic features that realized them are described in the following subsections.

3.1 Storytelling

The storytelling strategies used included the following: (1) self-narratives, i.e., "hardship" anecdotes, (2) encouraging audience self-narratives, (3) chronological descriptions of events, (4) personalization of animate or inanimate objects, and (5) visualizing scenes from the stories. The frequency of each strategy and the linguistic feature(s) that realized it are also described.

3.1.1 Self-narratives ("hardship" anecdotes)

Here, the focus was on the act of storytelling itself or the scientists' own tales of hardship. These strategies were enabled through the first-person pronoun, which was found in most of the samples.

Example 1

01 Anchor: Yes. So, what kinds of insects make you feel scared?

02 Questioner 1: Spiders, big caterpillars, caterpillars, bees, flies, ants, etc.

03 Scientist 1 : Yeah, I see. <u>**I**'ve also found it hard to deal with caterpillars or big green</u>

04 <u>caterpillars</u> <u>*(**watashi**-mo-ne, negate-de)*</u> since **I** was a little child, though **I** like other 05 insects.

06 Anchor: (laughs)

07 Scientist 1: **I**'m not like this anymore, as **I**'ve grown up. However, **I** still feel a little

08 scared of them, so **I** understand how you feel: fear without knowing what it really is.

09 Questioner 1: Yeah.

10 Scientist 1: There are various reasons why many people dislike insects. (Sample 1)

In this example, Scientist 1 talked about his own experience of hating a specific insect at line 03 and 04, as if trying to align his opinion with the questioner's personal experience and emotion expressed in 02. Almost every predicate describing his emotional experience with caterpillars had "I" as its subject. This was a clear example of how scientists narrated their own experience of a particular issue, as observed in 26.7% of the samples. Besides recounting negative experiences, the scientists sometimes gave more neutral self-narratives and could also provide more positive accounts of their experiences of key issues.

3.1.2 Encouraging self-narrative

Scientists sometimes reversed this strategy by allowing questioners to narrate their own stories of the issue in question, as shown in examples 3 and 4.

Example 2

01 Scientist 2 : Hello *(kun, kinnichiwa)*, [Questioner 2's name]

02 Questioner 2: Hello

03 Scientist 2: Nice to meet you. Have you dealt with a computer virus? Are you

04 infected?

05 Questioner 2: Now the Covid virus is here and we cope with it by wearing masks or

06 washing our hands. By the way, I recently noticed that my father has installed anti-

07 virus software on our home PC, and now I want to know what a computer virus is

08 and what happens when it infects a computer. (Sample 6)

In this excerpt, the scientist applied *kun*, an honorific suffix used to address younger males in line 01 before encouraging the questioner to tell his story about computer viruses (lines 03–04). This nomination strategy for encouraging self-narratives from questioners was found in 13.3% of all samples.

3.1.3 Description in chronological order

Another storytelling strategy was to describe a scientific process such as a chemical reaction, or the process of organizing a group. Such sequences were mainly expressed by conjunctive expressions connecting several clauses such as *te* or conditional forms (*tara* or *to* forms), which were found in 40% of the sample, as exemplified below:

Example 3

01 Scientist 03: For example, I've heard that you don't like flies so much, but do you

02 know that Arthropoda larvae are called maggots? Maggots have a caterpillar form

03 with a sharp head that looks like a grain of rice and eats the dead bodies of animals 04 […].

05 **When** an animal dies *(Doubutsu-ga shinu-**to**)*, flies immediately come over to

06 deliver their eggs *(hae-ga ton-de ki-**te**)* **and then** these eggs turn into maggots

07 […]. **If** there are no flies *(hae-ga inakat-**tara**)*, the dead body is left as it is

08 (*shitai-ga sonomama-ni nat-te shimat-**te***) **and then** causes such an enormous

09 impact. Germs pollute the air, there are more worms—and human beings become

10 more likely to catch a disease.

(Source 4)

Lines 05–10 of this example describe the order of events in the natural purification system, proceeding through the food chain and eventually decomposing. The conditional suffix "-to", which signifies the nature-related fact, is used to connect to two clauses, the latter of which (flies immediately come over to deliver their eggs *(hae-ga* 05 *ton-de ki-**te**))* is further linked to the 3rd clause on line 06 ("and then these eggs turn to be maggots") by the *te* form, which is used to describe sequences of more than two occurrences. The same usage of the *te* form is also found on lines 08 to denote the sequential order of unrealistic consequences, before which the conditional connective "*-tara*" is used to connect the 1st and 2nd clauses on line 07 and 08.

3.1.4 Characterization of animate or inanimate objects

A fourth storytelling strategy was to personalize animate or inanimate objects by situating them as agents of predicates, and particularly of transitive verbs or speakers of some quoted utterances. This strategy occurred in 13.3% of all data and the linguistic features that realized it are exemplified by the following excerpts:

Example 4

01 Scientist 4: The durian fruit is a fruit, but it diffuses its odor itself. **It tells various**

02 **animals (*oshirase-shi-teiru-no*): "I'm here, so come and eat me!"** ("***watashi -wa***

03 ***koko-ni arimasu-yo. tabe-ni-ki- te kudasai-ne*" *tte***).

04 Questioner 2: Oh, really? […]

05 Scientist 4: Yes. This smell makes **other animals come** to it, as if **they were**

06 **considering: "Hah, I guess it's ripened" (*ironna doubutsu-ga "oishii mi-ga***

07 ***jyuku-shita-n-da-na" tte*)**. […] Actually, **the durian has plans (*Dorian-wa nerat-***

08 ***tei-te*)** for their seeds to sprout and grow into new trees at other places. Surely, it's

09 not really thinking like this because it's just a plant, but still it can be said that **it has**

10 **these kind of plans** (***sakusen-wo mot-tei-te***) and ends up being eaten by animals.

11 This is why **it calls others with its odor, like, "I'm here!" (*"koko desu-yo" -tte***

12 ***yonde*-iru).**

(Sample 13)

This example includes both quotations and agency attributed to the durian. Despite being an inanimate object, the durian is presented as the subject of the transitive verbs in lines 01–02, 07–08, and 09–12.

a) It notifies various animals (*Oshirase-shi-teiru-no;* lines 01–02)

b) The durian has plans (*Dorian-wa nerat-tei-te*; line 07)

c) It calls others with its odor (*Yonde-iru*; line 11)

All the above examples place the durian as the subject of the transitive verb *(oshieru, yobu, nerau),* which may take an indirect or direct object. These expressions personalize the durian, treating it as if it were a human being. At the same time, both the durian or animals attracted by its odor either utter or reflect on the fruit in the following sentences:

d) It notifies various animals: **"I'm here, so come and eat me!"**

(**"Watashi -wa koko-ni arimasu-yo. Tabe-ni-ki-te kudasai-ne" *tte***; lines 02–03)

e) Other animals come to it, as if they were considering: **"Hah, I guess it's ripened."** (***"oishii mi-ga jyuku-shita-n-da-na" tte***; lines 05–07)

f) It calls others with its odor, **like, "I'm here."**

(***"koko desu-yo" tte*** *yonde-iru*; line 11)

All these expressions used the quotation marker "-*tte*", which functions the same as a coordinating conjunction, introducing the reporting clause by connecting it with the main clause. This linguistic feature realizes the storytelling strategy of characterizing animals or inanimate objects as agents of mental activities.

(5) Visualization using Onomatopoeia

The final storytelling feature in the data was to describe sensory experiences involving touch, taste, or smell using onomatopoeia, a strategy found in 13.3% of the data samples.

Example 5

Scientist 5: Yes. [goose or wild duck chicks] follow their parents, and walk, going "**chirp chirp" (*piyo piyo***). Immediately after they hatch from the egg, they can walk around. This characteristic in animals is known as "precocity," though the concept is a little difficult to understand. (Sample 8)

Example 6

Scientist 06: Have you ever heard an enormous noise like "**boom** (***doka-n,***)" which electric freight cars make when they start or stop running? (Sample 11)

Example 7

Scientist 07: Usually as rock begins to effloresce, it starts to feel rough (***zara zara)*** or separates into clay or sand, or mixtures of both parts. (Sample 15)

Examples 5 and 6 are examples of auditory onomatopoeia and 7 is related to the sensation of touch. This strategy would enable questioners to imagine each situation more vividly and shows how onomatopoeia functions as a powerful tool in science communication.

3.2 Expanding adaptation of metaphor (analogy)

Besides storytelling, the use of analogy between the object of a well-known theory and an issue under discussion was uncovered in 53.3% of all data. Example 8 shows how a familiar object of knowledge (lice [*Shirami*]) could be used to aid comprehension of a new phenomenon (grass lice [*Kusa-jirami*]).

Example 8

01 Scientist 5: There's a plant known as "Tussock lice" (*Yabu-jirami*), **whose seed**

02 **seems like tiny bugs.** Anyway, **the whole seed itself is known as "glass lice" (*Kusa-***

03 ***jirami*).**

03 As an urban kid, you've never heard of **"lice" (*Shirami*)**, right?

04 Questioner 3: Yes.

05 Scientist 5: It is the name given to a family of bugs […]. There are many kinds of

06 these bugs, and they are disgusting. While living inside clothing or hair, they

07 sometimes suck blood […]. **These tiny bugs** in the shape of white rice have **strong** 08 **tentacles, with which they hang from human beings** […]. These bugs suck human 09 blood. T**hen your skin goes extremely itchy**, and you get very annoyed. On the

10 other hand, there are **"seeds of lice"** (burs) which look exactly like these bugs, and

11 annoy us so much by **hanging from us**, and **take time to be removed**, making us

12 feel annoyed and disgusted. **Therefore, they were called "glass lice (*Kusa-jirami*)",**

13 due to similar meanings in both shape and annoying characteristics (Sample 02).

In example 8, the similarity between lice (*Shirami*) and glass lice (*Kusa-jirami*) is explained based on their appearance and other sensory characteristics which combine to irritate people. After the similarity of appearance was noted in lines 01–02 ("whose seed seems like tiny bugs"), the explanation of the bug-like qualities of this seed proceeded from lines 05 to 12. The central similarity is the way that both attach themselves to the human skin. Both lice and glass lice are described as "hanging" from humans in lines 08 and 11, and both use their "tentacles" to impart annoying sensations like itchiness (07–09 and 11–12). As Haru's (2017) analysis of analogy indicates, the characteristics of appearance and annoyance constitute regularities required to transfer meaning from the source domain (lice) to the target domain (glass lice). In the relationship α that is compatible with the formula "a (bug) : b (lice)＝α ("similarities in appearance and annoying characteristics") is applied to the formula "a (bug) : b (lice)＝c (plant) : x", then x can be guessed to be "d (glass lice) ", as Figure 2 shows.

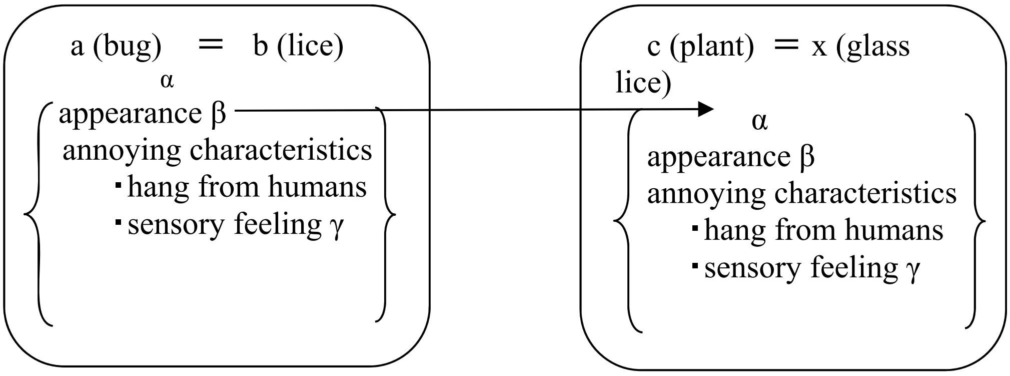

Figure 2: Transfer of relevance α towards target domain in source

Hayashibara's concept (2012, p. 53) of figurative language, i.e., "transferring the meaning of another word to signify the meaning of an intended word" can be applied to analyze this stretch of discourse. Scientist 8 utilized the figurative effect by transferring the meaning of "lice" to signify that of "glass lice", exemplifying the usefulness of figurative language as a science communication strategy. A similar conceptual transfer between the source and target domains was also found in the example below.

Example 9

01 Scientist 6: [Questioner 4], have you ever seen **goose or wild duck chicks?**

02 Questioner 4: Yes. Somehow, they seem fluffy.

03 Scientist 6: Yes. They follow their parents and walk, going "chirp chirp".

04 Immediately after they hatch from the egg, they can walk around. This characteristic

05 in animals is known as "precocity", though the concept is a little difficult to

06 understand.On the other hand, have you ever seen **a swallow chick**?

07 Questioner 4: 07 Yes, I have.

08 Scientist 6: Their **eyes have not even opened and they look so fragile**, immediately

09 after they've hatched, right? Ones like swallows, which can't move around at all for 10 a while after they hatch have something known as "**altriciality**". Animals are

11 separated into two categories of "precocity" and "altriciality", the former of whose 12 members can move around immediately and the latter of which need their parents'

13 protection for while. **Dinosaur**s are considered to belong to **the category of**

14 **precocity** because they are considered to have been able to **move around shortly**

15 **after their birth.**

(Sample 08)

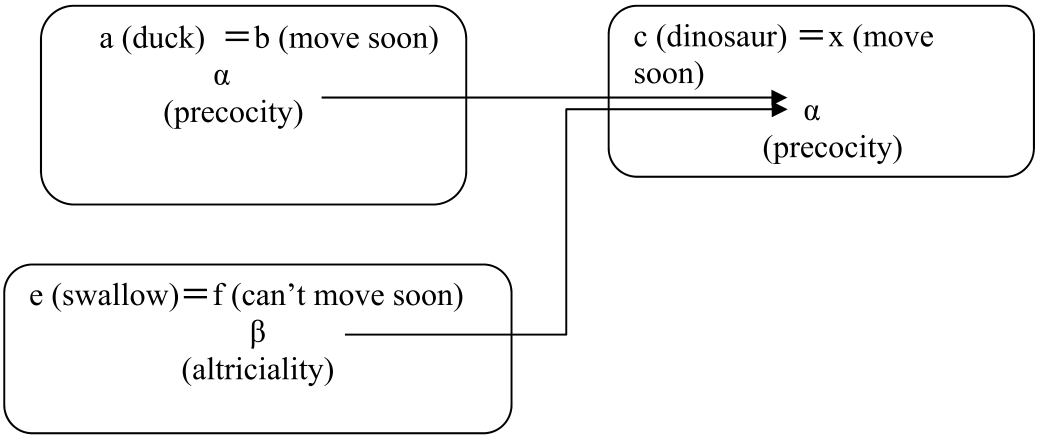

Figure 3: Guessing value by transferring relevance α towards the target domain (Sample 08)

Responding to questioner 4's original question "Did Tyrannosaurus carry their babies in the same way alligators carry babies inside their mouths?", the scientist introduced the concept of "precocity" as the relevant link between a reptile and their mobility immediately after hatching. He explained the need for parenting by replacing this concept with the one of post-incubation mobility. Firstly, geese or ducks were introduced to exemplify precocity in lines 03–06, from which altriciality was explained as an opposite case from lines 06–12. The question here concerned the parenting style of dinosaurs, which is closely related to the concept of precocity/altriciality. Eventually, the scientist arrived at the answer that dinosaur hatchlings did not require parenting, after revealing they belonged to the "precocious" category in line 13–15. Here, the value of *x* could be guessed after the regulation α, standing for the link between *a* and *b* in the source domain, was seen to also apply to the relationship between *c* and *x* in the target domain, while the opposite theory in regulation β was introduced as a non-applicable domain.

In both examples 8 and 9, the figurative meaning of the transfers was obvious. At the same time, both examples of metaphor share the rhetorical element of substituting unfamiliar information with a familiar concept. In example 8, the scientist began by explaining the original meaning of "lice" before transferring this image to "glass lice", whose meaning is relatively unknown. Again, the scientist in example 9 assumed that questioner 4 must be more familiar with geese or ducks than dinosaurs and used this image to explain the latter case, which was more cognitively distant (Lakoff and Johnson, 1980) for the questioner.

3.3 Other science communication strategies

Another science communication strategy focused on scientific *approaches* rather than knowledge itself. These were not realized by specific features of language but were conveyed through interaction, in which experts explained previous research and the current state of knowledge or focused on experimental procedures to clarify a scientific issue.

3.3.1 Examining the degree of knowledge

Rather than the specialist transmission of knowledge, this strategy utilized the interactional aspects of science communication, usually via the use of questioning.

Example 10

01 Scientist 7: [Questioner 3]-*san*, nice to meet you.

02 Questioner 3 Nice to meet you.

03 Scientist 7: Can I ask you some questions?

04 Questioner 3: Yes.

05 Scientist 7: You filled one container with boiled water and filled another with water

06 at room temperature at the same time?

07 Questioner 5: Yes. At the same time.

08 Scientist 7: How about the size of the two containers? Were their sizes the same?

09 Questioner 5: Yes. The same size.

10 Scientist 7: What did you expect to happen?

11 Questioner 5: I thought the plain water would freeze first, because it was colder

12 than the boiled water.

13 Scientist 7: Did you? Then you repeated this procedure several times?

14 Questioner 5: Yes, I repeated the procedure.

15 Scientist 7: So did the boiled water always freeze faster than the plain water?

16 Questioner 5: The boiled water froze faster.

17 Scientist 7: I see. Well… let me answer. I'd anticipated that this kind of question

18 might come up one day. However, I myself have never conducted this kind of

19 experiment.

20 The fact that the boiled water froze faster than the plain water went against your

21 expectations, right?

[…]

22 Scientist 7: Aristotle, who's said to have lived 2000 years ago, left many writings,

23 and in one of them, he said, "You'd better put boiled water under

24 sunlight to cool it down". And we doubted this advice, but

25 there's one boy who tried to check if this was actually true or not. In 1963, there

26 was a boy called Mpemba in Tanzania, and he gave a presentation in

27 the school biology class, and he stated that the boiled water froze first

28 rather than the plain water when he put them both in the fridge.

(Sample 3)

In this example, the scientist attempted to check the questioner's experimental procedure in lines 3, 5, 6, 8, 10, 13, and 15, focusing on elements such as the size, timing, or results of the experiment. These requests for clarification elicited valuable information about the experiment in summary form, at the same time avoiding simply transmitting directive and explicit knowledge of the facts in a top-down manner.

3.3.2 Explanation of the scientific approach rather than the content

This strategy consisted of researchers explaining previous research and how current scientific advances in knowledge clarified a particular issue. Alternatively, personal evaluations of an issue could be made to clarify it, as an alternative to emphasizing knowledge and the accomplishments of science.

Example 11

01 Scientist 7: Yes, then the boiled water froze before the water that was at room

02 temperature for a long time. The truth or falsity of this issue has been debated. So, the 03 fact that you confirmed with your experiment is established, but the reason why it

04 happens is still being debated now.

05 Presenter: You mean it's still not been clarified?

06 Scientist 7: Some paper explaining an experiment to solve this issue was published

07 in August last year (2020) in the biological journal "Nature", and the reasons

08 for this phenomenon have gradually been clarified recently. However, I still can't

09 really give an exact answer to your question. The exact and ultimate reason for your 10 results as your own discovery has still not been revealed.

[…]

11 Presenter: So please try this procedure: record your results as the results of various

12 experiments, in which you modify the conditions under some control.

13 Then, you may find some regularity or pattern, in which you realize that you get

14 similar results under a particular condition. If that happens, please note you can get

15 in touch with us again, OK? (Sample 3)

In the first seven lines of example 11 above, the researcher tried to explain the extent of scientific knowledge about the phenomenon—and what remained unknown. In line 5, the radio presenter checked with the scientist whether the questioner's inquiry could actually be answered, and between lines 6 and 10, the scientist responded that the reason for the phenomenon could be partly clarified but was not wholly understood. This was an admission of scientific fallibility and the contingency of all knowledge under the scientific method. The presenter, who presumably understood the program's agenda, suggested to the original questioner that the scientist's commitment to clarification also made them a questioner, before explaining how the scientific method is applied to explaining phenomena. Data generated under controlled conditions count as scientific evidence, and the presenter emphasized this aspect of the scientific method rather than attempting to transmit academic knowledge.

IV. Discussion

This study has demonstrated how scientists can communicate specialist knowledge to less-informed citizens in ways other than the deficit model. Discourse analysis of Japanese science communication provided evidence for strategies such as narrating the researcher's own experiences, encouraging audiences to share their experiences, describing events in chronological sequence, using onomatopoeic descriptions, using analogies that expand knowledge of the features of familiar entities to less familiar ones, and finally, personalization.

Moreover, interactive strategies such as checking the audience's epistemic status by requesting clarification and explaining scientific procedures rather than knowledge itself were also applied. The strategies above are now discussed as (1) the personalization of scientific logics in order to familiarize audiences with the corresponding phenomena or theories and (2) the resemblance between the personalization strategy (1) and the mechanism of analogy and how both relate to the process of acquiring epistemic status in the scientific domain.

4.1 Personalization leads to greater familiarity with scientific theories

Personalization in scientific narratives is similar to analyzing a single case deeply over a sustained period and in considerable detail. In education, personalization entails humanizing the learning process and placing the learner first, therefore going beyond the bureaucratic model of schooling [23]. In journalism, the process of personalization refers to how interviewers come to empathize with their subjects when questioning them in depth, as when Varma analyzed stories of San Francisco's homeless people [24]. Personalization can also be described as an irrational way of thinking, characterized by the belief that what others say or do is somehow personally relevant.

The above definitions of personalization suggest that scientific narratives contain abundant resources for making science personally relevant, such as anthropomorphizing animals or plants, or eliciting self-narratives from one's audience. Researchers' anecdotes of hardships (such as the scientist's description of her experience with caterpillars) or their elicitations of everyday experience (as when a questioner was asked about their experience with a computer virus) also humanize the corresponding scientific issue by encouraging audience empathy. Recounting events in chronological sequence with onomatopoeia also helps audiences to track scientific procedures and consequences as if they were occurring before their very eyes.

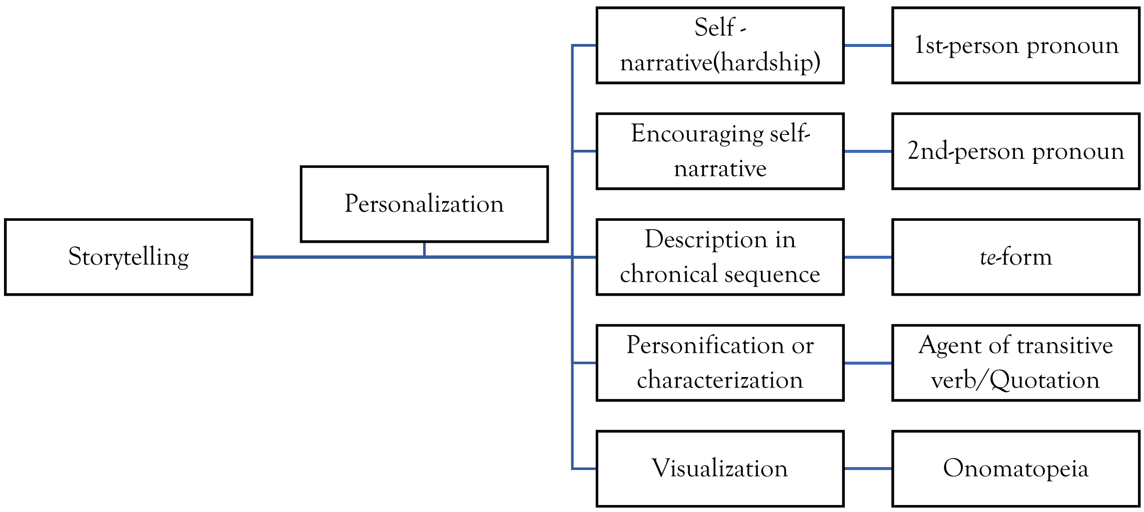

Figure 4: Structure of personalization in storytelling

Thus, storytelling strategies—such as providing and eliciting self-narrative, describing in chronological sequence, and anthropomorphism—are ways of personalizing unknown scientific knowledge as more familiar and understandable forms that are particularly effective for communication among stakeholders with markedly different epistemic statuses.

4.2 Personalization relevant to metaphor and contextualization

The strategies identified in the data aimed to familiarize audiences with scientific logic by linking it to what they knew about or had already experienced in their daily lives. Personalization thus translated vague frames into more detailed and concise ones, in which cognitively "faraway" theories were made to resemble more "proximal," understandings (i.e., ones derived from everyday experience). Moreover, the personalization of storytelling was also similar to the concept of metaphor. Both of these function synergistically to enhance understanding. Personalization can be seen as a process in which stakeholders' knowledge and experience of a specific issue are contextualized to bridge differences in their epistemic status.

This suggests that communication between non-specialists and specialists of differing epistemic statuses may be a form of low-context communication in which only a limited amount of knowledge is encoded. However, both personalization and analogy enable audiences to contextualize and accumulate knowledge by using familiar frames for the information that scientists want to introduce.

Thus, storytelling, metaphor, and personalization enable specific knowledge to be acquired more quickly by contextualizing novel concepts, even when these are normally difficult to grasp. This observation may also apply to intercultural communication, which resembles science communication since it requires cultural novices to readjust their communicative practices away from pre-existing social norms that are already mentally contextualized. Thus, strategies for overcoming differences in epistemic status such as personalized, in-depth storytelling that focuses on hardship, analogy, and epistemic inquiry might also help novices adapt to a new culture.

4.3 Implications for science communication as a speech genre

Many young researchers at the start of their careers are required to communicate science to the public. However, the vast majority have not received the necessary training to do so because most postgraduate degree programs do not cover public communication in scientific contexts and exclude other communicative approaches that lie outside academic discourse strategies.

Researchers have usually been trained in academic presentations, writing, and publication skills that enable them to communicate with specialists in their discipline. This spoken or written discourse is conveyed in broadly the same style and is highly contextualized. However, researchers may be required to communicate with the public at very short notice in a completely different style in order to build public acceptance of their work. Nourishing these novices with strategies for communicating about science in LC environments could help decouple them from the conventions of academic speech and written genres.

However, some researchers may still view strategies such as storytelling, analogy, and questioning as tarnishing the quality of their work and threatening the precise level of expression required in academic circles. For example, analogy utilizes logical similarities between two domains, assuming that the regularity and concept found in the source domain are also similar to that of the target domain. However, regularity α which governs domain A is not identical to that in domain B, so it is impossible to apply the uniqueness of domain A to domain B with 100% certainty, and too much emphasis on analogy comes at the cost of precision.

Here, I would like to introduce the well-established concept of "genre". Genre is defined as a system of staged, goal-focused social processes that realize the various purposes of speech communities [25]. Thus, scientific discourse includes genres that realize the communicative purposes of specialists, non-specialists, and their respective speech communities. The purpose of each speech activity differs: whereas the genre families of specialists are exchange information about highly academically contextualized issues, their non-specialist equivalents aim to persuade the public in order to obtain patronage from citizens and educate (in particular) younger members of the culture.

To communicate with the public, academics could be encouraged to use terminology that allows audiences to imagine a particular concept. Alternatively, signifying previous research may suffice to immediately evoke an academic concept. Thus, while interactions between academics share similar values and assumptions and center on the exchange of highly structured knowledge that has accumulated over a long period, public science communication should be popularized by focusing on the avoidance of audience boredom or confusion.

Both sets of genres must adjust the balance between popularization and concern for academic values. In fact, what matters most is whether the source and target domains are sufficiently similar or not since this could impact the persuasive force of the communication. Nowadays, researchers encounter various audiences and situations requiring different modes of messaging. In each speech genre, the degree of preciseness, correctness, and evidence should be carefully calibrated to reflect the speaker's aims.

V. Conclusions

This research has aimed to clarify science communication strategies between specialists and non-specialists in low-context environments. The study has considered how Japanese scientists communicate with the wider public to gain broader acceptance and fulfill their obligations to explain their specialist research. The data suggest that some linguistic features used in storytelling, analogy as metaphor, and interactive speech are crucial aspects of successful science communication.

Using transcribed data from a Japanese radio program entitled "NHK Telephone Consultation on Scientific Issues for Kids," the linguistic strategies employed by scientists replying to questions set by school-age children were investigated using sequential analysis. Four main storytelling strategies appeared in more than half of the data: (1) the speaker's own anecdotes of hardship, (2) the elicitation of audience narratives, (3) the chronological description of events, and (4) the use of onomatopoeia to help audiences visualize scenes from the narratives. Moreover, metaphor, questioning of the audience, and teaching scientific approaches rather than focusing on the content itself were also observed.

Overall, storytelling in scientific narratives functions similarly to analogy in metaphor, humanizing each scientific case by drawing on the speaker or listener's personal experience and describing scientific scenarios more visually via chronological description or onomatopoeia. These strategies operate synergistically to transform unfamiliar scientific frames into more personal and familiar objects, thereby enhancing understanding.

Furthermore, the strategies provide a means to rapidly contextualize specific scientific knowledge, obviating the need to learn an entire body of knowledge from scratch. Checking understanding and learning about scientific procedures also helps audiences gain an epistemic foothold to support their understanding of the discipline.

Young researchers should be equipped to acquire and utilize these science communication strategies and the language features that realize them. In so doing, they will honor their responsibilities to justify their use of public funds and explain how their research can solve social problems, thereby securing citizen patronage for science in the future.

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