Know Before You Speak: Supporting Global Team Formation with Social Profile Displays in Virtual Environments

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Global work collaboration creates invisible physical and social barriers. Collaborating across non-physical barriers can be communicatively and cognitively taxing, which may disincentivize workers to form and participate in global teams with diverse members. As virtual environments (VEs) enabled by VR and game technologies become prevalent in global work, it is important to consider the design of workers' profiles to socially display language information in a way that supports global team formation. We conducted an online study involving participants from the U.S. and Japan to find team members in a VE - Gather Town. Participants were asked to form teams and complete a slogan generation task under one of the following profile display conditions - no display, constant display, and adaptive display to supplement language and personal cues. We studied how participants' search cost and attitudes towards global teamwork were affected. Our findings reveal team formation strategies depending on workers' local cultures and profile information available.

CCS Concepts: • **Human-centered computing** → **Collaborative and social computing**.

Additional Key Words and Phrases: multilingual collaborative work, team formation, virtual environment

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1 Introduction

As the cornerstone technologies for global teams, computer mediated communication (CMC) tools (e.g., video conferencing) and emerging virtual environments (VEs) (e.g., Gather Town) make it viable for non-collocated team members to collaborate across time, geography, and national boundaries [36, 47]. Forming global teams can introduce diverse expertise, broader experiences and resources otherwise inaccessible locally for better creativity and higher problem-solving potentials [69]. By collaborating over CMC and VE, organizations and individuals may potentially reap the benefits of reduced operational costs from less frequent employee displacement for face-to-face meetings, and increased coworker reachability thanks to the highly accessible and portable medium in which these tools reside.

While VE appears to be a promising solution for global operations of teamwork, a set of communication and collaboration challenges can emerge due to the mediating properties of the technology (e.g., no or limited access to how partners look and sound). One such challenge is reduction in the

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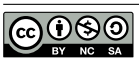

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availability of visual and social cues. Previous studies in CSCW have explored what type of information exchanged among collaborators may alter the processes and outcomes in teamwork [20]. For example, in multilingual teamwork where workers of different native languages collaborate to work, studies showed that video streams showing the faces of collaborating members [61, 67], can produce non-negligible effects on teamwork. However, most studies focused on supporting already-formed global teams to which members have been pre-assigned. With the widespread use of VE environments such as Gather Town — a platform that allows users to navigate digital spaces using avatars and engage in spontaneous conversations with others through visual, audio, and chat interactions — there are increasing opportunities for people to meet new colleagues, decide who to work with, and how to form work teams with limited cues and knowledge about one another, as seen in scenarios like hackathons, game jams, and corporate innovation projects. Little is known how VEs with social profiles containing information pertinent to collaborations (e.g., language skills, personality) made available (or unavailable) to workers impact global team formation and follow-up teamwork.

In global teamwork, working around uncertainties associated with language gaps or different cultural backgrounds among team members can prolong or inhibit the team formation process, which may impact how workers find a team to join and how teams recruit new members. While VEs are designed to selectively highlight critical information pertinent to global teamwork - such as highlighting one's language proficiency, cultural backgrounds and personality - individuals' perceptions on who are potentially better collaborators for them, and their strategies in forming and participating in global teams may also vary.

To better understand how profile display design in VEs influences global team formation, we conducted an online study in a 2D graphics-based virtual environment, Gather Town[1], with global participants from Japan and the U.S. (N=76). We manipulated how their virtual personal profiles looked like, which was designed to display cues of language proficiency (English versus Japanese) and personality traits for their avatars (as shown in Figure 1). We conducted a week-long study consisting of seven 2-hour team-formation sessions. In each session, a cohort of 10-13 participants[2], of which about half were native Japanese speakers and the other half were native English speakers, joined the same virtual space to form teams and then collaborated on a slogan generation task. Each session was randomly assigned to one of the three profile display conditions: no display of profiles, constant display of profiles, and adaptive display of profiles in the proximity to other participants. We contributed new observations that cultural differences emerge in perceptions and behaviors between Japanese and American individuals in team formation. In the follow-up interviews with the Japanese and American participants, we gained deeper understandings about how global workers handled perceived communication and collaboration barriers before and after team formation in the VE.

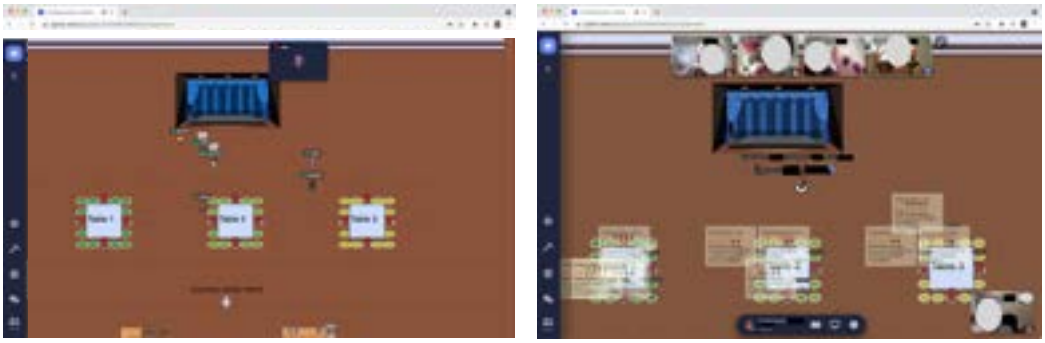
2 Related Work

2.1 Computer-Mediated Global Teamwork

Successful teams and teamwork depend on a number of contributing factors and processes, most notably the personnel, tools and tasks the team has to work with, as well as what synergistic outcomes the team can produce through intra-group interactions [18, 34]. For example, factors associated with personnel, such as team size, diversity, group personality composition and inclusiveness of team members, can affect a team's accessibility to expertise and resources, the team's capacity to perform specific tasks and team trust. Similarly, what technologies and tools are available for

[1]Accessed on 16th August, 2023: https://www.gather.town/

[2]Each participant joined only one session



(a) Gather Town without Profile

(b) Profile-Enabled Gather Town

Fig. (1) Virtual environments, such as Gather Town, allow users to navigate a digital space using avatars and engage in spontaneous interactions through visual, audio, and chat interactions. The figure compares the original Gather Town space with our **profile-enabled space**. Figure (a) depicts the original Gather Town space, where users navigate their customized avatars in a 2D environment and interact with others. Figure (b) illustrates our design of profile-enabled space, where the original environment is augmented with a social display. This display appears as a profile sticker to the left of the avatar, continuously updating its location based on the avatar's coordinates to ensure it moves in sync with the avatar. In this profile-enabled space, users can perceive others' self-selected characteristics, such as language proficiency and personality traits—information typically unavailable in face-to-face settings.

team communication and interactions and what affordances and/or limitations are present can also vastly impact teamwork processes and outcomes, such as productivity and individuals' attitudes toward such collaboration.

Computer-mediated global teams involving team members located in geographically dispersed locations make extensive use of CMC tools like videos or VEs to maintain team communication [30]. Therefore, global teamwork processes and outcomes are susceptible to influences of a myriad of personnel and technological factors. Previous studies have been investigating these areas in isolation, considering how specific technological features (e.g., impassiveness of VR) and human processes (e.g., trust) contribute to teamwork separately. One line of studies on computer-mediated global teams has been looking into how different technological features can be used to support cross-lingual communication in global teams, so it may better support team members speaking different native languages to bridge the language gaps in existing teams [12, 68]. Studies have found that CMC tools that can balance the agency between native and non-native speakers, and support non-native speakers to participate more in teamwork tend to also support the entire teams better [16, 49, 77, 79]. For example, automated dialogue transcription [49] and translation [77] are shown to be helpful in global teams, not for work replacement for non-native speakers to understand or speak in a second language, but their role in allowing non-natives to better catch up and participate in team discussion by using the tools to supplement their own language skills.

The common observation behind exploring these technologies is that people in global teamwork have various (unbalanced) language skills and in conversations dominated by native speakers, non-native speakers typically bare the cost of inability to catch up and a higher cognitive load by not speaking the common language used in a team as their native language [49, 60, 75], which leads to another line of studies looking into how the personnel and team formation factors affect the global teamwork [35, 57]. Previous studies have been aiming to enhance the communication process, such as grounding on shared concepts and mutual knowledge, between native and non-native speakers using CMC. For example, Pan et al. proposed designing interfaces to nudge native speakers

to actively share and redistribute task workload in team collaboration to reduce the amount of work non-native speakers have to perform [49]. Duan et al. investigated ways to raise native speakers' awareness of difficulties that non-native speakers faced in team communication. Lim et al. looked into supporting people's sense-making of multilingual social media posts as part of an online communication process [38], and Gao et al. highlighted the importance of conversational transparency for cross-lingual communication to unfold smoothly [19]. While this literature has produced an array of useful design interventions for supporting global teams, past studies focused extensively on supporting already-formed teams by setting up the teams and deciding on team formation a priori. It remains unclear whether team composition would exhibit variations if participants had the freedom to select their own team members, and how such dynamic team configuration might impact the outcomes of teamwork. As such, this aspect holds a significant interest for our current study.

2.2 Team Formation in Collocated and Virtual Environments

An effectively built team is one that sets a clear direction, offers the needed support, and comprises of members of diversity, while at the same time sharing the values and norms for collaboration [25]. As broadly identified and practiced processes of team building, prospective team members are in need of exploring, socializing, developing trust, communicating their individual interests and goals, and learning how to best work together [37]. Such processes can be even more critical to virtual teams, as it can be only more difficult to communicate and coordinate actions with the presence of physical constraints (distance, time zones), non-physical barriers (language gaps, work cultures), and other technological limitations (e.g., information and cues available) imposed on online interactions.

Specifically, VE-mediated team formation for global teams may face unforeseen challenges from two aspects - limited contexts and backgrounds shared by team members, and limited communication channels available to exchange signals. First, in offline, in-person teams, being physically collocated creates abundant opportunities for team-forming individuals to access a similar context and acquire similar experience outside of work, which has been shaped by the common physical environment they are in, before the team formation process starts. The shared context and experience can contribute to the establishment of shared knowledge or common ground that can be useful for team communication and coordination [35]. Previous studies have constantly shown that collaborators speaking the same native language and sharing the same cultural norms tend to solve problems together faster and better [15, 64]. In contrast, members of global teams are geographically dispersed, affiliated with different institutes or units, speaking different native languages, and/or following distinct cultural norms salient in their respective institutes or countries of residence. There tends to be not as much overlap in context and experience available for global teams to utilize in team formation.

Second, VE-mediated team formation is affected by the properties and constraints of VE tools, such as reduced visibility and fidelity commonly found in VEs built with 2D graphics [3]. For example, while it is possible to capture and represent a person's look realistically in VEs with avatars, it is arguably much harder for collaborators to make eye contacts in VEs than in physical encounters as the current VEs arguably are not as good as face-to-face communication in terms of visibility (e.g., spatial resolution of subtle behaviors like the locations of eye gazes) and synchronicity (e.g., time resolution of behaviors like the stating and elapsed time of eye movements) [14].

In order to facilitate online team formation, it is essential to create opportunities for people to bond and develop a sense of comfort and willingness to collaborate. Methods to support the processes include simply allowing time for people to get acquainted on a personal level [27], altering conversational norms (e.g., moving from asynchronous emails to synchronous instant messaging)

to improve the socializing experience [10], and adding cues or information to facilitate relationship building [51]. The approach of adding cues can render certain information more salient, and may subsequently alter the way people socialize with each other. Also, a distinction needs to be made between adding physical cues to simulate face-to-face communication, such as the visibility of facial expressions or hand movements, versus adding informational cues that are not necessarily available in face-to-face situations, such as a person's language proficiency and personality traits. Whether these cues ultimately aid or hinder virtual team formation requires further research. In this work, we display profiles that include a person's language proficiency and self-selected personality traits. These informative, self-presented cues reveal individual characteristics, potentially facilitate familiarization, and foster initial interactions among users [22, 80]. Consistent with self-presentation theories and applications to CSCW [17, 56], this setup enables users' discretionary and strategic selection of self-descriptions for interpersonal communication, which allows us to further investigate how various profile display designs (e.g., no display, constant display, and adaptive display) in VEs influence interpersonal communications and global team formation. We take a unique multilingual and multicultural perspective to approach the phenomenon. Although previous work has begun to leverage identity display as an intervention to understand team fracture and viability [9, 73], the lens of multilingual dynamics and team formation remains underexplored. This study aims to fill that gap.

2.3 Research Questions for the Current Study

In global team formation, people face the choice to work with people of similar or different backgrounds in multiple areas, such as expertise, locality, language, personality and culture. Previous work indicated both benefits and costs of these choices [66]. Working with people with greater similarity can potentially result in easier and smoother communication because of potentially higher overlapping knowledge and common ground [13, 31, 44]. Forming a team with people from different backgrounds may lead to greater diversity in knowledge and skills, offering a greater problem solving and creativity potential [69]. However, working in a heterogeneous group could be communicatively and cognitively taxing due to the extra work needed to learn about each other and to build up an appropriate set of shared knowledge and perspectives to enable collaborative work. When team members do not possess the same language proficiency, it can also be costly to find ways to communicate and work in face of the language gaps. With the intervention to display additional cues such as a personal profile in VE, co-workers' backgrounds become visible, which can support their decisions on whether to work with others from a different background or not by lowering the uncertainty workers face. Specifically, we pose research question RQ1:
RQ1 – During the process of online team formation, how does personal profiles display influence the composition of a global team?

Successful team formation requires workers to socialize, communicate individual interests and goals, and develop trust. Therefore, we expect to see that displaying personal profiles to make personal backgrounds visible will impact the ability to find preferable teammates, and influence the time and work required to set up a team [7]. Specifically, in a VE, we expect participants with access to personal profiles to find teammates at a reduced searching cost. This is because the increased accessibility of personal cues, such as language proficiency and descriptions of personality, would allow individuals to develop an impression of other workers beforehand, and develop and apply heuristics of team formation. The early insight can assist in estimating others' belief, aligning expectations before communicating with others, and supports decision-making on who to approach and which team to join. We further investigate:

RQ1.1 – During the process of online team formation, how does personal profiles display in the VE affect the cost to find teammates?

In collaborative work, co-workers from various backgrounds can hold different skills and knowledge, such as language proficiency, domain expertise, and local/cultural knowledge, which may benefit the collaborative task in the context of global work. However, to unfold the full potential of diversity requires communication and coordination, which can be challenging to globally diverse teams, and may subsequently impact work outcomes. It is also noteworthy that globally diverse teams formed by workers from multiple localities, such as Japan and the U.S., may not result in balanced recruitment across different sites. It is possible for a specific locality to become a majority subgroup with greater number of workers sharing the same origin in the team. Similarly, workers can fall into a minority subgroup where few or no other workers are sharing the same background. We anticipate that individual workers will be able to make more contributions when their localities are of majority in the team due to lower communication and coordination costs during the work time. We therefore ask:
RQ2 – During collaborative work, when groups are formed with members from multiple localities of residence (e.g., different countries), how does team composition impact the overall work outcome?

After collaborative teamwork, we also expect profile displays and team composition to have lasting effects on workers' attitudes toward working in a more or less diverse team. Maintaining a globally diverse team can be difficult given the increased cost in communication, which may affect workers' willingness to continuously participate in global teams. Design interventions, such as profile display, as well as positive experiences of working in a successful global team, may both contribute to sustainable global diversity. More specifically, we expect that adding richer personal cues through profile display in VE will lessen the collisions and obstacles during the work time, resulting in a more positive work experience and thus higher willingness to continue engaging in global teamwork. So, we ask:
RQ3 – After the collaborative task, how do profile display and team diversity affect collaborators' satisfaction and sustainability of a global team?

3 Method

3.1 Design of Profile Display for Virtual Environment

To explore the effect of profile display — features accessible in virtual environments (VEs) but typically unavailable in face-to-face interactions — on global team formation in VE, we first narrow down the focus of social display to language and personal profiles. These factors are anticipated to play an important role in influencing virtual global teamwork [18, 22, 63]. Then we designed and implemented a profile carrier in VE[3]. Gather Town, a 2D graphics-based virtual space that people could control their avatars to move on the map, has been taken as our test bed because it supports remote teams' participation on a large scale and it can be flexibly extended with additional components.

Dynamic Sticker Display in Gather Town
We designed and presented user profile as a dynamic, movable sticker display, following the avatar

[3]Our system is implemented as a Google Chrome extension for Gather Town to display social profiles and log movement traces, supported by a Flask server and SQLite database that stores user information and synchronizes the display. The extension was tested on Windows 10 and Mac OS 10.12.2, with Chrome version 92.0.4515.131. The source code will be made available to the community upon request following the paper's publication.

to move in the VE, so that individuals are augmented with access to cues about others in the space. This profile display mechanism was implemented in Gather Town as a software add-on to enhance social display. Each profile sticker rendered a personal profile block for each individual, containing user's self-reported language proficiency on a 1 to 5 scale and up to three self-selected personality traits. Displaying self-selected descriptions in user profiles enables strategic self-presentation that aligns with each user's personal preferences, and meets the common needs in voluntary interpersonal communication and team formation [55]. To maintain spatial alignment with the corresponding individual in the VE, the profile sticker was designed to continuously update its display location based on the avatar's coordinates, ensuring it moves in sync with the avatar (see Figure 1). Since profile stickers overlap when avatars move close to each other, we lowered the transparency of the sticker to avoid legibility issues and make cues on overlapped stickers readable[4]. To make information displayed on the sticker accessible for the global team, we utilized visual icons to present language proficiency and side-by-side multilingual texts for personal traits. In order to investigate the effect of profile display timing, the timing to prompt the profile is adjustable based on different proximity settings. Meanwhile, we logged avatars' moving traces and patterns on the map via the add-on, in a tuple of $(coordinate\_x, coordinate\_y, timestamp)$, for follow-up analyses.

Username

Our custom software is an add-on to the Google Chrome browser and runs separately from the Gather Town application. It adds the layer of sticker displays to the Google Chrome browser of each individual subject.

We have predetermined a list of 24 names of programming languages in English that are either popular or easy to read and understand. The names in the list were java, python, fortran, swift, go, oxygene, pascal, ruby, pearl, ada, emerald, sako, turing, spark, genie, dylan, cobra, kojo, snowball, topspeed, zebra, serpent, cyclone, kodu. In the webpage, subjects were asked to first select a unique participation ID. To avoid duplicated selections, each subject was randomly shown a subset of the aforementioned names to choose from. We specifically instructed subjects to remember the ID they chose, and offered them a button to save the ID they selected to the clipboard. Subjects then were asked to enter the ID they chose in a text entry box to validate that they remembered their selection as it is, or to test whether their ID was successfully saved to the clipboard. After having answered all the questions, when subjects clicked the "Go to Gather Town" button, the information they selected was sent and saved to the our custom server, and they were routed to the Gather Town entry page to provide a username. They were instructed to enter the participation ID identical to what they selected from the website as their username for their Gather Town avatar. It is crucial that the username entered at this step was exactly the same, as our custom software relied on the Gather Town avatar usernames to determine the mapping of self-selected profile information stored in the server. In addition, our software sent users' coordinates in Gather Town according to their usernames. Hence, having subjects register the same participation ID was important for us to link their movement log information to their profile displays. In order to ensure that each subject correctly entered their username as the participation ID that was selected, the hosts verified subjects' usernames in Gather Town with the information we received in the server.

Language Proficiency and Personality Traits List

We use the 5-star rating scale to represent an individual's self-reported language proficiency in English and Japanese, where more stars indicates higher proficiency (shown in Figure 2b). Because of the wide usage of 5-star rating scale in everyday rating scenarios, e.g. in the product rating

[4]Users can also easily control their avatars to move around and separate overlapping displays.

(a) Entry page to register profile (b) User's profile display

Fig. (2) Screenshots of the online teamwork environment. Left: Entry page to register profile, including user ID, language proficiency and personality traits. Right: With our plug-in extension is enabled, a profile containing a subject's username (labeled a), language proficiency information (labeled b), and personality descriptors (labeled c) displays to the left of the avatar.

or restaurant rating, it's usable and intuitive for participants to report and interpret such rating. As for the list of personal trait descriptors, we first created a candidate list based on big-five personality traits and related literature [23, 24, 54], reaching a good coverage of personal traits. Then, four researchers from Japan and the US reviewed the initial list of adjective words together and filtered out a shorter list. We decided to remove significantly negative traits (e.g. withdrawn, timid, inefficient, irritable, unintelligent) to avoid negativity biases in team formation. After reaching a consensus to keep 20 major personal traits, we created semantically identical lists for global participants, one in English and the other in Japanese. Later in the study, participants were asked to select three traits out of the list in the version of their native language to represent themselves.

3.2 Study Design

In this study, participants were asked to form groups and then work with the group they belonged to to generate *English* slogans for a *Japanese* product in Gather Town. The slogan-generation task was designed to motivate collaboration by drawing on diverse expertise, language skills, and cultural backgrounds, encouraging participants to leverage their unique perspectives within a global team. To investigate the effect of availability and display timing profile cues have on global virtual team formation, three experimental conditions were designed: profile absent (no display – **ND**) condition in which participants did not see any profile stickers, displaying profiles all the time (constant display – **CD**) condition in which participants were able to view profile stickers constantly from the moment they enter the virtual environment, and a condition of popping up profiles when participants got close enough (adaptive display – **AD**). The participants in CD condition had a *global view* of everyone in the VE, knowing their language proficiency and personality traits, while the participants in AD condition had a *local view* of nearby workers' profiles. Meanwhile, in the AD condition, the neighbors' profiles popped up at the same time as their popup videos appeared. A between-subject experiment was conducted in which participants only experienced one of the three aforementioned conditions. To mitigate the potential effects of imbalanced distribution of participants' localities of residence, an approximately equal number of participants recruited from Japan and the U.S. were included in each session. The entire virtual teamwork study took place within Gather Town without using other communication media or tools, allowing participants to join from their current locations remotely. The study protocol was reviewed and approved by the Institutional Review Boards (IRB) in both Japan and the affiliated U.S. university.

3.3 Participants

We used an online research platform, Prolific, and a Japanese recruitment service of similar functions to Prolific to recruit participants who met the following criteria: they (1) were above age 18 and (2) had access to internet and were able to join the virtual space Gather Town; (3) native Japanese speakers residing in Japan or native English speakers living in the United States, simulating the global work scenario that individuals have various language and cultural background. In our recruitment notice, we merely mentioned the search of speakers in their respective native languages to perform a two-hour-long conversational task, with the additional advisory to expect the usage of English to Japanese participants, although English proficiency was not a requirement for them to join the study. We did not inform them of who they were joining the study with. Participants from both native languages were not instructed to converse in any particular language, and had no limits to which language they chose to participant with.

76 participants[5] were recruited for this study, including 50 females, 25 males, and 1 non-binary. 34 US participants were aged between 19 and 58 ($M = 29.65, SD = 10.87$), while 42 Japanese speakers were between 20 and 56 ($M = 33.96, SD = 10.62$). The Japanese participants (20 females, 22 males) had educational level ranging from high school to graduate degree. Their self-assessed English proficiency using a 7-point Likert scale (1 = very poor, 7 = very good), showed listening, reading, and writing skills above 3.5 (means ranging from 4.00 to 4.73). However, their speaking skills were moderately low ($M = 3.34, SD = 1.46$). More than half of them rarely or never engaged in English conversations in their everyday lives (16.67% never and 35.71% occasionally/not on a monthly basis). The U.S. participants (31 females, 3 males) had a similar educational range. Their self-assessed Japanese proficiency using a 7-point Likert scale, was notably low for all listening, speaking, reading, and writing skills (all means ranging from 1.09 to 1.50). Most (79.41%) never engage in Japanese conversations daily. We excluded data from one English speaking participant under the constant display condition due to a technical issue resulting in incomplete data collection. The language proficiency of all participants is shown in Figure 3.

Participants were recruited and organized to attend one of the seven Gather Town sessions according to their availability, with an expectation of 6 Japanese participants and 6 U.S. participants[6]. Participants were informed about the IRB approval of the study, along with their right to withdraw at any time. Each Gather Town session was then randomly assigned to one of the three profile display conditions: no display (2 sessions, $n = 21$), constant display (3 sessions, $n = 32$), and adaptive display (2 sessions, $n = 23$).

3.4 Procedure

The procedure of the online between-subject experiment is shown in Figure 4. Just before the study, Japanese and U.S. participants joined separate 10-minute Google Meet sessions, where researchers provided a brief overview of the entire experiment pipeline in their native languages (the content of the briefing was the same for both sessions). Afterwards, participants downloaded the software and extensions necessary to participate in the study under the researchers' instructions and support. After completing the initial setup of the add-on, participants were asked to open the entry page (shown in 2a) to self-register their usernames, Japanese and English language proficiencies, and 3 personality traits out of a list. To avoid clicking position bias, we randomized the display positions of personal traits on the entry page for each participant. Once finished, they entered the Gather Town space to receive a more detailed explanation of the two tasks (team formation and then slogan

[5]One participant faced technical issue. We, therefore, excluded this data point from the analysis.
[6]Due to ad hoc fluctuations in participant availability on the day of the study, the number of Japanese participants was approximately equal to the number of U.S. participants.

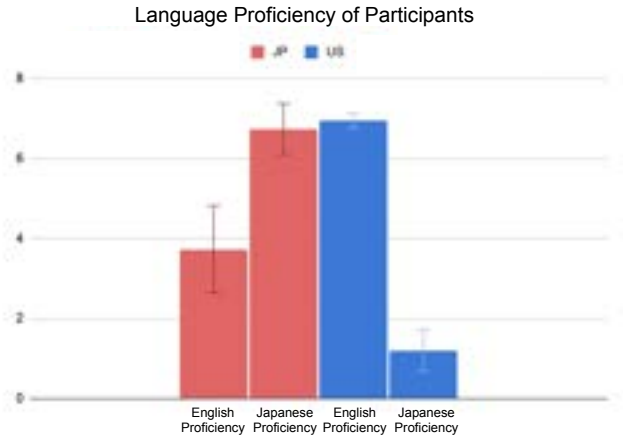


Fig. (3) Japanese participants have high Japanese proficiency and low English proficiency, while U.S. participants have low Japanese proficiency and high English proficiency.

generation task) in both Japanese and English. Researchers double-checked with participants to make sure that they had access to profiles aligning with experimental conditions and that their avatar username in Gather Town was consistent to what was selected from the entry page. Otherwise, researchers kept their interventions to a minimal during the experiments, except for answering participants' logistic clarification questions in their native languages. Subjects were instructed to enable audio and video when participating in team formation and slogan generation tasks.

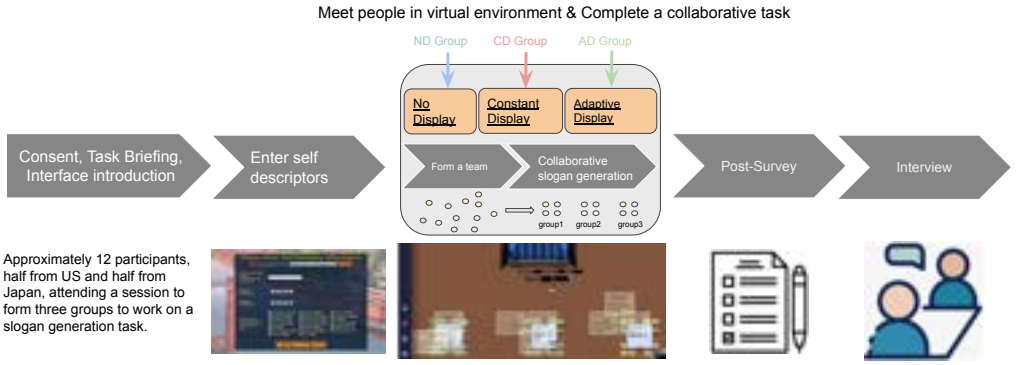


Fig. (4) Procedure of the online between-subject experiment

Team Formation: The participants were first instructed to form a group of three or four. They were given 20 minutes to rotate around tables and talk to as many people as they wished. They were also told that they were free to communicate in any language of their choice. They were instructed how to move around in the virtual space and how to talk to others in the space.

Collaborative Task - Slogan Generation: After forming groups, participants were asked to engage in a 20-minute group discussion in which participants worked with their group members and generated slogans for a Japanese product in English. A Google Docs containing a brief description of a Japanese product, in this study the onigiri mold, and a worksheet was provided to participants

to work on. The worksheet also specified the mission to accomplish, the constraints of the task, an area to record the username of every team member, and an example of the expected outcome. The worksheet serves as a common workspace for each group to write down all slogans they came up with. All members of a group were given the access to edit and comment on the document.

At the end of the task, participants completed a post-study survey written in their native language, followed by a 10-15 minute individual interview in their native language. Participants were monetarily compensated after study completion, with the rate of $15 per hour. The study plan was reviewed and approved by institutional review boards in both Japan and the U.S.

4 Measurement

Logs for Movement Distance

All participants' movement trace in the VE was recorded. The *movement trace* is recorded as a sequence of participants' (x, y) coordinates in the virtual space with time stamps in chronological order, where x is the distance to the left boundary and y is the distance to the top boundary. The positions of each participant is automatically captured by our Gather Town extension tool every 330 milliseconds and all data entries were stored in a database. The logs are used to further reconstruct participants' movements and calculate moving distance (see Figure 5 for sample reconstruction of movement traces from one session of the study). The moving distance indicates how long participants walked around in the 2D space. Therefore, it serves as a proxy measure of the cost paid to search for group mates or join a group.

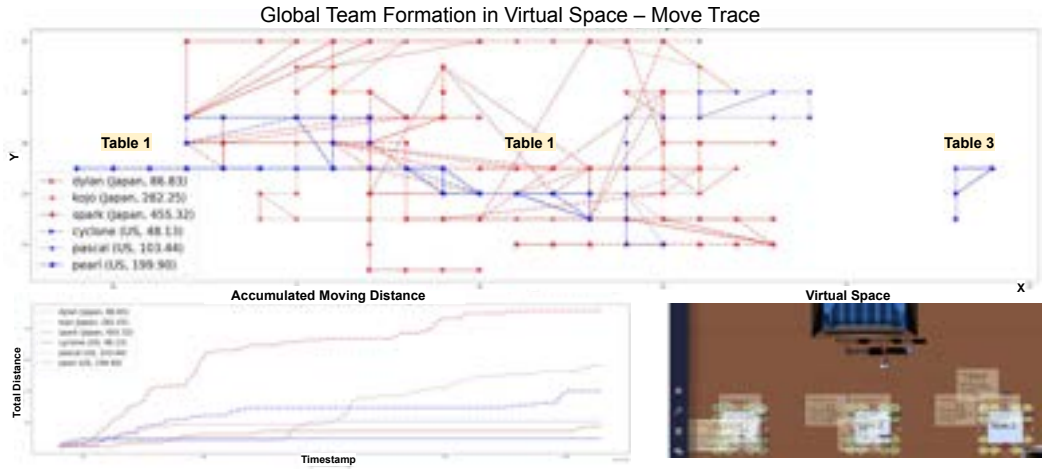


Fig. (5) Reconstruction of the participants' move trace in VE based on the series of x-y coordinates, sampled and recorded in the log file of a real session. We selected a constant display (CD) session, and filtered 3-minutes log data at the early stage of team formation. Due to the space limitation and visibility, we only plotted two participants ranked with the longest travel distance from each country and one participant ranked with the lowest travel distance from each country. The numbers in the legend indicate the total moving distance in the sampled duration

We computed participants' moving distance during the team formation phase when they were actively searching for other partners to form teams from the log file. We detected whether participants were moving based on the displacement of participants' position in the virtual space over time in the log data. Since the team formation task lasted 20 minutes, we partitioned the team formation data to 10 2-minute temporal blocks, which aims to capture participants' major

movements while neglecting those local variations occurred during a relatively short period of time (e.g., people moving back and forth around the same spot in seconds). We then calculated the value of log-transformed moving distance per time block to account for the skewed distribution of raw distance for each participant.

Survey Responses

Post-study survey responses were collected from each individual after they finished the task. We examined and adapted pre-validated survey instruments on teamwork experience with necessary revisions to match the context of the current study [2, 43, 72]. The final survey consists of three subscales for measuring (1) participants' satisfaction about the teamwork experience (e.g. "I am satisfied with the teammates I worked with", "I am satisfied with the results of our group work", "The members made me feel involved in the group"; Cronbach's $\alpha = 0.89$.), (2) attitude toward team diversity (e.g. "It was important to develop a team of people with diverse backgrounds.", "It was important for me to join a team with people from Japan (U.S.)."; Cronbach's $\alpha = 0.94$.), and (3) perceived availability of information needed for team formation (e.g. "I was able to procure sufficient information to help me decide who to form a team with", "I got to know everybody before I made my decision to be in a group."; Cronbach's $\alpha = 0.76$.). All questions were translated into Japanese for the survey.

To probe participants' willingness to continuously participate in global teams, the survey asked participants to report their satisfaction and inclination to work with others from either the same or different locality of residence. The questions will help us understand the sustainability of global teams as individuals have to be willing to work with others of different backgrounds for global teams to sustain.

All survey questions were discussed by all co-authors and modified to reach agreement to ensure the validity and ability to answer of the questions. Seven-point Likert scales (1 = strongly disagree, 7 = strongly agree, 4 = neither agree or disagree) were used to collect responses for all items. Participants were prompted to answer all items according to their experiences within our study sessions.

Interview

Qualitative responses were collected from multiple post-session interviews administered in parallel by three of the co-authors. These *semi-structured interview* were conducted to obtain additional feedback around participants' experiences with the team formation process, the work performed in the team, and the tools provided such as the VE and profile display. We aimed to gain deeper understandings on attitudes and decisions associated with the team-formation process. Some interview questions asked included "How did you decide which person to talk to?", "How did you decide which table to join?", "Did you ever move to another table? Why?" and "What did you think about the profiles? Did 'language proficiency' or 'personality' info affect your behavior in any way?" The post-session interviews were audio-recorded and transcribed using an automated transcriber *Otter.ai*[7] first and then manually verified.

Group Productivity

To keep track of the group work outcome, we collected the slogans generated from the worksheets that were assigned to each working group formed during the study. To measure group productivity, the co-authors segmented and coded the slogans produced by each group, as documented in the worksheets. As formed working groups can vary in size (the number of members working in the

[7]Accessed on 16th August, 2023: https://otter.ai/

team), we normalize slogan counts against group size to ensure a fair basis for comparison across different groups. Additionally, the quality of the slogans was assessed using an integrated score based on both the number of ideas generated and the cultural relevance of the product. For example, in the case of the onigiri mold, cultural relevance factors include time efficiency, affordability, hygiene, shape control, and more.

To sum up, the study involves measurements at both individual and group levels. At the individual level, we measure the searching cost for finding a teammate or joining a group during team formation with individuals' movement traces. We also measure individual participants' team formation experiences and attitudes toward continuously working in global teams with a survey instrument. We also interview individuals to gain deeper understandings about their experiences, expectations and reasoning. At the group level, we're interested in assessing how profile display for team formation affects the ultimate group productivity in work. We calculated normalized number of ideas (slogans) generated in each group to approximate the level of productivity that each group achieved.

5 Results

Based on quantitative data from movement logs and survey responses, and qualitative data from interviews, we performed a mixed method analysis to understand how profile display impacts team formation and team collaboration. We reported the composition of global team, individuals' partner searching strategies and travel distance (searching cost) during the process of online team formation (R
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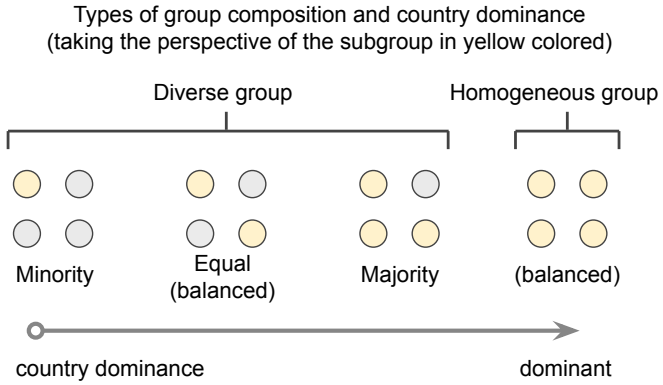


Fig. (6) Individuals' affiliation with groups in different composition and subgroup population (taking the perspective of the subgroup in yellow color; yellow dots represent individuals from one country, while the grey dots represent individuals from another county)

5.1 Quantitative Data Analysis

To examine how profile display affects the group composition (RQ1), we first determined the group composition according to the inclusion of members from different countries of residence (shown in Figure 6), categorizing the group as homogeneous (all individuals from the same country) and heterogeneous group (diverse group that has individuals from various countries). In order to consider the background of individuals, we further assigned labels to individuals based on the final group composition (as shown in Figure 6). In each heterogeneous group, participants were labeled

as *majority* or *minority* depending on the dominant population based on country of residence (i.e., Japan or the U.S.) within the entire group. For example, if a group has more Japanese than American participants, all Japanese participants are labeled as the majority and the remaining participants are labeled as minority. If there is an equal number of participants from both localities, all are labeled as *equal*. Since both the independent and dependent variables are categorical, and all expected counts exceed 1, we conducted non-parametric chi-square test [41] to analyze the effect of profile display conditions on group composition.

To further investigate how profile display conditions and participants' localities impact participants' involvement in a diverse group (RQ1), we built a nominal logistic model[8], taking group homogeneity as a dependent variable and profile display type and country-of-residence as independent variables. A nominal logistic regression model was used instead of a chi-square test because the analysis involves three nominal variables. In order to explore how displaying personal profiles in the VE affects individuals' efforts expended on finding teammates (RQ1.1), with consideration of their ultimate participation in a diverse group, we built a linear regression model[9] for moving distance in the VE, which takes participants' profile displaying conditions, original country, majority level in the group and the interaction between the last two variables as independent variables, and takes individual's moving distance as the dependent variable. The group's ID nested with the day of session and participant's ID nested with the group belonged were taken as random variables.

To investigate how the formed groups performed in the collaboration task under the influence of disclosed language proficiency and personality traits, as well as group composition (RQ2), we built a linear regression model for the analysis[10] on slogan quality, the number of slogans and Japanese culture reference in slogans separately, where U.S. dominance level (defined by the number of American participants subtracted by the number of Japanese participants in the group), profile display condition and their interaction are independent variables. To account for the variability and uncertainty existing in data, we took group nested with the date and the date as random variables.

To understand how experiencing specific display conditions, group compositions and individuals' country of residence impact subjective evaluation on working with others from the same and different countries in the study (RQ3). We conducted linear regression on three survey items, asking about individuals' satisfaction towards the group formed and the collaboration within the group, asking individuals' inclination to work with people sharing the same country of residence and asking their attitude toward working in a team with diverse backgrounds. Independent variables kept the same as previous[11].

[8]The nominal logistic regression analysis is used since all variables of interest, including group homogeneity, profile display type and participant's locality, are all nominal data. Besides, the example size is sufficient to meet the requirement of multinominal logistic (requiring at least 10 cases for each independent variable [1]). We compared the model with and without interaction between country of residence and profile display factor, and selected one without interaction factor due to lower AIC score (72.46), indicating a better model fit. The model selected is: GLM(in_homogeneous_group ~ original_country_group + profile_condition)

[9]LMER(moving_distance ~ original_country_group + profile_condition + majority_level + original_country_group * majority_level + (1 | uuid:group) + (1|group:day)), we went through the model selection process and did not include the interaction of profile display condition and majority level due to loose degree of freedoms. Besides, we checked VIF score (all under 2.4) to avoid potential collinearity risk.

[10]LMER(slogans_score/#slogans/Japanese_culture_reference ~ profile_condition + US_dominance + profile_condition * US_dominance+ (1 | group:day + (1|day)). Besides, we checked VIF score (all under 2.4) to avoid potential co-linearity risk.

[11]LMER(satisfaction/inclination_with_same(different)_language_group ~ original_country_group + profile_condition + majority_level + original_country_group * majority_level + (1|uuid:group) + (1|group:day))

Day	Formed Group ID	Profile Display	Group Formation Stage		Language Proficiency Range	
			#US	#JP	US's Japanese	JP's English
1	1	No display (ND)	0	3	NA	1-3
	2	No display (ND)	3	1	1-2	2-2
	3	No display (ND)	1	2	1-1	2-2
2	1	Constant display (CD)	2	2	1-1	4-4
	2	Constant display (CD)	2	2	1-1	3-3
	3	Constant display (CD)	2	2	1-1	2-3
3	1	Adaptive display (AD)	3	1	1-1	4-4
	2	Adaptive display (AD)	4	0	1-1	NA
	3	Adaptive display (AD)	0	5	NA	1-4
4	1	No display (ND)	1	2	1-1	1-2
	2	No display (ND)	3	1	1-1	3-3
	3	No display (ND)	1	3	2-2	2-3
5	1	Constant display (CD)	1	3	1-1	2-4
	2	Constant display (CD)	0	2	NA	2-2
	3	Constant display (CD)	3	1	1-1	3-3
6	1	Adaptive display (AD)	3	1	1-1	3-3
	2	Adaptive display (AD)	0	3	NA	1-3
	3	Adaptive display (AD)	1	2	1-1	1-3
7	1	Adaptive display (AD)	3	1	1-1	3-3
	2	Adaptive display (AD)	0	3	NA	1-3
	3	Adaptive display (AD)	1	2	1-1	3-3

Table (1) This table shows outcomes of the group formation stage and slogan generation stage. US codifies U.S. participants, while JP represents Japanese participants. The language proficiency range signifies the lowest to highest self-rated language proficiency score on a 1-5 scale from profiles of that particular group.

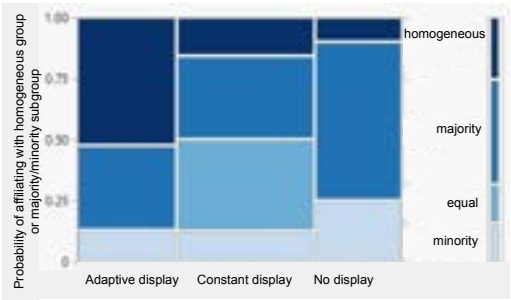


Fig. (7) Distribution of individuals' affiliation with homogeneous groups or heterogeneous groups as a member of minority/majority country of residence in the group across profile display conditions.

5.2 Effects of Profile Display on Group Composition (RQ1)

To better understand how profile display affects group formation, we analyzed the composition of formed groups across profile display conditions. A total of 21 groups were formed in our study under different profile display conditions (shown in Table 1). 6 groups were homogeneous, each formed by participants from a single country, while 15 groups were heterogeneous, consisting of participants from both countries ($\chi^2(2, 21) = 1.94, ns$). If we zoomed into the affiliation with a

Day	Profile Display	Talking Duration in minute(s)
1	No display (ND)	20.60
2	Constant display (CD)	21.00
3	Adaptive display (AD)	23.01
4	No display (ND)	17.41
5	Constant display (CD)	24.00
6	Adaptive display (AD)	15.80
7	Adaptive display (AD)	21.59

Table (2) This table shows the duration when participants were actually communicating during the team formation task

heterogeneous group (as shown in Figure 7), we observed that balanced groups were more likely built when the profiles were constantly displayed.

We observed a significant main effect of the profile display condition on individuals' ultimate participation in groups of various compositions, which can be homogeneous or heterogeneous. The condition of adaptively displaying profiles (AD) significantly influenced participants to end up in homogeneous groups, consisting solely of Japanese or American participants ($\chi^2(2, N = 75) = 14.59, p < 0.05$). The odds ratio [11] is $OR = 10.13$, 95% $CI[2.20, 63.17]$, indicating that participants in the AD group were approximately 10.13 times more likely to join a homogeneous group[12]. No significant difference was observed in group composition between the constant display and no profile display conditions. Both of these groups were more likely to end up working in a heterogeneous group compared to the adaptive display group. We also found a significant correlation between country of residence and individuals' likelihood of joining a homogeneous group. American participants were more likely to work in a heterogeneous group than Japanese participants ($\chi^2(1, N = 75) = 6.99, p < 0.05$). The odds ratio is $OR = 0.13$, 95% $CI[0.03, 0.50]$, indicating that Japanese participants were approximately 0.13 times less likely to join a heterogeneous group.

Participants, particularly those from Japan, reported to have utilized the profiles to actively get a sense of the background of others and the configuration of the current group, preparing beforehand and making decisions on whether to approach others. They developed communication norms, like forming an expectation of which language to use when speaking with one another, accordingly. One of participants experienced adaptive display condition said:

> *"It would have been nice to see profiles at all times. If I could see the profiles of people far away, I might have gone to talk to them out of curiosity. I couldn't see the profiles of people at other tables, so I just checked the profiles of the people at my table. I was curious to know how well the foreigners could speak Japanese. If they knew some Japanese, we might be able to speak in Japanese." (P44, JP, AD)*

Some participants from the U.S. also said that profile helps them obtain and share background information, as well as estimate other's expectation of the interaction:

> *"I thought it was informative, because it tells you the language proficiency that the person speaks and also the description of self. I thought that was a pretty cool feature because*

[12]To interpret the effect size, we use the following guideline: odds ratios (OR) of 1.68, 3.47, and 6.71 correspond approximately to Cohen's d values of 0.2 (small), 0.5 (medium), and 0.8 (large), respectively.

you tell someone that you're an introvert that you don't really like to interact with other people, so I thought it was a really good profile." (P31, US, CD)

As for selecting which group to join, Japanese participants said they were avoiding to be the minority of a group because of the potential communication pressures, and chose to talk to other Japanese when feeling nervous about speaking English, which tends to be a non-native language to the Japanese participants.

"I thought it would be difficult for a regular Japanese person like me to join a group with only Americans. I was very anxious to be in a situation where there were multiple Americans and I was the only Japanese, so I wanted to avoid such a situation." (P36, JP, CD)

"At first I was nervous not knowing what it would be like, so I looked for a Japanese person to approach and talk to." (P38, JP, CD)

"If I was the only Japanese in the group and the Americans' Japanese levels were like 1, I think we would both feel anxious about being able to communicate. "(P37, JP, CD)

On the other hand, US participants approached Japanese participants for curiosity about their distinct backgrounds:

" I'm trying to like find the tables that had like more Japanese people because I want to learn more and interact with them." (P16, US, ND)

Although participants in both language groups factored language proficiency in their group formation decision-making process, one of the elements that also determined the outcome of the team formation was the perceived willingness of other participants to maintain a conversation.

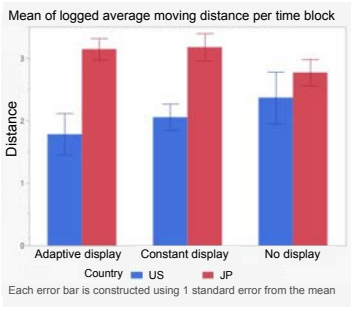
" After I went around to talk to as many people as I can, I just finally found people that were like pretty much interested in what I was talking about, some of them asked questions." (P2, US, ND)

" I talked to a good variety of different people. And then I just ended up on table one, and I was like oh, this seems like a solid group of people and it was two people from Japan and two people from the USA so I figured that was a good match I kind of based it off of our locations I figured if there was a good mix of people that would be a good team." (P9, US, CD)

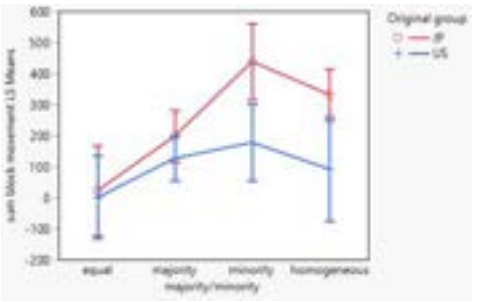
However, according to the group composition data (shown in Table 1), there were also occasions when a table was attended by a larger number of Japanese participants, resulting in a change in conversational dynamics. It discouraged those who wanted to be at a table surrounded by more interactive participants. The timing of profile display, especially in this scenario, may have prompted some U.S. participants to explain this phenomenon with the assumed language barrier of Japanese participants because they have a different native language, while overlooking the actual variation of English proficiency among them. This reasoning may explain why some Japanese participants with higher English proficiency also formed a team in Japanese majority groups.

"Well, there was a table, I can't remember what number, like people just weren't talking very much. I think there might have been a language barrier for people who spoke Japanese primarily and couldn't speak a lot of English, and you have some English speakers and they were sticking together at the table. It just wasn't easy for communication." (C3 D3 pascal t1 - what code?, US, AD) (P14, US, AD)

It is worth noting that not all Japanese participants who ended up in balanced or U.S. majority groups demonstrated the full extent of their English language proficiency during the team formation task, neither. This can be demonstrated by the shift in impression on these participants after their



(a) Moving distance of Japanese and English participants by profile display conditions.



(b) Moving distance of participants by the majority/minority status of their localities of residence

Fig. (8) Search cost during team formation.

involvement in the slogan generation task, as some U.S. participants reported to have changed their opinion on certain Japanese participants they worked with:

> *"I talked to them pretty much the whole entire last 10 minutes, but with the Japanese lady that I worked with, that my impression changed with her because at first she didn't say anything, like during like the group conversation that we were having before the team, but then once she saw the um… advertisement that was on the rice, squares, no it was triangles, that's when she started talking. So I was like okay, so, so I kind of assumed that she didn't know English because she would not say anything, and when she started talking I was like okay, she knows." (P2, US, ND))*

> Interviewer: Were they Japanese or American?
> Pearl: Japanese. So it's just kind of like, oh, no, you're not just someone on my screen you're a whole person." (P7, US, CD)

5.3 Searching Cost for Finding Teammates (RQ1.1)

To further understand how country of residence and profile display affect individuals' decisions on who to work with and which group to join, we analyzed the moving distance of participants.

5.3.1 When Being from Different Countries and Experiencing Different Profile Display Conditions. A significant main effect of country of residence has been observed on moving distance ($F[1, 60.79] = 13.27, p < 0.05$), with Japanese workers traveling a greater distance than American workers to find potential team members across all three conditions (Figure 8a). Additionally, profile display condition had a significant impact on the distance participants moved to form a group ($F[2, 11.52] = 4.18, p < 0.05$). Those in the constant display condition made participants travel farther to form a group ($M = 248.13, SE = 28.23$) compared to those in both the no display ($M = 146.00, SE = 36.75$) and adaptive display ($M = 126.53, SE = 34.55$) conditions.

People from different countries utilized various strategies to move in the space and used various criteria to find their teammates or join a team. U.S. participants reported two main approaches: they either stayed at one table and waited for people to approach and communicate; or they actively traveled around the space to meet different people. Native English speakers were looking for people who were easy to communicate, for instance, with low language barrier and personality match:

> *"I just went to a table that was empty and waited for people to come." (P18, US, ND)*

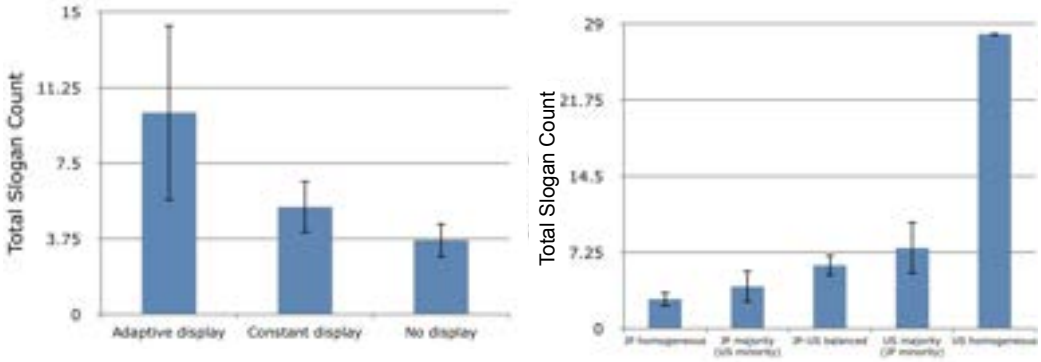
> *"Initially I went to someone who had the same kind of explanation or self descriptor. And then once I got more comfortable talking to people, that's when I went off to different areas and talk to different people." (P5, US, CD)*
>
> *"I kind of just went around the tables to see if I can find people to talk to. And then after a while I kind of found people who were open like how I was talking and then I stayed there." (P1, US, ND)*
>
> *"if there was somebody who I was able to easily talk to at the beginning then I was like okay cool, I'll just stick with them. (P32, US, CD)"*

Japanese participants, although also tried to initiate conversation in a group, faced challenges. Most of them,reported that they would go from table to table to listen to different conversations, evaluate if they are able to understand and communicate with the group and then decide whether they could join these discussions. They checked others' Japanese proficiency, sought for groups with good atmosphere, and searched for people who were willing to accommodate to language gaps or adapt to their speech rates. According to them, reasons to leave a table include English native speakers' speaking was difficult to comprehend or the pressure to speak out increased. The search cost, therefore, elevated for non-English-speaking Japanese participants when almost all of the other participants they encountered were not able to speak Japanese, driving them to move further to explore other possibilities:

> *"I had an active image of foreigners, and I sat and waited for a while at an empty table, thinking that the foreigners would come to me. But no one came. I thought I would have to make a move, so I started to move. I peeked at some groups from outside to see if the atmosphere was good." (P46, JP, ND)*
>
> *"Several groups had already begun to form, so I approached them to see their mood. I tried to get close enough to hear what they were saying to see if I could understand them, but I had no clue what they were talking about. After staying there for a while, I started to understand, but somehow I felt that the group had already formed and I was an outsider, so I moved on to another group. I moved on to the next group randomly and arbitrarily. Eventually, I settled at a table with only Japanese people." (P48, JP, ND)*
>
> *"When the pressure to speak grew heavy, I moved to another table." (P33, JP, CD)*
>
> *"Listening to the English was hard, and I wanted to move to another table because the atmosphere was not conducive to listening back. " (P40, JP, AD)*
>
> *"I decided to stay there, thinking I could rely on the Japanese, who seemed to speak English well." (P47, JP)*

5.3.2 When Ultimately Being Majority/Minority in the Group. We observed a significant main effect of people being a majority or minority for their country of residence in a group on moving distance ($F[3, 18.02] = 6.64, p < 0.05$). People as minority in a group or in a homogeneous group traveled a significantly greater distance than people in balanced group to find potential team members across all profile display conditions[13](Figure 8b). Post-hoc Tukey test shows that Japanese participants as minority in the group ($M = 438.18, SE = 61.60$) or in a homogeneous group ($M = 332.09, SE = 39.53$) tended to move significantly more to approach other participants in the virtual space than Japanese participants in an equal size as American participants ($M = 22.76, SE = 71.39$), indicating they paid higher travel costs to be a minority in the group or form a homogeneous group. Besides, people

[13]Forming homogeneous group is harder from the perspective of probability as well (with 6.06% possibility, assuming 6 JP and 6 US form 3 equal-sized groups.). As such, paying higher search cost is reasonable to reflect the difficulties.



(a) Group productivity across profile display conditions

(b) Group productivity across group compositions

Fig. (9) The Outcomes of Collaborative Work

who worked in balanced groups seemed to have settled quicker than others, resulting in significant less travel cost.

Only a few Japanese participants sought for opportunities to converse with U.S. participants and tended to join groups with more U.S. participants. However, they faced language difficulties while being a minority in the group. A trade-off existed between satisfying the hope to talk to US participants and finding a group appropriate for their language proficiency which could have further increased search cost expenditure: finding such place is not easy and they were moving in the space to find

> *"At first, I thought I wanted to talk with Americans since it was a great opportunity. But once I joined a group with Americans, I regretted it because I could not keep up with them." (P40, JP, AD)*

When no profiles were displayed, passively waiting at the table for others to join or randomly talking to someone nearby for team formation seemed to be a common strategy adopted. When profile displayed in VE, participants had an anchor to plan ahead who to approach, either someone similar or dissimilar to themselves in terms of localities and personality. People from different countries were observed to see the team formation task differently, where Japanese workers took the process likely more as making decision on which group to join, while American workers took the leadership to find other members to join and would actively approach others.

5.4 Group Performance (RQ2)

To better understand how country of residence, profile display and country dominance affect collaborative work after groups were formed, we analyzed the productivity of slogan generation of formed groups. Although profile display condition did not have a statistically significant effect on the group productivity ($F[1, 3.98] = 0.82, ns$), we observed that AD and CD possibly made participants generate more slogans ($M = 9.57, SE = 3.38$; $M = 5.39, SE = 2.76$) than ND condition ($M = 3.66, SE = 3.38$) (as shown in Figure 9a).

We further checked the effect of group composition on productivity. We observed a significant effect of U.S. dominance on the number of slogans generated: groups with more American participants than Japanese participants came up with significantly more slogans ($F[1, 11.08] = 7.15, p < 0.05$), as shown in Figure 9b. Groups consisting of American participants as majority and Japanese as minority achieve higher group productivity ($M = 7.67, SE = 2.47$) than groups formed only by

Japanese participants ($M = 2.80, SE = 0.66$)[14]. We observed that such group composition also outperform other group compositions, which are Japanese dominant groups and balanced groups ($M = 4, SE = 1.51$; $M = 6, SE = 1$), except the homogeneous group consisting of only American participants ($M = 28, SE = 0$). The high productivity of slogan generation may be attributed to the English language skills present within the team. It is worth noting that there is a sharp contrast between US homogeneous group and Japanese homogeneous group consisting of only Japanese participants in terms of productivity. JP homogeneous group generated the lowest number of slogans while US homogeneous group generated the highest number of slogans. As such, considering all formed groups as a whole, the productivity gap among groups formed could be huge depending on group composition and the relative proportion of participants from a specific country.

As for the quality of teamwork outcomes, no significant effect of U.S. dominance level and profile display condition has been found on the quality of the slogans (*ns*). Higher Japanese dominance level did not increase the slogan quality. It could be possible that Japanese participants faced challenges to externalize their knowledge using non-native language, making their contributions towards quality and cultural reference small in comparison.

Although Japanese participants may achieve limited productivity when working in homogeneous group, they could still contribute to globally diverse groups when working together with American participants. Japanese participants contributed with cultural and domain knowledge to the diverse group. American participants working with Japanese participants recognized their contributions on bringing culture-specific knowledge to the teamwork. However, working with other people from different background is challenging with the presence of language barriers, as reported by the participants:

> *"She (a Japanese participant) was great. I liked how she taught me how to say the word that I actually just forgot, but she taught me about the item that we had in our team work, and she taught me about the culture. I felt a lot for her too." (P31, US, CD)*

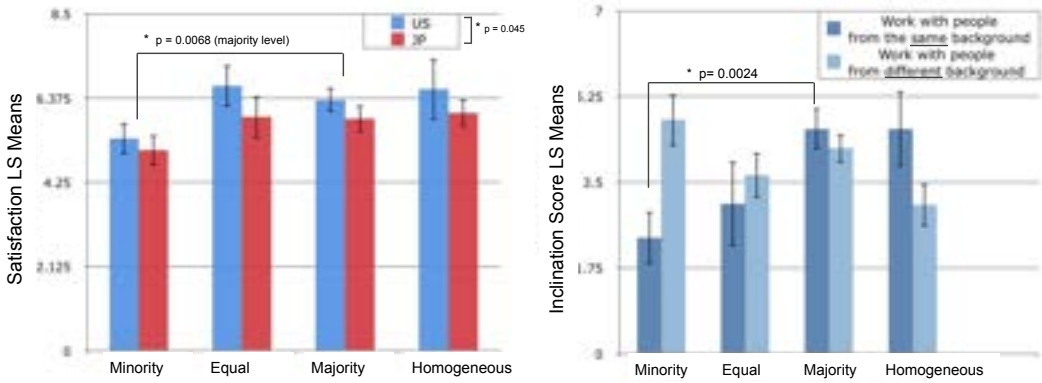
> *"He (a Japanese participant) explained a lot. Like he explained from like, how much it costs. So like, you know, what it does, and like, where people would use it was very helpful." (P16, US, ND)*

Interview responses from Japanese participants confirmed the salience of language gap in a diverse team:

> *"The Americans' English was so fast that I had no idea what they were saying." (P45, JP, CD)*

American participants have been considering the possibility to converse in Japanese instead, which is actually possible with today's AI-driven machine translation technologies, to allow better global participation:

> *"There was a three person team, one of my Japanese participants was, seemed to have a better communication. Thinking back I wish I would have them converse in Japanese, so the third person could have given us some ideas." (P3, US, ND)*



(a) Satisfaction towards collaborative work (b) Inclination to work with diverse people

Fig. (10) The Collaborators' Evaluation of Teamwork

5.5 Individuals' Satisfaction on Collaborative Work and Inclination towards Diversity (RQ3)

To better understand how country-of-residence, profile display and country dominance affect collaborators' subjective evaluation on the teamwork, we analyzed individuals' satisfaction rating and inclination towards working with others with same or different backgrounds.

5.5.1 Satisfaction Gap in Unbalanced Team. Group members' satisfaction indicates to which extent the individual's expectations toward group work are met, implicitly reflecting a shared attitude inside the group toward the collaborative task and the co-workers [40]. In this study, the dominance of group members' country-of-residence was observed to have a main effect on the collaboration satisfaction ($F[3, 21.94] = 3.78, p < 0.05$), where individuals' expectation fulfilment were higher if their localities are of majority in the group (as shown in 10a). Individuals felt significantly less satisfied with the collaboration work if they are the minority in the group ($M = 5.30, SE = 0.31$) in comparison to those whose country is the majority of the group ($M = 6.08, SE = 0.25$), according to the Post-hoc Tukey test. Individuals in such unbalanced groups were observed to be generally less satisfied than the balanced group ($M = 6.47, SE = 0.47$) and homogeneous group ($M = 6.82, SE = 0.53$). In addition, Japanese participants were observed to have significantly lower satisfaction than American participants ($F[1, 31.15] = 6.43, p < 0.05$). As such, satisfaction gap existed in groups with unbalanced group composition and among people from different countries.

5.5.2 Work with Others from the Same Country or Different? Collaborating in a global team necessitates people to coordinate and work with others from the same or different backgrounds, in this study, we observed a significant main effect of the country imbalance of the group composition on individuals' inclination to partner with people from the **same** background ($F[3, 21.77] = 6.62, p < 0.05$). Figure 10b illustrated participants' inclination towards working with people from the same background versus working with people from a different background (each participant was asked to self-report both inclinations). Participants in a homogeneous group or being the majority of the group were observed to be more inclined to work with people from the same background than a different background, while participants in a balanced group or those in the minority showed a lower inclination to work exclusively with people from the same background.

[14]We reported descriptive statistics here because of limited data collected at the group level, causing the loss of degrees of freedom (interaction factor of condition and group composition), e.g. US homogeneous groups were not formed in AD condition.

In participants' response on the inclination to partner with people from **different** backgrounds, we triangulate participants' attitudes towards diversity. Interestingly, Japanese participants who were in the minority within a group showed the highest inclination to work with people from a different background ($M = 5.50, SE = 0.73$), although this difference was not statistically significant (*ns*). This reveals a distinct pattern compared to some other Japanese participants, who tended to prefer working with people from the same background.

The analysis of the interview also suggested that the multilingual participants could explore different strategies when looking for potential teammates. English native speakers could have focused more on whether they could communicate with the people they encountered during team formation. This emphasis on communicability seem to diminish the attention to diversity especially when profile displays were available. However, Japanese native speakers seemed to have an ideal team composition in mind involving people of both language backgrounds, and they would use the displayed information and travel to find partners that fit this description. The reason to the noticeably higher inclination for Japanese speakers to work with people from the same language background in the adaptive display condition remains unclear, and we will need to investigate further to understand the mechanism behind this major attitude shift.

Maintaining a global team can be challenging. In the interviews, participants primarily expressed concerns about lack of participation, communication difficulties, and issues with inclusion:

> *" There were people who didn't speak up." (P59, JP, CD)*
>
> *"That one of our team members did not speak fluent English so a concern was about how we would effectively communicate to include him." (P17, US, ND)*
>
> *"Since I was the only native English speaker, I worried that I would slow the group down (that they would feel like they had to speak in English to accommodate me)." (P18, US, ND)*
>
> *"Because only Japanese people were present, opinions from foreigners could not be taken into account (Note: This participant worked in a US homogeneous group). (P51, JP, AD)"*

6 Discussion

In contrast to in-person teamwork, where people have numerous opportunities to develop shared knowledge and common ground, fostered by the collocated physical environment, virtual global teams face challenges related to personnel and technical issues when forming a group. From the perspective of personnel challenge, individuals in the global team come from dispersed geographical location, possibly making them hold different native language skills, different cultural norms and various expectation on the collaboration with others. In the VE, such information about diverse background are implicit and unknown to other workers due to limited capacity to convey and perceive social cues in computer-mediated communication, causing cognitive uncertainty about the others' language expertise, abilities and personalities of individuals in the space. This uncertainty may lead to low visibility to others and unawareness of available talents, which can influence the team formation process and consecutive collaborative work. Displaying social profiles in virtual environments (VEs) before people speak to each other impacts their communication strategies and the coordination costs typically required to establish shared understanding. This includes decisions around who to work with, what roles to assume within the group, and how to align on common goals.

6.1 Effects of Displaying Social Cues on Global Team Formation in Virtual Environment

Our findings indicate that, while initially unaware of the presence of people from a different language background, profile interventions in VE significantly influence individuals' ultimate participation in diverse groups and their contribution to the formed group. Compared to the

condition with no social profile displayed, presenting additional personal information in worker profiles within VE (AD and CD) – such as language proficiency and personality traits – can indeed help team members become more aware of each other's language ability, cultural background, and personal characteristics. This enhanced awareness supports comfort-building prior to interaction, helping individuals feel more at ease with potential collaborators. By reducing cognitive uncertainty during the team formation process, these social cues align with uncertainty reduction theory [58] and can ultimately enhance the productivity of the formed groups.

However, our results also show that how profile is displayed - particularly the **timing** of when such social cues become available – can impact individuals' participation in diverse groups differently. While the adaptive display (AD) tends to encourage individuals more likely to join homogeneous groups, the constant display (CD) made individuals join mixed groups. A possible explanation lies in individuals' tendency toward *risk aversion* [53]: people often prefer to collaborate in environments with lower uncertainty to increase the chances of successful coordination.

In the CD condition, social cues are persistently available, giving individuals ample time to gather and process information about others. This continuous access supports comfort-building and reduces uncertainty, making it easier to consider joining a more diverse group. In contrast, under the AD condition - where profile information is only shown when users are in close proximity - individuals are limited in their ability to preview group composition and gather a broader understanding of potential collaborators. The reduced time to process information raises the cognitive cost of decision-making and may discourage individuals from exploring diverse groups. As a result, they may gravitate towards others similar to them to minimize perceived risks and foster trust more easily [29, 71].

When working with individuals from different backgrounds, concerns such as language barriers and performance anxiety — stemming from the fear of not contributing effectively in a non-native language — can arise compared to collaborating with those from similar backgrounds [33, 39, 78]. In our study, individuals experiencing constant display (CD) had full control over whether and when to pay attention to profile information, which may have allowed them to anticipate and set expectations regarding potential challenges before interacting with others [62]. In contrast, adaptive display (AD) captured individuals' attention simultaneously as they approach others, limiting their control over when they read the profile information. As a result, individuals may experience a higher cognitive load due to the limited time to both read the profile and engage with others, leaving them less prepared for potential challenges before interactions begin. Furthermore, displaying profile information alongside video channels may exacerbate confirmation bias [45]. Users may overestimate the level of collaboration difficulties based on video cues, as they take the profile information as confirmation, or vice versa. Due to an overestimation of collaboration difficulties, individuals may choose to stay with people who share the same background, leading to more homogeneous groups.

In summary, the use of profile information reduced cognitive uncertainty and increased individual contributions to group activities. Additionally, adaptive display had a greater impact on the decision-making for individuals joining homogeneous groups compared to constant display. Furthermore, displaying profile can either motivate individuals to explore the space or reduce their exploration, depending on their cultural backgrounds. These insights can guide the future design of social displays in virtual environment (VE) for global group formation, informing both the content and timing of displays.

6.2 The effect of Group Diversity and Country Dominance on Global Collaboration in Virtual Environment

Our findings show that group diversity influences individuals' contribution to the collaboration productivity of the formed group. However, this effect is interestingly not uniform and depends on which country-of-residence dominates within the group. Specificallyhomogeneous groups of U.S. participants were observed outperform all other group compositions and achieved the highest collaboration productivity while homogeneous Japanese groups showed the lowest productivity. This contrast suggests that group homogeneity does not guarantee better outcomes across the board - its impact is influenced by the interaction between cultural norms, linguistic norms, communication styles, and collaborative dynamics.

One possible explanation lies in cultural differences in team interaction norms. US people, coming from a low-context culture [26], tend to engage in direct, explicit communication and often prioritize individual contributions and quick decision-making. In a homogeneous setting, such shared norms may facilitate efficient coordination, reduced ambiguity, and faster alignment on goals, thereby enhancing productivity.

In contrast, Japanese people - typically representing a high-context culture - tend to rely more on implicit cues, social harmony, and group consensus [26, 46]. While these norms can be strengths in long-term teams, they may slow down collaboration in short-term, unfamiliar group settings, especially in a virtual environment where subtle social signals are harder to detect. In homogeneous Japanese groups, this may lead to implicit communication, prolonged decision-making, or reluctance to disclose opinions - all of which can reduce productivity in fast-paced, time-limited collaboration contexts.

These findings challenge previous work [15, 21], which found homogeneous groups outperform diverse groups. Instead, we suggest that the benefits of homogeneity are influenced by the nature of group interaction norms and how well those norms support efficient collaboration under specific conditions, such as unfamiliar team members or remote work.

Comparing the U.S. homogeneous group to more diverse group compositions, the drop in productivity may be explained by the difficulty of building shared goals and expectations for collaboration. In diverse groups, people may naturally group themselves based on cultural or linguistic similarities — an effect known as social categorization[59]. This can lead to intergroup biases[28], where members feel less connected or trusting of those from different backgrounds, making communication and coordination more challenging. While diversity brings valuable skills - for example, U.S. people contributing language expertise and Japanese people offering knowledge of product features - these benefits can be limited if the team struggles to establish common ground.

In sum, our results extended the understanding of group diversity by highlighting that not only the group diversity matters, but the dominant country-of-residence within a group also matters, which decides the skills and intelligent resources available to the group[15]. While our study focuses on collaboration between U.S. and Japanese people, where predominance of English as an international language may have influenced group dynamics. Future work can broaden this lens to explore global teamwork across a wider range of cultural contexts and examine two non-English-speaking countries.

[15]When calculating he diversity score by Blau's index [4] ($1 - \sum_{lower}^{upper} {p_i}^2$) or entropy, the same diversity score could correspond with different country dominance, e.g. homogeneous Japanese and homogeneous U.S., 25% Japanese and 25% U.S. Although the diversity score are the same, the corresponding group performance varies due to the dominant country.

6.3 Dilemma of Being Minority with Limited Language Skills

Although being in the minority by country-of-residence is common and often valuable in globally diverse groups, our findings show that individuals in the minority face notable challenges. Compared to those in balanced or homogeneous groups - where satisfaction levels tend to be more even - individuals in minority positions report significantly lower satisfaction than their majority group peers. This disparity in satisfaction may create a sense of unfairness and imbalance within the team, which aligns with previous findings on intergroup dynamics [6, 70]. According to the sustainability framework [52, 65], uneven satisfaction levels within a team can undermine the stability and long-term sustainability of global collaboration.

For individuals who joined a group as a minority - specifically, Japanese people in our study - significantly greater effort was required to move around the virtual space and find a group that aligned with their expectations. This higher search cost suggests that joining a group as a minority was more challenging. Despite these difficulties, many still chose to join diverse groups, indicating a strong value placed on global collaboration and cross-cultural experience. This finding aligns with prior work on cosmopolitanism [50]. Our results further support this, showing that minority participants were more likely than majority participants to believe it was unnecessary to work with others from the same background and preferred collaborating with those from different backgrounds. However, joining a group as a minority may still lead to feelings of being an outsider, due to unfamiliarity with the dominant group's language, culture, or unspoken social norms and practices [6, 70].

Following the collaboration, individuals who were minorities in their groups reported relatively lower satisfaction. This mismatch between the high effort required to join a group and the low satisfaction experienced afterward highlights a dilemma: while these individuals valued contributing to diverse teams, they faced substantial challenges in building shared language, expectations, and collaboration norms with members from different backgrounds. This aligns with prior work [42, 76, 78], which highlights the difficulties of being a minority in global work settings. As a result, such experiences may prompt minority members to seek alternative groups in the future, ultimately threatening the sustainability of already-formed teams.

6.4 Design Implications Toward Diversity and Inclusion for Global Team Formation and Collaboration in Virtual Environment

Designs Social Profile - Display All or Adapt Display for Me? Social profile displays are powerful cues in virtual environments (VE) that help foster users' sense of comfort and willingness to collaborate before interaction begins. Making these profiles accessible helps reduce uncertainty and supports comfortable, confident team formation.

To make social profiles effective in building comfort and supporting diverse collaboration, future designs should give users control over when and how they access profile information. In addition, users need to have sufficient time to process information on the profile before interacting with others. Furthermore, the design efforts need to maintain awareness of the presence of social cues without overwhelming users.

The mode of profile display also plays a critical role. On one hand, showing profiles in close proximity - via a pop-up when someone is nearby - can make information salient and timely. However, it can also create pressure to multi-task, forcing users to process social cues and respond in real time, which may be cognitively taxing. On the other hand, persistent profile displays allow users to browse freely and track potential collaborators, but they risk causing attention fatigue [5, 32] due to constant visual load.

Thus, future designs should balance adaptivity, agency, and social cue saliency. For example, using hover-triggered displays so profiles appear only when the user shows interest; leveraging private back channels, such as a chat window or sidebar, to quietly introduce profiles of nearby users.

Designs with Culture-Awareness The impact of profile displays is not culturally uniform. Individuals from different cultural backgrounds were observed to use profiles in distinct ways: some were motivated to actively explore the space and engage with others, while others relied more heavily on the information provided by profiles to make interaction decisions without extensive exploration. These behaviors suggest that cultural norms shape how users interpret and use social cues in VE. As a result, a one-size-fits-all design approach may limit accessibility and engagement across diverse user groups.

To make social profiles effective and culturally inclusive, future designs would better to adapt the visibility, timing, and salience of profile cues based on users' cultural expectations and preferences. In addition, tailoring the level of implicitness or explicitness of social cues can be considered. For instance, offering more ambient or indirect cues in high-context cultures, and clearer, more structured information in low-context cultures.

Designs for Group Diversity, Sustainability and Communicability

Our findings reveal that individuals engage with group formation and profile information in diverse ways. Some prefer to join existing groups, while others initiate new ones. Similarly, some treat profiles as sufficient sources of decision-making, while others use them as a starting point to gather more information. Additionally, individuals vary in their capacity to process additional social cues in real time. Importantly, social profiles are not only a tool for perceiving others, but also a means for users to express themselves and match potential collaborators. This bidirectional exchange of social cues should be carefully considered in future design efforts.

To best support the diverse user needs in processing social cues and forming teams, future designs could consider to customize profile display strategies for different user needs and behaviors. Besides, customizable profile content can be allowed for users to choose what to share, for example, incorporate non-verbal communication tools (e.g., emojis or badges) for quick and inclusive signaling.

In addition to supporting diversity, future designs should also promote the sustainability of collaboration. Reducing satisfaction gaps, particularly between minority and majority members within the imbalance group, can enhance long-term team stability. Social profile displays can be extended beyond team formation to act as ongoing social interventions during group work, helping individuals stay aware of their collaborators' status. For example, future designs can explore dynamic profiles that allow individuals to update or share their current feeling or concerns throughout collaboration, supporting mutual understanding.

To further promote inclusiveness in multilingual teams, prevalent language support tools can be integrated into the platform (e.g., translation, simplified phrasing) [8, 48]. These tools have the potential to bridge communication gaps from a language perspective and support smoother collaboration.

7 Limitations and Future Directions

Although we established that displaying profiles differently can affect the diversity of formed groups and country-of-residence influence the global team work, this study has some limitations. First, we did not run another experiment to have people form groups again from the same population to compare group composition from different trials. Although this can give us a better understanding on the sustainability of formed groups, it requires higher costs and more time. Under these resource constraints, we took workers' satisfaction rating as a proxy. Second, we didn't measure participants'

actual personality traits via scales. Instead, we have participants self-select the descriptors. This design choice aligns with real-world communication practice as how people self-select and self-report to present themselves in team collaborations. While there can be a discrepancy between individuals' true characteristics and their self-selected characteristics, questions around why and how people manage their self-presentations in social communication aren't the current focus of research, but would warrant further research in the future. Third, we set pop-up proximity for adaptive display to be the same as video channel pop-up. However, making profiles pop-up in different ranges of proximity may affect how workers perceive and utilize it. We leave this investigation for future work. Fourth, although established that country dominance level influenced the group outcome, we did not measure how the individuals contributed to the group work, e.g. how much they talked and what they contributed. We leave the space for future work. Fifth, the sample size (n=76) warrants consideration. Recruitment was impacted by pandemic-related constraints and the logistical complexity of conducting a group experiment across two countries. Although we observed statistically significant results in our quantitative analysis, the sample size for between-subject with three experimental conditions could raise concerns about statistical power. To alleviate this limitation, we utilized a triangulation research method [74], integrating participants' individual behavioral data, perception data, interview data and group interaction data. This approach allowed us to cross-validate findings from multiple perspectives, thereby enhancing the credibility and trustworthiness of our results despite the sample size constraint.

This study focuses on how social profiles influence the team formation process, without accounting for virtual space configurations, such as the appearance, size, or functional layout of the virtual environment (VE). Future work can explore how the design of VEs might better support global collaboration and reduce the search cost required to find and join suitable teams. Furthermore, future research could apply similar designs in diverse linguistic and cultural contexts (non-English-majority) to enhance the generalizability of the findings.

8 Conclusion

Global online collaboration must navigate both physical obstacles, like language differences, and social challenges, such as varying expectations and work cultures. To enhance social cues in VEs for global team formation, our focus is on designing a social display that highlights language and worker profiles, emphasizing diversity and inclusion. We carried out a study examining how enhanced profile displays in VEs influence users' global team formation and collaborative behaviors. In a slogan generation task, participants from Japan and the U.S. were assigned to one of three conditions: no profile display (ND), constant display (CD), or adaptive display (AD). Our findings suggest that profile displays offer linguistic and personal cues, enabling global workers to recognize available language options and anticipate communication styles, thereby fostering more productive group contributions. However, adaptive displays may introduce uncertainty during interactions, making individuals more inclined to engage with homogeneous groups to mitigate collaboration risks. Profile displays affect workers from different cultures in varying ways, so the design of profile displays requires consideration of cultural factors. Factors like workers' backgrounds, the availability of profile information, and the dominant background within a group impact team formation efforts, teamwork outcomes, and satisfaction levels. Our research offers design recommendations to optimize VEs using profile displays to support diverse and effective global teamwork.

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