Beyond Lingua Franca: System-Facilitated Language Switching Diversifies Participation in Multiparty Multilingual Communication

MEI-LING CHEN, National Tsing-Hua University, Taiwan
NAOMI YAMASHITA, NTT Communication Science Labs, Japan
HAO-CHUAN WANG, University of California, Davis, USA

When multiple non-native speakers (NNSs) who share the same native language join a group discussion with native speakers (NSs) of the common language used in the discussion, they sometimes switch back and forth between common language and their native language to reach common ground. However, such code-switching makes others feel excluded and thus not considered appropriate during formal meetings. To offer NNSs more flexibility to code-switch in a group discussion while minimizing the cost of excluding others, we introduced a language support tool that automatically detects between two pre-defined spoken languages, and then transcribe as well as translate them into another language (common language or NNS's native language). In a within-subject study involving 19 quads (two Japanese and two Chinese) in a collocated setting, participants were asked to perform a series of decision-making tasks with and without the tool. Results showed that the language support tool encouraged diverse use of language during a meeting, resulting in more equal participation from each group member. Although the perceived quality of collaboration became lower, it also elicited helping behaviors among the NNS pairs.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**; • **Human-centered computing →** Empirical studies in collaborative and social computing

KEYWORDS

Multilingual communication; dominance; participation; variation of language use

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1 INTRODUCTION

Due to incompetent language proficiency, it is challenging for non-native speakers (NNSs) to follow on-the-fly conversations [36] and contribute their ideas in multilingual communication when using a designated common language. Instead of taking an initiative, NNSs are prone to

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Author's addresses: M.L. Chen, National Tsing-Hua University, Hsinchu, Taiwan; N. Yamashita, NTT Communication Science Labs, Kyoto, Japan; H.C. Wang, University of California, Davis, 1 Shield Ave, Davis, CA.

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just following other's communication. Such submissive behaviors may diminish their influence on final decision making in the multilingual organizations. On the other hand, being unaware of NNSs' difficulties, native speakers (NSs) tend to be more talkative and may control the direction of conversations with their linguistic advantages [32]. According to Feely et al., such NSs' advantages may have a negative effect on the long-term development of global organizations [7]. For example, it may hurt the diversity and lead to reduced productivity [5]. The NSs' more expressive communication styles may also affect the power balance among multilingual team members which may be detrimental to resource distribution and social outcomes in the workspace [4].

To encourage diverse participation in multilingual contexts, previous research has leveraged the power of real-time language support such as automatic speech recognition (ASR) and machine translation (MT). Research has shown that ASR generated transcripts improve NNS comprehension and facilitate common grounding in triadic (two NSs and one NNS) conversations [21]; however, the transcripts do not seem to help NNS contribute more during their discussions. On the other hand, machine translation (MT) has the potential to facilitate NNS contribution by allowing them to speak in their native languages; yet, research shows that translation errors caused by MT can confuse people to comprehend each other's idea [35]. Using a common language or lingua franca, remains necessary and common in practice.

While previous research on multilingual support tools has focused on NS-NNS pairs and triads with two NSs and one NNS, we are interested in supporting multilingual groups consisting of multiple NSs and multiple NNSs. In such multilingual groups, the conversation dynamics may differ significantly as the actionable options that each group member can undertake for communication become numerous. For example, NNSs who share the same native languages can have side conversations in their own languages when facing language difficulties, rather than staying silent. Indeed, previous work shows that NNS members in multilingual groups sometimes switch back and forth between common language and their native language (i.e. code-switching) to reach common ground efficiently [15].

In this paper, we study quads consisting of two NSs and two NNSs and focus on code-switching behaviors among the two NNSs. By introducing a language support tool that automatically detects between two pre-defined languages, and displays transcripts as well translations, we aim to understand how such language support tool influences NNS's code-switching behaviors, and the overall group dynamics.

We estimate that the introduction of such technology has the potential to release NNSs from the social norm to adopt a common language in multilingual group discussions. NNSs may feel less pressure to use common language in group discussions because the tool automatically detects their spoken language from the pre-defined languages and translates them into common language when it's activated. As a result, NNSs may frequently switch back and forth between their native language and common language to quickly confirm understanding or consult with the other NNSs when using the tool. Such behavioral changes may lead to increased contribution from NNSs, resulting in more diverse participation of the group members.

To explore our research questions, we conducted a within-subject laboratory study with 19 quads (each consisting of two Japanese native speakers and two Chinese native speakers who also speak Japanese as a second language). Since the Chinese speakers were students living in Japan, their common language was Japanese. Each quad performed two survival tasks in different conditions: with-tool and without-tool. In the with-tool condition, a language support tool embedded with automatic language identification (LID), ASR, and MT was provided to all

participants. By pre-defining the acting languages as Japanese and Chinese, the tool automatically detected the participants' language, showed the transcripts and translated results of the respected language - when participants talked in Japanese, the tool generated Japanese transcripts and showed Chinese translation; when a participant switched to Chinese, the tool generated Chinese transcripts and showed Japanese translation.

The results of quantitative and qualitative analyses suggested that the language support tool made NNSs expressing more their idea by liberating them from using a common language. NNSs switched back and forth between native and common languages according to their needs, which resulted in a greater variety of language use during their group discussions. Some NNS's dependence to the tool also elicited helping behaviors from the other NNS. However, interestingly, the participants rated the quality of collaboration significantly lower when using the tool. Interview findings suggest that although the tool provided a chance for NNSs to express complicated ideas, the listeners then had to focus on understanding the translated results, which unfortunately stopped the flow of conversation. From these insights, we suggest design implications to delineate the design space of future language support tools.

2 BACKGROUND

To situate our study, we start with discussing the literature about the language difficulties of NNS and its consequences in multilingual teams. Next, we take a deeper look at NNSs' communication strategies in groups consisting of multiple NSs and NNSs. We discuss how NNSs switch languages in the multilingual group discussions. Finally, we discuss the language support technologies to facilitate NNS participation in multilingual groups.

2.1 Multilingual Group Discussion

In global teams consisting of multilingual members, common language is often used to smooth the group collaboration. However, NNSs usually experience higher cognitive workload by using a second language. For instance, NNSs require more time and effort to follow the conversation and they could easily get lost in the quick pace of conversation [35]. Under such circumstances, NNSs tend to feel anxious and less competent in the group [13], which make them relatively quiet during group discussions. As a result, NSs tend to lead the discussion with minimum contribution from NNSs.

As such, NSs are more likely to have more power to lead the direction of conversation by initiating topics or control the dynamics of interaction [28]. However, from a group dynamics perspective, some members dominating a group discussion causes ineffective decision-making process [14] and lower performance of final decisions [12] since they are eliminating the chances of cultivating diverse ideas. Moreover, the dominant behaviors of some members pose threats to maintain long-term relationships among group members [2].

2.2 Code-switching in Multilingual Group Discussions

Although group members tend to use common language in multilingual group discussions, NNSs may sometimes switch their language (i.e. code-switch) to their own native language when there are other members who share the same native language with them. The timing of code-switching is affected by social factors such as the combination of interlocutors, as well as the social context of the talk or the topics of the discussion [8]. Beyond speaking in a common language or a native language, NNS can adopt code-switching to alternate between different languages across

conversational threads, in a conversational thread, or even a single utterance while maintaining grammatical correctness [24, 25]. In pragmatic use, according to Romanie et al., NNSs often code-switch to their native languages when they cannot express complicated ideas/concepts in a common language [32]. Then other NNSs who are more fluent in the common language can help translate the idea.

Although code-switching benefits NNSs by allowing them to reach common ground more efficiently, research shows that it makes other people feel excluded [1]. A previous study has shown that NNSs tend to minimize the amount of code-switching during formal meetings [9]. Informed by this literature, we expect that NSs feel less excluded if a tool can automatically detect NNS's spoken language and translate them to common language whenever they code-switch to their native languages. Allowing NNSs more flexibility to switch languages in a group discussion may encourage more contribution from NNSs while minimizing the cost of excluding others.

2.3 Current Technologies to Support NNSs in Multilingual Groups

To encourage more participation from NNS in multilingual contexts, previous research has leveraged the power of real-time language support such as automatic speech recognition (ASR) and machine translation (MT). Previous works show that ASR-generated transcripts improve NNS comprehension and MT results help NNSs produce more ideas in brainstorming tasks [35]. The ASR-generated transcripts and MT results can also serve as collaborative resources to enhance the process of common grounding between NS and NNS members [3]. For example, research shows that allowing NSs to identify key points of their discussion on ASR-generated transcripts improved NNS comprehension [21].

However, most of the previous research focused on understanding the communication behaviors in pairs (NS and NNS) or triads (two NSs and one NNS), it is unknown how the presence of two NNSs would affect the group dynamics. Hence, in our study, we expect that the NNS pairs would leverage the leeway for code-switching to make confirmation and share ideas with each other in their native language, which may motivate more participation. In addition, past studies mainly focused on distributed settings. It still leaves an open question whether and how language technologies support or hinder multilingual collaboration in a collocated setting, because it makes participants easier to have side conversations. In sum, our study focuses on collocated multilingual groups consisting of multiple NSs and NNSs, in order to understand how a language support tool that automatically transcribes and translates a spoken language affects NNS's code-switching behavior and NNS participation.

3 HYPOTHESES

When the language support tool is available, we expect that NNSs feel less pressure to speak in common language, since the tool translates their native language to the partner's native language when necessary. As a result, NNSs may contribute complicated ideas in their native language, which may not happen when the tool is not available. Furthermore, NNSs may confirm their understanding with their NNS partner or ask for some quick feedback from their NNS partner before discussing their ideas with the whole group. Thus, we have the following hypothesis H1:

> *H1. The variety of language used will be greater when the language support tool is available rather than when the tool is unavailable.*

The flexibility to switch languages in a group discussion may lead to more active involvement of NNSs. For example, being able to talk with the other NNS in their native languages and confirm with each other, NNSs may be more engaged in communication and take more initiatives to express their idea with other members than when shifting languages is not possible. Therefore, we posit hypotheses H2 and H3:

H2. NNS will show more initiating behaviors when the language support tool is available rather than when the tool is unavailable.

H3. NNS will participate in communication more when the language support tool is available than when the tool is unavailable.

With the active idea initiation and participation from NNSs, we expect that it will improve the group dynamics and lead to diverse participation during the discussion, leading to our hypothesis H4:

H4. The participation of individual group members will be more equal in the group when the language support tool is available rather than when the tool is unavailable.

As we have mentioned, the dominant behaviors in group conversation hamper the diversity and negatively influence group performance. However, when the language support tool is available, through more diverse participation NNSs may be able to introduce ideas that are different from those of NSs, resulting in better group task performance. We also predict that diverse participation and increased performance will lead to more satisfactory experience in collaboration. Hence, we posit hypotheses H5 and H6:

H5. The performance on the survival tasks will be better when the language support tool is available rather than when the tool is unavailable.

H6. Both NSs and NNSs will perceive better quality of collaboration when the language support tool is available rather than when the tool is unavailable.

4 METHOD

We conducted a within-subject laboratory experiment to examine how the availability of language support influences the processes and outcomes of team communication in collocated multilingual groups. Overall, 19 quads of participants (i.e., 76 participations in total) performed collaborative decision-making to decide what are the necessary items to have for a series of hypothetical survival tasks. All groups were asked to reach consensus on the final ranking of 9 salvaged items provided by the survival task. There were two conditions, with- and without-tool. In the with-tool condition, the language support tool was provided to all participants, and participants had the freedom to use it (or not) according to their needs. In the without-tool condition, there was no language support tool provided. All participants attended the group discussion face-to-face.

4.1 Participants

In our study, there were 76 participants in total, including 21 females and 55 males. The participants aged from 18 to 44 (M = 24.25, SD = 3.49). We recruited Japanese native speakers and Chinese native speakers as participants by distributing flyers and social media posts on the

campus of a major Japanese university. Chinese native speakers were also required to be able to use Japanese as a common language for communication. Both Japanese native speakers and Chinese native speakers were required to be able to receive our instructions in English. All of the participants were randomly assigned to 19 quads. Each quad consisted of two Japanese native speakers and two non-native Japanese speakers.

The 38 Japanese native speakers (5 females, 33 males) were all university students and have lived in Japan since they were born. Their mean age is 22.92 (SD = 2.43). In the recruitment survey, we asked them to self-evaluate the language proficiency in terms of their listening, speaking, reading and writing skills on a 6-point Likert scale (0 = cannot use it at all, 1 = very low to 5 = very high). The results showed that the Japanese participants could barely use Chinese as communication language (M = 0.34, SD = 0.53). They also had limited experience communicating with Chinese people in everyday life (M = 2.97, SD = 2.15 on a 7-point Likert scale from 1 = never to 7 = very often). They also self-reported how frequently they used language support tool such as machine translation in their daily life (M = 3.55, SD = 1.87 on a 7-point Likert scale from 1 = never to 7 = very often).

We also recruited 38 Chinese native speakers currently studying at a university in Japan, including 26 international students from China and 12 students from Taiwan (16 females, 22 males). Their mean age was 25.58 (SD = 3.88). They were asked to self-evaluate their Japanese language proficiency on a 6-point Likert scale (0 = cannot use it at all, 1 = very low to 5 = very high). Their mean self-evaluated Japanese proficiency was 3.20 (SD = 1.09), which is modest to high. Besides, 33 of them have passed the JLPT (Japanese Language Proficiency Test, which is a standardized test for assessing Japanese proficiency) from the highest level N1 to the lowest level N5 (N1: 21, N2: 12, N5: 1). Compared to Japanese native speakers, they self-reported the frequency of using language support tool like machine translation (M = 4.29, SD = 2.04 on a 7-point Likert scale from 1 = never to 7 = very often) higher.

4.2 Materials

4.2.1 Survival Tasks. To simulate collaborative work in multilingual organizations, we modified a series of decision-making tasks including Ocean, Desert and Lunar survival tasks [17] and used them as the topics of group discussion. Each survival task illustrated a fictional scenario that participants had to rank the given salvaged items in order to survive in the harsh environment. For each group, members were asked to discuss the use of each item and reach an agreement on the ranking. Participants in each group firstly ranked 6 items individually. Then, participants formed two same-language pairs (i.e. Chinese pairs and Japanese pairs), discussed and reached an agreement of the 6 items. Note that the 6 salvaged items given to Chinese pairs and Japanese pairs were slightly different: there were 3 shared items, and 3 unshared items, which only appeared in either the Japanese or Chinese pair (see Figure 1 for an illustration of item assignments). After the sub-group discussions, they gathered together, formed a 4-person group and discussed all 9 items as a whole group. The purpose of the modification is to simulate real-world situations where workers in multilingual organizations can have prior discussion with the colleagues who share the same native language for decreasing the cost of grounding [33]. Besides, shared items were for different native language pairs to share some commonality to trigger future whole-group discussion. Having partially shared information among group members is also common in real-world workgroups. Once same-language pairs reached an initial agreement internally and considered themselves ready for a joint discussion, the Japanese and

Chinese pairs worked together as a big group and discussed the final ranking based on the list of a total of 9 items.

4.2.2 Post-Task Survey. To evaluate how the language tool influenced the experience during the task, we asked participants to fill out the post-task survey to assess their perceived quality of collaboration (e.g., "Being able to understand each other's thoughts", "levels of satisfaction with final ranking") after experiencing both with-tool condition and without-tool condition respectively.

4.2.3 Answer Sheet. The participants were instructed to write down their individual ranking and same-language pair ranking beforehand the group discussion. After the participants reach an agreement in group discussion, they wrote down the final ranking numbers on the paper answer sheet.

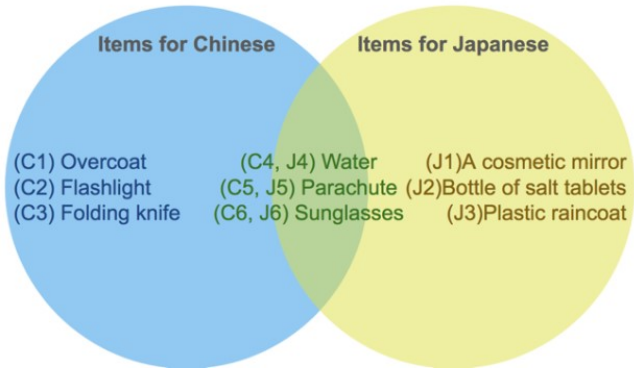

Fig. 1. We assigned different sets of items to Chinese and Japanese speakers. The overlapping area in the illustration represents the shared items.

4.3 The Language Support Tool

In our study, we prototyped our collocated language support with four iPad Pro tablets and the Google Translate app pre-installed in the tablets. By pre-defining two languages, the Google Translate app could automatically detect the two languages, transcibe and translate them into the other language. Since our participants consisted of native Japanese and Chinese speakers, we set the two acting languages as Japanese and Chinese for the study. In short, the app provided two functions, (1) automatic language identification of the two pre-defined languages (i.e. Japanese and Mandarin Chinese), and (2) speech translation between the two pre-defined languages. As shown in Figure 2, the language support system showed the automatically generated transcripts and translations simultaneously.

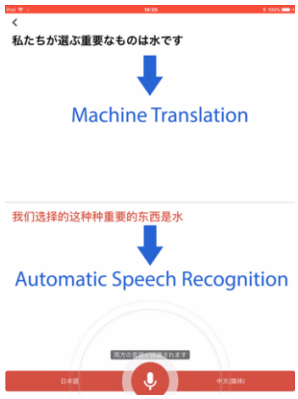

Fig. 2. The interface of the real-time language support tool. In this figure, a Chinese utterance is translated to Japanese ("The most important item we chose was water.")

Informed by the literature of shared display design, we decided to arrange the spatial layout of the tablets as shown in Figure 3 to ensure individual operating behaviors with the tablets remain peripherally visible to other group members. The design intends to enhance group members' mutual awareness of one another's intents in communication. The behavioral signals of activating the app to translate, or skimming over the display to read a translation can help others correctly interpret the current states of collaboration. Also, physical behavioral signals can help streamline role-switching and encourages more dispersive contributions among group members in collocated setting [16, 19, 26].

4.4 Setup

Participants were led to the laboratory room and assigned to the fixed seats around a square table. Japanese native speakers were seated side-by-side along one side of the table, while Chinese native speakers were seated side-by-side along another side of the table, opposite to the Japanese participants (see Figure 3). Four iPad Pros, the language support tool, were put on the center of the large square table so that all participants were able to see and reach them. In order to improve the quality of voice detection, all of the participants were asked to wear headphones with a built-in microphone. Four laptops were also provided and put next to the participants to fill out the post-task and post-experiment survey. We also set up 3 cameras, one for recording the group discussion from bird's eye view while the other two were used for capturing Japanese and Chinese pair discussions and recording post-task interviews.

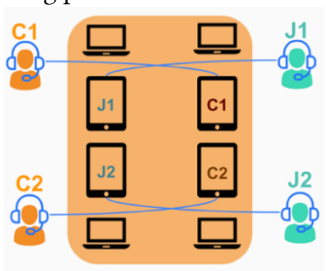

Fig. 3. Two Chinese and Two Japanese participants were seated side-by-side. Each participant's speech was transcribed/translated and shown on the opposite side of the table.

4.5 Procedure

After entering the laboratory room, the participants filled out the informed consent forms. One of the researchers briefly introduced the procedure of the whole experiment to all participants. All of the instructions and task documents such as survival task scenario and survey were given in English for consistency; however, when participants had any questions, the researchers made clarifications in their native language, and ensured that instructions and materials were well-understood. To begin with, the researchers demonstrated how to use the language support tool and asked each participant to use the tool to briefly talk about what did they do yesterday one by one in their native languages.

After the participants learned how to use the tool, they were asked to engage in a training session. In this session, participants performed the Ocean survival task with the purpose of getting familiar with the language support tool as well as the task. They were asked to rank individually according to the importance of three different items (maps of the Atlantic Ocean, chocolate bars and mirror) for survival if they were lost at sea and waiting to be rescued. After the individual ranking, the Japanese native pair and Chinese native pair discussed the items and figured out the final joint decision of ranking together. When one pair were talking, the other pair were instructed to observe the discussion along with the working language support tool. The instruction was made to inform the participants of various ways of using the tool in a group discussion as well as the possible drop in translation quality when used in rapid interactive conversations.

Once participants completed the training session, they were instructed to work on two main tasks (Desert survival task and Lunar survival task) in different conditions: with and without the tool. The orders of the tasks and conditions were counterbalanced. In the with-tool condition, we provided the language support tool but didn't obligate the participants to use it – we instructed them that they can use whatever language they want to use, and it was up to them whether they use the tool or not.

After completing the two main tasks, all participants were given a short semi-structured interview in their native language for 10 to 15 minutes. The interview questions focused on how participants made use of the tool to follow others' idea or express their thoughts. Also, we asked them if they noticed any difference regarding group dynamics between the two conditions.

5 MEASURES

We collected two types of data, the objective measures include participants' communication behaviors and performance of item ranking in the survival tasks. As for subjective data, we measured participants' perceived quality of collaboration with a survey instrument.

One of our goals is to understand how the language support tool influenced group dynamics and communication behaviors in groups. However, since we attempted to observe naturalistic interactions among group members, and allow them to use the tools upon their demands, we didn't impose the participants to use the language support tool even though the tool was made available to them. Hence, we excluded the groups which didn't attempt to use the tool at all in the following analyses. After all the pre-processing, we analyzed the data collected from 13 groups which tried to use the tools at least once in the with-tool condition.

5.1 Measurement of Variety of Language Used

Firstly, we calculated the speaking time of each participant according to the video-recording of discussion sessions. One of the researchers annotated the label of start time and end time for each utterance by following simple coding rules: (1) Backchannels and laughter should be excluded, (2) participants who talked to themselves should be excluded, (3) for cross-talks, every conversational overlap is included. If the participants made a brief stop more than two seconds, then the next utterance would be a new start.

Afterwards, we calculated the variety of languages used in the group discussion. Since we didn't impose the participants to use Japanese as the common language, Japanese, English and Chinese were all the options for them. Consequently, we calculated the percentage of each language used in each group. Since we aim to understand how various the use of different languages was, we calculated the entropy of language used percentage which represented the distribution of languages emerging in each group. Entropy is often used to quantify the amount of uncertainty a specific event would happen [30]. In our case, we are concerned about the uncertainty involved in the participants' use of different languages. For example, if the participants used a common language throughout their discussions, there would be no uncertainty in their use of language. Thus, the entropy of language selection in this case would be zero. Conversely, the entropy value of the variety of language used ranged from 0 to 1.58. The higher the value, the greater is the level of uncertainty, or variety of using different languages. The highest value of entropy (i.e. 1.58) is achieved when each language was used for the same amount of time.

Language Used Percentage P(L)= total amount of speaking time of (Japanese, English or Chinese)/ total amount of speaking time of one group.

$$Entropy\ of\ P(L) = -\sum_{k=1}^{n} P(L_k)\log_2 P(L_k)$$

5.2 Measurement of Diversity of Participation

The previous study suggested that there was a strong correlation between the dominant behavior and speaking time in the task-oriented scenario [18, 31]. Hence, to measure the levels of participation in our study, we made use of the video-recordings of group discussion sessions, annotated the starting and finishing time for each utterance, and used the annotating results to calculate the speaking time of each participant.

Based on the coding rules in the measurement of variety of language used, we calculated the percentage of participation of each participant in their groups. With respect to understanding how diverse the participation was, we calculated the entropy of participation percentage. The entropy value of diversity of participation ranged from 0 to 2. The higher entropy value represents the higher uncertainty of participation. That is, if we got the greatest possible value of entropy (i.e. 2), the participation would be the most diverse.

Participation Percentage P(A)= total amount of speaking time of one participant/ total amount of speaking time of one group.

$$Entropy\ of\ P(A) = -\sum_{k=1}^{n} P(A_k)\log_2 P(A_k)$$

5.3 Measurement of Initiating or Following Behaviors

For the further analysis of how the language support tool affected the initiating and the following behaviors of NS (e.g., Japanese native speakers) and NNS (e.g., Chinese native speakers using Japanese as a second language), we narrowed our focus to the subset of groups which decided to use Japanese as the common language in the baseline condition (without-tool condition). For groups choosing to use English as the common language, both Japanese native speakers and Chinese native speakers were NNS, and thus were not feasible target for this analysis. In the end, 8 groups were included in this analysis.

Since our central focus is to see whether and how the language support tool can support NNSs to actively participate in group discussions, we developed a binary coding scheme that classifies whether an utterance is an initiating conversational act that open up a topic, or a following act that's responding to a previous utterance, as shown in Table 2.

Table 2. The binary coding scheme of communicating behaviors

Code	Definitions	Examples
Initiating (I)	Including starting a new topic, changing to a new topic and leading the group discussion to a new direction.	A: "Based on what we have discussed before, maybe first we can think that what's the most important thing." B: "I will say it's water." A is coded as (I).
Following (F)	Including following other's idea, giving others agreement/ disagreement and aligning with other's idea.	A: "Based on what we have discussed before, maybe first we can think that what's the most important thing." B: "I will say it's water." B is coded as (F).

After coding participants' each utterance, we calculated the percentage of NNSs' initiating behaviors as follows.

Percentage of NNSs' initiating behaviors P(I)= total amount of speaking time of NNSs engaging in an initiating conversational act / total amount of speaking time of the group.

5.4 Measurement of Performance: Ranking of Items in Survival Tasks

After finishing both of the Lunar and Desert survival tasks, each group was required to come up with the final ranking to reflect the group's consensus. We measured the distance between the final ranking of each group and the ground truth [17]. Hence, the smaller the distance, the closer it was to the ground truth, which means that the performance was better.

5.5 Measurement of Quality of Collaboration

We measured the quality of collaboration through a survey of 7-point Likert scales (from 1 = strongly disagree to 7 = strongly agree) with 3 questions, including: *"We could understand each other's thoughts*", *"In general, I am satisfied with our collaboration on the task."*, and *"Overall, I am satisfied with the final group ranking of the items."* All of the questions formed a reliable scale

(Cronbach's alpha = .85). The average score of the three items was calculated to represent the quality of collaboration in the analysis.

6 RESULTS

6.1 Variety of Language Used

H1 addressed that there would be a greater variety of language used when the language support tool was available in the group discussion. To get a big picture of the language choices during the group discussion, we firstly calculated the percentage of speaking time of all emergent languages. The result shows that Japanese was used the most (M = 65%, SD = 0.29), followed by Chinese (M = 23%, SD = 0.18) and English (M = 12%, SD = 0.26) when the language support tool was available. When the tool was not available, Japanese was used the most (M = 63%, SD = 0.47), followed by English (M = 35%, SD = 0.47) and then Chinese (M = 2%, SD = 0.03).

Next, to assess the variety of languages used during the group discussion we calculated Shannon's entropy on the distribution of languages used in each group. The entropy value would be the highest if each language (Japanese, English and Chinese) was used for the same amount of speaking time in one discussion. Further, we conducted a paired t-test to compare the entropy value between the two conditions. The entropy value was significantly higher in with-tool condition (M = 0.80, SD = 0.42) than without-tool condition (M = 0.21, SD = 0.28); $t(12) = 5.58$, $p = .0001$ (see Figure 4). This result indicates that the tool indeed had an effect on encouraging participants to use the different languages. Hence, H1 was supported by the study.

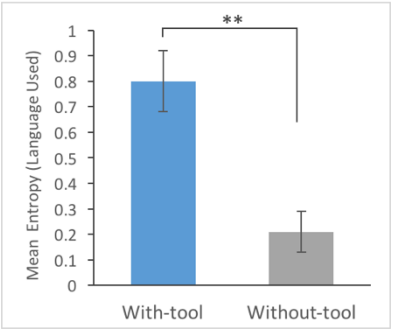

Fig. 4. Mean entropy of language used (error bars represent standard errors), $^{**}p$=.00.

6.2 Initiating Behaviors and Participation of NNS

As for H2, we aim to understand whether the language support tool can elicit more initiating behaviors of NNS in group discussion. We focused our analysis on the subset data consisting of groups that used Japanese as the common language in the baseline condition where there's no support (N = 8), so that we can clearly define the roles of NS and NNS in such groups.

To test the hypothesis, we conducted a paired t-test to compare the percentage of initiating behaviors of NNS in each group for both with-tool condition and without-tool condition. On average, NNS took more initiatives actively when the language support tool was available (M = 41%, SD = 0.08) than not having the tool (M = 31%, SD = 0.15). However, a paired t-test showed no significant difference between the two conditions $t(7) = 1.94$, $p = .09$ (see Figure 5). Hence, statistically we didn't have strong evidence to support H2.

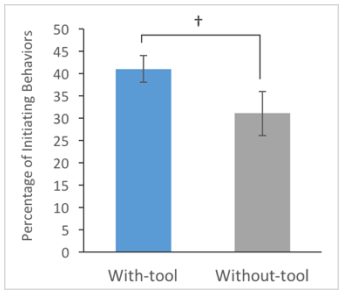

Fig. 5. Percentage of initiating behaviors of NNSs (error bars represent standard errors). †p=.09.

To test H3, whether making the tool available could motivate NNS to participate in multilingual discussion more than without having the tool, we again limited our analysis to a subset of data, including only the groups (N = 8) that voluntarily used Japanese as the common language when language tool was not available. A paired t-test was conducted to compare the level of participation of NNS in with-tool condition and without-tool condition. Although there was a distinct difference in mean entropy values between conditions, higher in with-tool condition (M = 60%, SD = 0.12) than in without-tool condition (M = 54%, SD = 0.14) (see Figure 6), the result was non-significant $t(7) = 2.12$, $p = .07$; thus, there was no strong statistical support for H3.

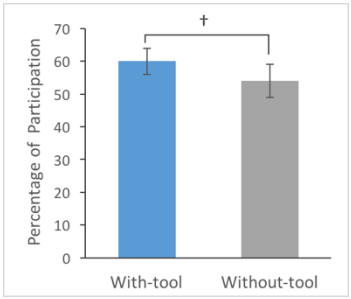

Fig. 6. Percentage of participation of NNS (error bars represent standard errors), †p=.07.

6.3 Diversity of Individual Participation

To test H4, firstly, we calculated the Shannon's entropy based on the distribution of individual participation in each group. A higher Shannon entropy value indicates that there is greater uncertainty or randomness in the distribution of participation. That is, we would reach the highest entropy value if each participant had the exact same amount of participation.

Afterward, we conducted a paired t-test to compare the entropy value in with-tool condition and without-tool condition. The mean entropy value was significantly higher in the with-tool condition (M = 1.86, SD = 0.14) than without-tool condition (M = 1.77, SD = 0.17); $t(12) = 2.58$, p =.02 (see Figure 7). The result shows that when the language support tool was available, the participation would be more diverse and less centralized in general. Therefore, as predicted, H4 was supported.

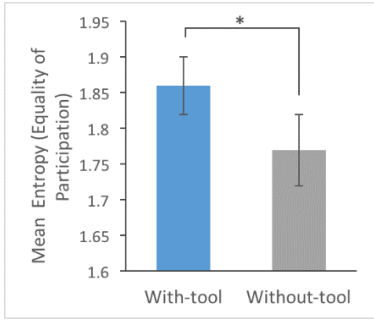

Fig. 7. Mean entropy of participation (error bars represent standard errors). *p=.02.

6.4 Performance of Survival Tasks

As for H5, we examine whether the language support tool improved group performance. According to the result of paired t-test, there was no significant effect to determine that the language tool improved the performance (M = 20.46, SD = 4.41) compared to without accessing the tool (M = 22.15, SD = 6.08); $t(12) = 0.64$, p =.53. We didn't have any statistical evidence that confirms the effect of language support on task performance. H5 was not supported in our analysis.

6.5 Perceived Quality of Collaboration

With respect to H6, we want to confirm whether the language support tool facilitated the collaboration among multilingual group members which was measured by the subjective scores reported in the post-task survey. To test H6, we conducted a paired t-test on the self-reported scores of quality of collaboration for both NSs and NNSs (see Figure 8). Contrary to our expectation, there was a significant result showing that perceived quality of collaboration was lower when NNSs were allowed to use the tool (M = 5.72, SD = 0.62) rather than when the tool was not available (M = 6.08, SD = 0.61); $t(15) = 1.93$, p = .04. Similarly, for NSs, the language support tool also significantly decreased their perceived quality of collaboration. NSs felt lower quality of collaboration when the tool was available (M = 5.42, SD = 1.04) rather than there was no tool (M = 6.13, SD = 0.56); $t(15) = 2.64$, p = .02. Apparently, the tool negatively affected the perceived quality of collaboration which contradicted to the direction of effect hypothesized in H6. This result drew our attention and motivated us to dig into the qualitative data of semi-structured interview in the discussion session.

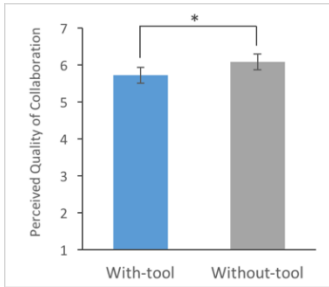

Fig. 8. Scores of NNSs' perceived quality of collaboration (error bars represent standard errors). *p=.01.

7 DISCUSSION

Overall, our quantitative results show that the introduction of a language support tool that offers the flexibility of code-switching led to more diverse participation in the multilingual groups. It's noteworthy that the language support tool had motivated the NNSs to actively switch between common languages and native languages as they needed. The tool endowed NNSs with more freedom to select languages according to personal constraints (lacking proficiency in the common language) or situational constraints (e.g., discussing difficult topics). In our observation, NNSs also seemed to take the initiatives as well as contribute their ideas more actively during their group discussions even though the statistical results were not significant. Also, as shown in Fig. 8, using the tool seemed to negatively influence the perceived quality of collaboration. To explore these findings in more detail, we looked into our qualitative data and discussed in the following sections.

7.1 How NNSs Used the Language Support Tool

Previous studies suggested that automatic transcripts generated by ASR can help NNS catch up the contextual information useful for comprehending the communication content [10, 21, 22, 23]. Aligned with previous finding, from interviews we noticed that NNSs in this study picked some keywords from the ASR transcripts to confirm their understanding. Although MT results were also provided to NNSs, they did not seem to pay much attention to it because they were full of errors.

As for supporting NNS to contribute more ideas, generally, they reported that, with MT, it was very helpful to be able to deliver their ideas in native languages especially when intending to express proper words they didn't use often in daily life. Specifically, NNS made use of the language support tool to elaborate their ideas in two ways. The first way was to totally rely on MT to express their ideas. This approach was often taken by NNSs who had difficulties communicating in common language. NNSs often started off by using colloquial sentences as in regular conversations. However, they soon figured out that the quality of MT results were worse in long sentences, which made them consciously decrease the complexity of sentences.

The second way, which was also the main approach, was to use the MT function only at critical moments. This approach was often taken by NNSs who were rather fluent in common language. It has been suggested that, instead of using MT for complete sentences, it would be better to give the controllability to users so that they can draw on the tools depending on the social contexts [9]. In this study, we looked into how users would make use of the language support tool when the controllability was given. From our observation and interview, we realized that some NNSs treated the language support tool as an "agent for vocabulary lookup", which fulfilled the urgent need to continue unfinished utterances when they cannot recall specific words in the common language.

Overall, compared to expressing their idea with common language all the time, allowing NNS to alternate between the common language and the native language seemed to make them feel at ease expressing their idea.

> *"I felt relieved when the tool was always ready by my side. For example, without the tool, when I didn't know how to say something, I had to explain it using other words. When the tool was available, I could speak in Chinese, and the other Japanese understood what I wanted to say by looking at the translation. To complete my sentence in Chinese, it just took me less than 5 seconds."* (C1, NNS)

In addition, the tool seemed to allow NNSs with moderate language proficiency to express deeper and complicated thoughts to other members, which was not possible in their common language:

"(In the "without-tool" condition) When I had no choice but to use Japanese, all I was able to say was to tell them (the Japanese) about the ranking order by using two to three simple words." (C8, NNS)

As such, the tool seemed to allow the NNSs to articulate more complicated ideas into speech which they would have given up otherwise. Overall, the language support tool appeared to be beneficial to NNS participants since it allowed them to quickly check their understanding as well as to articulate ideas in their native languages with immediate support that's light-weight and cost-efficient to use.

7.2 Volunteering Behaviors to Facilitate Multilingual Conversation

7.2.1 Nonverbal Cues Disclosing the State of Comprehension. From our observations, we found that the nonverbal cues available in face-to-face situations helped the NNS participants to disclose their level of comprehension. NS participants could evaluate the levels of language proficiency of NNS participants by observing how often NNSs gazed the results of language support tool. NSs could also observe the facial expressions of NNS participants and other non-verbal channels such as intonation to probe whether NNSs followed up the conversation or not. This observation resonates with the previous study showing that difficulties in comprehension made NNS show more apprehensive nonverbal cues in multilingual communication [11]. In our study, when NNS participants looked confused while looking at the tool display, NS participants started to check the transcripts to see if his words were correctly recognized, rephrased the incorrect words or repeated the sentence again as well as slowing down the talking speed. While previous work suggest that NSs have difficulties interpreting the silence of NNSs (i.e. whether it is caused by NNS's lack of comprehension or they simply have nothing to say [34]), our findings suggest that the language support tool could serve as a means to unveil the status of NNSs by inducing relevant non-verbal behaviours from them. For example, if a NNS participant starts to watch the transcripts/translation during NS's speech, it often means that he/she is having some comprehension problems; when a NNS glances or tries to initiate the tool which transcribes and translated his own voice, it often means that he wants to say something.

7.2.2 Translation Errors Triggered Helping Behaviors. Though the automatically generated transcripts and translations may sometimes confuse participants, consistent with previous research, it also triggered some voluntary helping behaviors from the participants who had higher language proficiency [10, 21]. In our study, all the participants could check all the transcripts/translations since all the tablets were placed on the center of the table. When NNS participants started to pay attention to the tablet, it easily drew everyone else's attention. They may start attending to the tablets and began to correct the transcript/translation errors to avoid misunderstanding. For example, there was one Chinese speaking participant (CA) who had moderate Japanese proficiency and used Chinese predominantly to express his ideas. However, the MT function generated Chinese-to-Japanese translations with errors. The other Chinese (CB) who noticed the errors interrupted the conversation to correct the errors orally in Japanese. After that, CB also explained to CA what happened in Chinese. The side-talks between Chinese native

speakers happened naturally, and provided a peer-support mechanism to facilitate multilingual conversation.

This case suggests that although the language support tool didn't always offer perfect translation, it actually created an opportunity for other NNSs with better language proficiency to facilitate the conversation. Previous studies reported that NNSs may tend to pretend themselves well-comprehending and well-following the conversation even when they actually didn't [27]. Our findings show that language tools can have the function to expose NNSs' states in comprehension, and having other members to observe how individuals use tools can induce helping behaviors.

7.3 Collaborating via the Language Support Tool

7.3.1 Breaking the Flow of Conversation.

Even though the tool helped NNSs to express complicated ideas and induced helping behaviors from other members, the participants rated the quality of collaboration significantly lower when the tool was available to use than when it was not available. From the interviews, we identified the reasons why they perceived lower quality of collaboration when using the tool. First of all, some participants reported that the language support tool broke the flow of conversation. When NNS participants spoke in their native languages (Chinese), the NS participants had to switch their focus on the tool and could not do anything but to wait until one complete translation was generated:

"When the Chinese participant used the tool, we all became silent and focused on the tool display. I noticed that our communication got more sequential with no overlaps." (J37, NS)

"We had to wait for the translation. I sometimes felt the flow of our conversation was lost." (J38, NS)

Some NSs also noted that they felt awkward to focus on the tablet display when discussing face-to-face:

"When we used the tool, everyone was looking at the tablet display, rather than looking at each other's face. I felt like I was talking to a machine." (J12, NS)

Furthermore, when the language tool did not show the correct translations or was interrupted by network problems, they had to try again or come up with some creative ways to resolve the problem. For example, NS participants made some guesses from the translation and asked the NNS participant if their understanding was correct by rephrasing the idea. A fluent NNS participant can also help the non-fluent NNS to translate his/her ideas when the tool did not seem to work properly. It appeared that the members felt responsible for clarifying and understanding the non-fluent NNS participant's idea even when the translation quality was low. The clarification process was similar to a quiz to guess the NNS participant's idea, which broke the flow of conversation:

"When the Chinese used the tool, I focused on the tablet. Understanding their speech on the tool became the immediate priority matter. We paid attention to the translation and tried hard to understand what the Chinese participant was trying to say. When we got it right, we were satisfied, and discussion stopped. I think we lost the context." (J34, NS)

Finally, using the tool may have distracted the attention of participants especially for the NNS. Most NNS participants checked the transcripts as they spoke in their native language – they used

the transcripts as a rough indicator of translation accuracy. Although the tool helped NNS participants to express their ideas more thoroughly, they reported that they had to intentionally alter their speech style in order to adapt to the mechanism of machine detection.

> *"when I used the tool, I tended to use simple and detectable sentences. Before talking, I would consider how to make the sentence easier to be detected."* (C26, NNS)

Consequently, using the tool in discussion could have changed the dynamics of group collaboration. Some resources such as time and attention need to be allocated in order to make it more useful.

7.3.2 The Role of Language Proficiency in Using the Language Support Tool.

It's worth noting that NNS participants who had moderate language proficiency seemed to be influenced by the translation errors the most. According to the interviews, the translation errors sometimes seemed to make the Chinese participants feel more confused and less confident about their Japanese proficiency:

> *"It was most distracting when I could partly understand what the Japanese were saying. I tried to listen, read the transcripts and translation at the same time. I had no idea whether I should focus on listening or reading, when to switch my attention to the tablets, and whether I should focus on transcripts or translation. If I can fully understand Japanese or I cannot understand it at all, it probably would not be so distracting."* (C5, NNS)

Previous research has shown that the translation errors hinder people's comprehension in conversation [35, 36] and inconsistencies disrupted the establishment of common ground [37]. However, in our study, NNS participants with different levels of language proficiency appeared to use different strategies and possess different attitudes towards the current language support tool, which may affect the multilingual group dynamics.

8 DESIGN IMPLICATIONS

As we have shown, allowing NNSs to shift languages with system support appears to be helpful in reducing the cost of speaking. Also, we noticed that in the collocated setting, the social and contextual cues available raised team members' awareness of one another's state of understanding, which may induce helping behaviors in the conversational flow. In the following sections, we delineate design implications for future iteration of multilingual language support.

8.1 Customizing Language Support based on Language Proficiency

From the findings of the interview, we noticed that levels of language proficiency may influence how NNSs perceived and made use of the tool to express their thoughts. For comprehension, if the NNSs were barely able to understand the common language, they can only rely on the system. On the other hand, if the NNSs have moderate language proficiency, the discrepancy between their own understanding of the messages and the corresponding machine-generated translation may make them more confused. Therefore, we suggest that the tool can provide different modes of language support based on user's language proficiency. For users who have a lower level of language proficiency, it would be helpful with the support of complete translation. As for users who have higher language skills, since they can catch up most of the contextual cues in the conversation, it may be helpful enough if only some specific words related to the topic are displayed to them through automatic transcription.

8.2 Eliciting Helping Behaviors from Bilingual Speakers

In our study, when a group contained a NNS with low Japanese proficiency, the other NNS who had higher Japanese proficiency played as a mediator to correct language errors made by people or by machine to avoid misunderstanding.

What's not entirely clear is how to systematically motivate and elicit the helping behaviors from the more capable bilingual speakers. It's noteworthy that the helpers are still NNSs themselves, and therefore contributing to helping other people is still likely to incur extra cognitive burden to them. Previous work has identified that having NS to provide help to NNS will not much increase the cognitive workload to NS [21], but now we need bilingually-fluent NNSs to volunteer serving as a "language bridge" between NSs and other NNSs.

What we may consider is to devise specialized support (e.g., visualization or highlighting tool) or assigning specialized roles for these bilingual NNSs to relieve their burden. For example, a highlighting tool may allow the bilingual speakers to indicate the exact problems on automatically generated transcripts or translation without having to speak up, which may be more efficient and less effortful to them.

Besides, the side-talk between NNSs in our study also made the later discussions more efficient. The NNSs who had higher language proficiency can make clear clarifications and resolve the questions raised by another NNS through side-talk (often in their native language). Although the language support tool detected NNSs' utterances and showed the translation to NS, when the side-talk happened, NNSs appeared to unconsciously decrease their volumes, thus resulting in lower quality transcripts or translation. There's need to help participants keep the same volume even they speak in the native language.

8.3 Behavioral Signal-Aware Language Support in Collocated Communication

It is worth noting that nonverbal cues such as gazing, pressing and pointing on the language support tool exhibited the intentions of participants. Keeping gazing at the tablets may represent the participant's need for transcript or translation support in order to follow the discussion. Pressing and pointing behaviors may indicate that the participants are intending to contribute to the group discussion. Overall, the nonverbal interactive behaviors toward the tool can potentially increase participants' awareness of what was happening in the conversation, and help detect the underlying, unspoken bottlenecks in communication. This heightened situational awareness [6] is beneficial to improve multilingual group collaboration. Future language support design may consider the opportunities afforded by nonverbal behavioural signals exhibited in interactions for developing multilingual tool that go beyond using only natural language technologies as the mechanism of support [29].

8.4 Keeping the flow of conversation

When NNS participants used the language tool to express their ideas, it often broke the flow of conversation because the other members centered their attention to the tablet and focused on understanding that single utterance. By focusing too much on the clarification process (i.e. making guesses and confirming what the NNS participant said), they seemed to lose the context of the main conversation. To remind them the flow of the main conversation and get them back on-topic, a function that visualizes the topic chain may help.

Another way that may potentially help reduce the participants' attention to the tool is to incorporate a text-to-speech synthesizer. If the tool can read the translated sentences out loud,

other members may still guess the content by picking up the keywords while making use of each other's facial expressions.

9 LIMITATIONS AND FUTURE WORK

There are a number of limitations in this experiment. First of all, we recruited Japanese native speakers and Chinese speakers to participate in our study. However, the communication behaviors may be affected by various cultural factors or social norms. In our study, although the Chinese speakers were NNS in the scenario setting, from our observation, they seemed to be more talkative in general. Future studies will need to identify techniques and methods to be able to consider culture as another factor that affects the group dynamics. Secondly, according to the spatial layout of the tablets, it tended to be easier for the listeners to physically reach and press the microphone buttons to start voice detection. However, in bidirectional communication, it is also essential for the speakers to control whether to transcribe or translate their words in a handy way. The roles of individuals who initiate language detection may also be an important variable affecting group dynamics in the multilingual contexts. Alternative designs that affords system controllability of different roles could be one direction of future work. Third, while code-switching can be very useful to multilingual communication, it's not clear yet under what circumstances, constraints and conditions, individuals would be more or less motivated to code-switch. Group members' language skills in one or multiple languages are one interesting aspect to investigate in the future. Clearly, individuals lacking bilingual skills are unlikely to code-switch, whereas group members all adept in a common language may have no need to code-switch. Future studies looking into these issues will help further inform the design of language support tools that incorporate human skills in the system loop of multilingual communication.

10 CONCLUSIONS

We conducted a laboratory study to examine the idea of easing NNSs' burden of speaking the common language by alternatively providing a language support tool which allowed them to switch back to their native language depending on conversational contexts.

We found that the tool encouraged NNS to elaborate their ideas more actively and it becomes an immediate support to NNSs. Also, we found that although the translation errors may distract the participants, it elicited the helping behaviors such as oral clarification from fluent bilingual speakers which may fill the linguistic gap between NSs and NNSs. Consequently, our results suggest that by allowing language shifting behaviors of NNSs with flexibility in multiparty multilingual communication, it has the potential to cultivate more diverse idea as well as enhance group dynamics by increasing the variety of language selection and potentially the participation of NNSs. Our findings also open up an opportunity to consider future design decision of involving backchannels and behavioral-aware support in multilingual communication.

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