CHARACTERISTICS OF INTERPERSONAL PHONETIC COMMUNICATION IN RESONANCE DURING CO-CREATION

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ABSTRACT

This study is aimed to understand the relationship between resonance and interpersonal phonetic communication during co-creation from the following points of view: linguistic functional factors and paralinguistic factors. The novice designers were assigned a concept generation task in pairs from the two nouns, "weather" and "stationery". Linguistic function tags were contracted into five tag groups, Stuckness, Question, Seriousness, Proposition and Positiveness. The results suggest that phonetic communication in resonance showed significantly lower Stuckness and higher Positiveness towards the counterpart's utterances; Silence-based conversation was significantly observed when both were in creative states but had not reached resonance; Resonance was significantly more likely to occur with communication where one mainly spoke and the other also responded with utterances, neither one spoke in dominant amounts, or both spoke in equal amounts.

This study will contribute to understanding and facilitating resonance, which is an essential phenomenon in individual/interpersonal/group creativity, with practical implications, especially for co-creative concept generation and sustainable creative flow in collaborative design.

Keywords: Resonance, Communication, Concept generation, Collaborative design, Creativity

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1 INTRODUCTION

Creativity in design can be viewed as the designer's own creativity, creativity supported by the collaborative behaviour of multiple designers, and creativity for the item designed in terms of social meaning (Nagai *et al.*, 2003). These categories of design creativity can be understood in relation to the varying understandings of design itself (Taura and Nagai, 2009). The authors explore social creativity, the second category above, to better understand the dynamics of human factors in the co-creative design process, where they clearly distinguish the co-creative design process from the co-operative design process by observing the nature of the process from a perspective of social innovation design (Matsumae and Nagai, 2018, 2019). According to the authors, the goal and each designer's roles are well-defined, and designers share explicit knowledge in the co-operative design process. Meanwhile, the co-creative design process is characterized by the lack of a well-defined goal at the start, where the designers autonomously form and sustain a creative flow while sharing both tacit and explicit knowledge based on an intersubjectivity that has been established and enhanced among them. During co-creation, collaborative designers sometimes experience an exceptionally important creative cognitive state called resonance. This study focuses on understanding the characteristics of interpersonal phonetic communication during the state of resonance from the perspective of linguistic and paralinguistic interpersonal communication, investigating what kinds of communication can evoke resonance. It will contribute to help designers and facilitators enrich communication during collaborative design process.

2 RELATED STUDIES

2.1 Resonance in creativity studies

Designers empirically know that their creative states are not stationary, but that they dynamically change along with the design process, with or without resonance. Nagai emphasizes the importance of resonance, especially when design is understood as the pursuit of an ideal rather than as drawing or problem-solving, since resonance can be evidence of idealness and elevate designers' personal motives beyond empathy (Depraz and Cosmelli, 2003; Nagai, 2015; Nagai and Taura, 2017; Taura *et al.*, 2012; Taura and Nagai, 2010). Goncalves et al. also seem to cover this creative moment within stimuli that designers may encounter, and which brings them to peak inspiration (Gonçalves *et al.*, 2013). Thus, resonance during the design process has been regarded as an essential phenomenon in design creativity studies, whether in individual or group. Furthermore, in the context of social creativity during the co-creative design process, resonance can be understood as an interactional synchrony of group flow that can enable the merging of individual collective experiences in a group, allowing mutual participation, contribution, and creation (Csikszentmihalyi, 1998; St. John, 2007; Sawyer, 2011; Woodman *et al.*, 1993).

These studies on resonance have mainly been conducted and discussed qualitatively, though Matsumae et al. attempted to grasp resonance as an internal phenomenon quantitatively with multimodal bio-signals to better understand its relation to creativity (Matsumae *et al.*, 2022). They successfully detected resonances from multimodal bio-signals using the Hidden Markov Model (Shoji *et al.*, 2023).

2.2 Communication in collaborative design

The roles of communication in collaborative design have been studied from different perspectives, corresponding to what kind of collaboration is expected in the design process and to the internal or external interaction. Communication can be regarded as a means of facilitating design process, from concept generation to production and delivery (acceptance). There have been numerous studies of design communication to support cooperative collaboration in relation to creativity (Antoniou *et al.*, 2019). Gonçalves et al. discussed its internal role among designers as a stimulus to support inspiration peaks (Gonçalves *et al.*, 2013), while most other studies have focused on its external role in improving interactions such as examining, understanding, and agreeing on sets of concepts and modalities in interactive experiences (Bilda *et al.*, 2008). Effective interpersonal and emotional communication is a critical factor in enhancing group involvement and collaboration (Park, 2007) and overcoming moments of being stuck to support the flow of creativity (Shah *et al.*, 2019). The roles of these types of communication, in practice, are achieved multimodally (Schuller et al., 2013): phonetic and non-phonetic, verbal and non-verbal, and linguistic, paralinguistic, and non-linguistic. The significance of paralinguistic communication has been increasingly recognized in recent decades (Kraus, 2017) as the

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development of measuring technologies has allowed researchers to investigate quantitatively what was previously accepted as a convention, i.e., that communication success or failure often depends not merely on the content of a message, but as much or more on how one expresses and delivers it (Sanders, 1984; Zhou et al., 2004). Moreover, Won et al. explored relationships between communication and creativity and found a significant linear correlation between the synchrony of non-verbal communication and creativity (Won et al., 2014).

3 RESEARCH METHOD

The authors used datasets from a previous study. That previous study adopted the perspective of a multimodal bio-signal dataset, while this study took adopted the perspective of a phonetic communication dataset. Detailed information on the experiments can be found in the references (Matsumae et al., 2022). The experiments had examinees engage in paired concept generation as a (possibly) co-creative task that could evoke resonance. The interpersonal phonetic communication data recorded during the experimental task were processed and analyzed from both linguistic and paralinguistic perspectives. The obtained datasets, with and without resonance, when both members of a pair were in creative states were compared to investigate the characteristics of interpersonal phonetic communication needed to reach resonance.

3.1 Experiment

Fourteen pairs comprising twenty-eight undergraduate students in their third and fourth years at the School of Design at Kyushu University in Japan participated in this experiment. Each of them confirmed in advance that they had experienced resonance during concept generation in collaborative design on a daily basis. They practiced with an icebreaking exercise and individual concept generation so that they could get accustomed to the experiment in advance. Then, after a 10-minute break, they were assigned pair concept generation for about 20 minutes based on a combination of two polysemous nouns, "weather" and "stationery," referring to the discussions in previous studies (Costello and Keane, 2000; Nagai *et al.*, 2009). To avoid any inhibitions they might feel, examinees were told that there would be no evaluations of their concepts. Immediately after pair concept generation, each of the examinees individually reviewed their pair work with recorded materials, video, and worksheets made during the pair concept generation work, and the examiner recorded each of their reviews on their creative states and detailed thinking process in a common template (Figure 1).

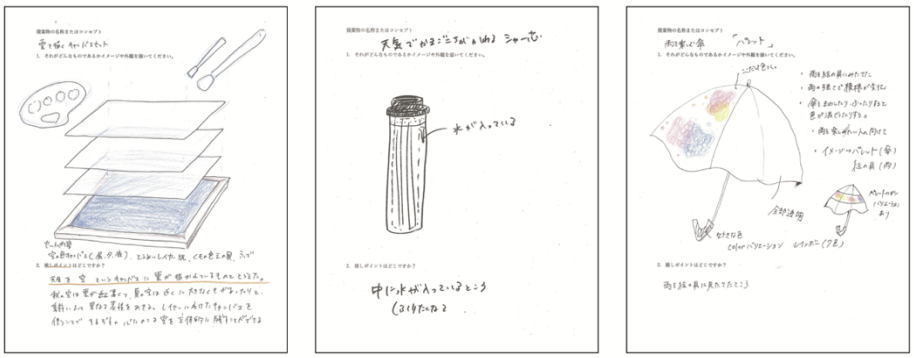

Figure 1. Examples of pair concept generation from two nouns, "weather" and "stationery" (left:" a canvas set to draw clouds", center: "a refill of mechanical pencil which drawing texture changes by weathers", right: "a pallet umbrella coloured by rain drops")

Immediately after the experimental task was finished, the examinees were each asked to record transitions in their creative state during the experimental task basically on a 3-level scale that considered cognitive resolution. They were instructed to try to fill it in within the range of 0: non-creative state, 1: moderately creative state, and 2: strongly creative state. They were also allowed to use -1 or 3, but only when they could not fit their outlying response in the range of 0 to 2. For consistency throughout the experiment, a pair of examiners interviewed each examinee to add the examinee's thinking processes to the record sheet reviewing the video taken during the experiment, and tagged this information in an experiment timeline corresponding to the transitions of creative states. The examinees were also asked to specify the timing of when they felt resonance. In this review

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process, the role of the examiners was not to evaluate but to record what examinees described following a common procedure. These subjective evaluations can be regarded as considerably reliable, as the reported resonances in this same dataset were also detected solely from multimodal bio-signals with an accuracy of 77-80% (Shoji et al., 2023).

3.2 Creative states and resonance

The authors binarized the creative state into creative or non-creative states for each examinee based on the transition of the creative state, the thinking process, and the recorded video. The threshold was set for each examinee to binarize the creative state based on their descriptions, with a creative state recorded above the threshold marked as "creative" and that below as "non-creative." Based on the individual subjective evaluation of the creative states above, the creative state in a pair was categorized into three categories: one where neither of the examinees in a pair was in a creative state (LL), one where one of the examinees in a pair was in a creative state (HL), one where both examinees in a pair were in a creative state (HH) and, additionally, one where both pairs felt resonance (RR). Aiming to compare the datasets with and without resonance when both members of a pair reached a creative state, R is defined as HH with RR and $\overline{R}$ is defined as HH without RR. Figure 1 provides an example of the processed datasets used to describe creative states in a pair between examinees A and B (Figure 2).

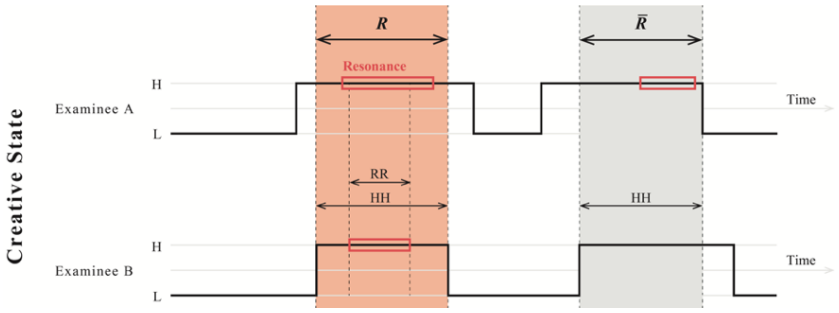

Figure 2. Examples of binarized creative states in a pair

Each dataset acquired from the experiment was divided into data analysis units of 15 seconds. This unit length of 15 seconds is approximately the shortest duration of resonance and the shortest to allow a grasp of phonetic communication characteristics in this study. A total of 679 units were analyzed, with 265 of them being R and 114 of them being $\overline{R}$. They were analyzed by comparing the datasets R and $\overline{R}$ in relation to phonetic communication, assessing both linguistic and paralinguistic factors.

3.3 Phonetic communication

Phonetic communication was examined by assessing both linguistic and paralinguistic factors, not from individual perspectives but from interpersonal perspectives. We focused on its functions among linguistic factors to help us grasp the general conversational flow and on amounts of utterances (e.g. silence and conversation balance) among paralinguistic factors.

3.3.1 Linguistic factors

Linguistic factors were analyzed based on 12 linguistic function tags applied to each data analysis unit of transcribed conversation from the video recorded during pair concept generation: Move, Question, Hesitation, Block, Support for Move, Support for Block, Overcoming, Deflection, Interruption, Yes and, Deviation, Humor (Sonalkar et al., 2013). These 12 tags were then summed up for each data analysis unit (15 seconds) and contracted into 5 tag groups (TGs) by principal component analysis (hereafter PCA) and cluster analysis to grasp basic trends. For consistent evaluations, a specific examiner assigned the most appropriate tag to each of the shortest meaningful utterances and applied the tag chosen to the units that covered the utterance. The tag was applied to the longer unit when it overlapped more than 2 units. The ratios of each TG observed were compared between datasets R and $\overline{R}$.

3.3.2 Paralinguistic factors

Paralinguistic factors were understood depending on the amounts of utterances, silence, and conversation balance within a pair and these were compared between datasets R and $\overline{R}$. Silence has

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recently been recognized as having a programmatic linguistic role (Ephratt, 2011). Conversation balance is one of the major factors used to evaluate dominance in conversation and is thought to reflect the relationship of the pair (Itakura and Tsui, 2004). Silence was analyzed based on the total silent periods a pair experienced and was quantified by analysis units of 15 seconds. Analysis of conversation balance was based on a skewed ratio with analysis units of 15 seconds. The skewed ratio presents an absolute value for the difference between each ratio, that ratio being each examinee's utterance length divided by the total utterance length in a pair. For instance, the ratio is 20%pt for a unit of 15 seconds when the pair's total silence is 5 seconds and one member of the pair provides 6 seconds of utterances while the other provides 4 seconds (Their absolute difference of 2 seconds is divided by their total utterances of 10 seconds).

3.4 Statistical validation

The results of analysis underwent a goodness-of-fit test to validate whether the skew in analysis unit distribution observed for the specific characteristics was statistically significant. Theoretical ratios used for it were as shown in Table 1 (*R*: 39.0%, $\overline{R}$: 16.8%, and *Others*: 44.2%), based on the numbers of units observed (*R*: 265, $\overline{R}$: 114, and *Others*: 300) divided by the total (679). *Others* here refers to the units recorded with both being a non-creative state (LL) or one of the pair being in a non-creative state (LH) by the definition of *R* and $\overline{R}$.

Table 1. Theoretical ratios used in goodness-of-fit tests

	R (HH)	$\overline{R}$ (HH)	*Others* (LL/LH)	Total
Number of units	265	114	300	679
Theoretical ratio	0.390	0.168	0.442	1.000

4 RESULTS

4.1 Linguistic factors

PCA was carried out with five principal components so that the cumulative contribution ratio exceeded 90% in results with the PC load, shown in Table 2, and then its PCA results were subjected to cluster analysis and assigned to five tag groups (TG) named according to the respective TGs observed as shown in Table 3: Stuckness, Question, Seriousness, Proposition, and Positiveness.

Table 2. Loadings at 5 principal components for each linguistic function tag

Linguistic Function Tag	PC 1	PC 2	PC 3	PC 4	PC 5
Move	0.562	0.798	-0.181	-0.085	-0.074
Question	0.080	0.168	0.980	0.041	0.001
Hesitation	0.047	0.039	-0.001	-0.191	0.979
Block	0.000	0.024	0.054	0.024	-0.013
Support for Move	0.819	-0.569	0.033	-0.009	-0.020
Support for Block	-0.003	0.012	-0.005	0.024	-0.004
Overcoming	-0.001	0.000	0.007	0.000	-0.006
Deflection	-0.002	0.003	0.006	0.002	0.002
Interruption	-0.001	0.006	0.001	-0.012	-0.012
Yes and	0.017	-0.074	-0.016	-0.016	0.031
Deviation	0.001	0.012	-0.001	0.019	0.002
Humor	0.063	0.062	-0.058	0.976	0.185

Table 3. Linguistic function tags observed in each Tag Group (TG)

Tag Group (TG)	Linguistic Function Tags Observed (Fewer/More)
Stuckness (TG_A)	Fewer: all tags
Question (TG_B)	More: Question, Block, Overcoming, Deflection
Seriousness (TG_C)	Fewer: Humor/More: Hesitation
Proposition (TG_D)	More: Move
Positiveness (TG_E)	More: Support for move, Move

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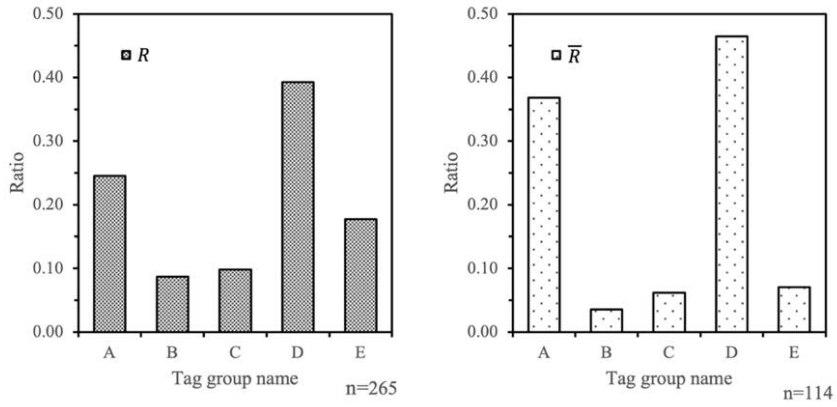

Figure 3. Ratio of observed TG with and without resonance（left: with, right: without）

Chi-square tests and residual analyses of the incidence of each TG showed that the incidence of TG_A is significantly lower and that of TG_E is significantly higher in R than in $\overline{R}$, as shown in Figure 3 ($p< 0.05$). A goodness-of-fit test was performed for the results above, showing more positiveness (TG_E) and less stuckness (TG_A) in R than in $\overline{R}$. It also confirmed for both that the distribution was significantly different from the theoretical ratio ($p< 0.05$), as shown in Table 4 and Table 5.

Table 4. Results of goodness-of-fit test for TG_E: Positiveness

	R (HH)	$\overline{R}$ (HH)	*Others* (LL/LH)	Total
Observed value	47	8	23	78
Theoretical value	30.442	13.096	34.462	78.000
Deviation	9.006	1.983	3.812	14.802

Table 5. Results of goodness-of-fit test for TG_A: Stuckness

	R (HH)	$\overline{R}$ (HH)	*Others* (LL/LH)	Total
Observed value	65	42	148	255
Theoretical value	99.521	42.813	112.666	255.000
Deviation	11.975	0.015	11.082	23.072

4.1.1 Paralinguistic factors (silence)

The frequency distribution diagrams of silent periods showed a general mountain shape for R and double-peaked pattern for $\overline{R}$. No peak was observed at 13-14 seconds for R, unlike in $\overline{R}$ (Figure 4).

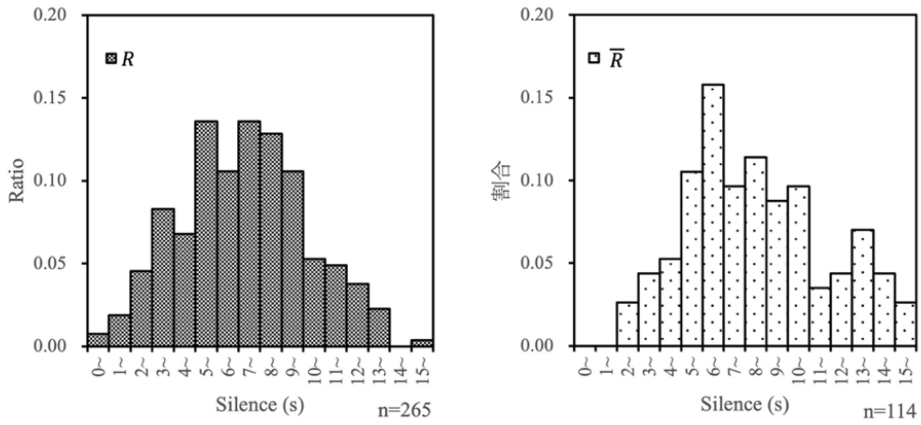

Figure 4. Silence in 15 seconds with and without resonance（left: with, right: without）

Performing a goodness-of-fit test on the distribution where the silence totalled 13-14 seconds, it was confirmed that the distribution was significantly different from the theoretical ratio ($p< 0.05$), as shown in Table 6.

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Table 6. Results of goodness-of-fit test for silence times of 13-14 seconds in 15 seconds

	R (HH)	$\overline{R}$ (HH)	*Others* (LL/LH)	Total
Observed value	10	14	17	41
Theoretical value	16.001	6.884	18.115	41.000
Deviation	2.251	7.357	0.069	9.676

4.1.2 Paralinguistic factors (conversation balance)

Examining the shape of the histogram for conversation balance, the incidence tended to be higher at 20-50%pt in *R* than in $\overline{R}$ (Figure 5), although a statistically significant difference was not obtained by the Wilcoxon rank sum test ($p < 0.05$).

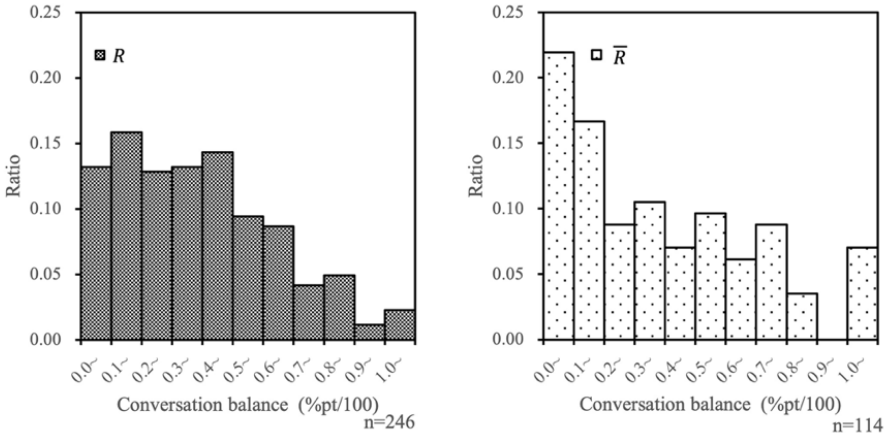

Figure 5. Conversation balance with and without resonance (left: with, right: without)

Performing a goodness-of-fit test on the distribution where the conversation balance skew was 20-50%pt, observed a higher incidence in *R* rather than $\overline{R}$. It was confirmed that the distribution was significantly different from the theoretical ratio ($p < 0.05$), as shown in Table 7.

Table 7. Results of goodness-of-fit test for conversation balance skewed 20-50%pt

	R (HH)	$\overline{R}$ (HH)	*Others* (LL/LH)	Total
Observed value	107	30	87	224
Theoretical value	87.423	37.608	98.969	224.000
Deviation	4.384	1.539	1.448	7.371

5 DISCUSSIONS

5.1 Linguistic factors

R showed significantly lower Stuckness (TG_A) and higher Positiveness (TG_E) compared to $\overline{R}$. Both *R* and $\overline{R}$ are analysis units used in creative states, but *R* reached resonance whereas $\overline{R}$ did not. These results may suggest that there is a *stuck* situation where each subject is immersed in his/her thoughts and enters a creative state that does not require mutual communication in $\overline{R}$. Meanwhile, there is mutual communication consisting of positive responses toward each other's words in *R*.

A goodness-of-fit test indicated that the distribution of Stuckness (TG_A) and Positiveness (TG_E) differed in *R*/$\overline{R}$/*Others*. Focusing on deviations between the observed and theoretical values in Positiveness (TG_E), there was a tendency to have the largest deviation from the theoretical value with a larger number of occurrences in *R*, while there was also a tendency to have deviation but with a smaller number of occurrences in $\overline{R}$ and *Others*. This indicates that frequent positive responses to the words of one's counterpart represented one of the characteristics of communication in resonance. Positiveness (TG_E) was the TG observed when there were many words used to indicate understanding/agreement with a counterpart's words. Laughter with the words to move forward the interaction mainly appeared as back-channels or repetitions of the counterpart's words in the

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conversations recorded. Some studies have reported that such back-channels or repetitions of a counterpart's words play the role in conversation of delivering a psychological response to information received from the counterpart to sustain and facilitate the ongoing topic and even to inspire concept generation (Paulus and Brown, 2007; Rickards, 1999). These can suggest that a response in *R* to an idea proposed with comparatively more back-channels or repetitions of the counterpart's words elicited a positive psychological response from the counterparts, sustained their creative flow, inspired their concept generations, and brought them to resonance. Thus, this quantitatively exhibited the importance of both mutually sharing ideas and inspiring each other with positive back-channels and repetition of the counterpart's words, leading to resonance even when both were already in creative states.

Focusing on deviations between observed and theoretical values in Stuckness (TG_A), there was a tendency to have larger deviations from the theoretical value with a smaller number of occurrences in *R*, while there was a tendency to have deviations with a larger number of occurrences in *Others*. There tended to be no deviations between observed and theoretical values in $\overline{R}$. This suggests that Stuckness is inversely proportional to a heightened creative state of mind. Stuckness (TG_A) appears when there are fewer utterances or when a conversation only slowly develops because utterances remain with static contents for longer periods. These observations suggest that, with higher creative states, more active interpersonal communications are conducted and the creative flow is accelerated.

5.2 Paralinguistic factors (silence)

As seen in Figure 4, the frequency distribution diagrams of silent periods of 15 seconds showed a general mountain shape with a peak around 6-8 seconds for *R* and two peaks at 6-8 seconds and at 13-14 seconds for $\overline{R}$. The mountain shape distribution with a peak at 6-8 seconds in a 15-second unit indicates utterance-based conversation while that with a peak at 13-14 seconds indicates silence-based conversation. This suggests that $\overline{R}$ is characterized by silence-based conversation when compared with *R*. A goodness-of-fit test indicated that the distribution of silent periods between 13 and 14 seconds differed in *R*/ $\overline{R}$/*Others*. There was a tendency to have some deviation from the theoretical value with a smaller number of occurrences in *R*, while there was a tendency to have deviation with a larger number of occurrences in $\overline{R}$. There tended to be no deviation between observed and theoretical values in *Others*. To summarize, silence-based conversation was observed in $\overline{R}$. These results can be interpreted to suggest that mutual communication was sustained in *R*, while each participant in $\overline{R}$ was immersed in individual creative thinking without utterances but that it enhanced creative states, and that each participant just stayed silent in non-creative states in *Others*.

5.3 Paralinguistic factors (conversation balance)

As seen in Figure 5, a tendency toward a higher ratio of conversation balance skewed with 20-50%pt was observed in *R*. A conversation balance skewed with 20-50%pt means that the utterance ratio in each pair is between 3:2 and 5:1. This suggests that the more frequently observed conversation balance in *R* is where one person mainly expresses something and the other also responds with utterances, neither one utters things more frequently, or both express utterances in equal amounts. The conversation balance appeared as one person mainly talking about their idea and the other responding with a longer back-channel or repetition of the other's words, as can be observed in their recorded conversation. A similar tendency is reported in daily conversation characterized by asymmetry, contrary to the common belief that daily conversation between peers is characterized by symmetry and equality of participation (Itakura and Tsui, 2004) .

The recorded conversation contents along with the conversation balance above can support the importance of pairs sharing ideas and inspiring each other with positive back-channels and repetitions of a counterpart's words, which lead to resonance. A goodness-of-fit test indicated that the distribution of conversation balance skewed with 20-50%pt differed in *R*/$\overline{R}$/*Others*. There was a tendency to deviate from the theoretical values with a larger number of occurrences in *R*, while there was also a tendency to have some deviation with a smaller number of occurrences in $\overline{R}$ and *Others*. These suggest a characteristic of communication in *R* where the frequently observed conversation balance was skewed by 20-50%pt, one person expressed the most utterances and the other also responded with utterances, neither one expressed utterances dominantly, or both expressed utterances in equal amounts. These

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results can be interpreted to mean that conversation balance where one mainly talks about one's idea while the other responds to such utterances with a longer back-channel can lead to resonance.

6 CONCLUSION

6.1 Summary

The findings of this study on the characteristics of interpersonal phonetic communication in resonance during co-creation follow:

- Linguistic communication – Resonance showed significantly lower stuckness and higher positiveness towards the counterpart's utterances.
- Paralinguistic communication (silence) – Silence-based conversation was significantly observed when both were in creative states but had not reached resonance.
- Paralinguistic communication (conversation balance) – Resonance was significantly more likely to occur with communication where one mainly spoke and the other also responded with utterances, neither one spoke in dominant amounts, or both spoke in equal amounts.

These findings do not indicate cause-and-effect but will contribute to understanding and facilitating resonance, which is an essential phenomenon in individual/interpersonal/group creativity. They are also rich in practical implications for collaborative design communication, especially in the case of social innovation design, where co-creative participation and sustainable creative flows are essential among stakeholders.

6.2 Limitations and future research

This study has limitations in terms of the communication channels considered, the number of participants, and the cultural diversity of the participants, as described above. Further investigation will be needed to apply these findings to more diverse situations. Considering multi-modality in communication will provide a broader and more integrated understanding of resonance.

Resonance, a phenomenon experienced among collaborative designers during co-creation, has only recently been grasped and detected quantitatively (Matsumae et al., 2022; Shoji et al., 2023). Further studies to examine its characteristics and impacts on individual/social creativity and co-creative design process are desired to be explored in future.

ETHICAL STATEMENT

This study was approved by the Institutional Review Board of Kyushu University, and the research conducted accordingly.

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