INTERNATIONAL DESIGN CONFERENCE – DESIGN 2024
https://doi.org/10.1017/pds.2024.110

Characteristics of paralinguistic communication indicating pre-resonance during co-creative design grasped by decision tree analysis

Karen Shichijo and Akane Matsumae ✉

Kyushu University, Japan

✉ matsumae@design.kyushu-u.ac.jp

Abstract

The study aims to grasp the dynamic characteristics of paralinguistic communication during co-creation and has developed an analysis methodology by clustering the conversational patterns and determining the criteria more often observed in pre-resonance. The results suggest that pre-resonance is characterized by less silence, a rapid transition in exchanging ideas under one's initiative, and a conversation with equal amounts of utterances between both in a pair. This study reveals implications for better communication that lead to resonance, an essential phenomenon in collaborative design.

Keywords: *resonance, design creativity, paralinguistic communication, collaborative design, quantitative analysis*

1. Introduction

In design, creativity can be perceived in various ways: as a product of collaborative efforts by multiple designers, as a designer's individual creative expression, and as creativity based on the social significance of the item being designed (Nagai *et al.*, 2003). These dimensions of design creativity can be better understood by considering the diverse interpretations of design itself (Taura and Nagai, 2009). In their exploration of social creativity, the authors delve into the first form of creativity, collaboration, aiming to gain deeper insights into the dynamics of human factors within the co-creative design process. They draw a clear distinction between co-creative and cooperative design processes by observing the nature of the process through the lens of social innovation design (Matsumae and Nagai, 2018; Matsumae *et al.*, 2020). According to the authors, a cooperative design process is generally characterized by well-defined goals and explicit knowledge-sharing among the designers. Conversely, the co-creative design process as its transitional phase is characterized by the lack of a well-defined goal. The designers instead autonomously create and sustain a creative flow while sharing both tacit and explicit knowledge based on an intersubjectivity that has been established and nurtured between them (Ehkirch and Matsumae, 2024). During co-creation, collaborative designers occasionally experience *resonance*, which is understood as key evidence of their creative states in ideal pursuing design process rooted in the post-industrial context (Taura and Nagai, 2009). This study is focused on illuminating the qualities of paralinguistic interpersonal communication, called *pre-resonance*, that arise before this state of resonance, exploring the types of communication that can evoke this unique creative state.

1.1. Resonance in creativity studies

With or without resonance, designers empirically understand that creative states are not stationary, but that they are dynamic and change along with the design process. Nagai relates the importance of resonance, especially when design is understood to be the pursuit of an ideal rather than a drawing or a problem to be solved, since resonance can be seen as arising from idealness and can elevate the motives of designers beyond empathy(Depraz and Cosmelli, 2003; Nagai, 2014; Nagai and Taura, 2017; Taura et al., 2012; Taura and Nagai, 2009). Goncalves et al. also appear to touch on this creative moment within stimuli that designers may encounter and which brings them to peak inspiration (Gonçalves *et al.*, 2013). As a result, the concept of resonance during the design phase has been recognized as a crucial aspect of studies of design creativity, whether at the individual or group level. Moreover, in the realm of social creativity during the co-creative design process, resonance can be understood as an interactional synchrony of group flow, one that can enable the merging of individual and collective experiences in a group to enhance mutual participation, contribution, and creation (Csikszentmihalyi, 2014; Patricia, 2007; Sawyer, 2011; Woodman *et al.*, 1993). However, studies of resonance have so far mainly been qualitatively based. Matsumae et al. have tried to analyze resonance quantitatively by using multimodal bio-signals to better understand its relation to creativity (Matsumae *et al.*, 2022) and have successfully detected unobservable resonant states via observable multimodal bio-signals using the Hidden Markov Models (Shoji *et al.*, 2023), which is a stochastic model method used to estimate unobserved state variables by way of observed variables (Markou and Singh, 2003).

1.2. Communication in collaborative design

The significance of communication in collaborative design has been examined from various perspectives, depending on the type of collaboration anticipated in the design process and the nature of interactions, whether internal or external. Communication serves as a tool to facilitate the entire design process, from concept generation to production, delivery, and response. A substantial body of research has explored design communication to support cooperative collaboration as it relates to creativity (Antoniou *et al.*, 2019). Gonçalves et al. have discussed its internal role, highlighting its part in supporting inspiration peaks among designers (Gonçalves *et al.*, 2013), while many other studies have focused on its external functions of enhancing 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 stands out as a crucial factor when fostering group engagement and collaboration (Park, 2007) and when overcoming bouts of creative stagnation, thus promoting the flow of creativity (Shah *et al.*, 2019). These types of communication are employed in a multimodal fashion in practice (Schuller *et al.*, 2013), encompassing the phonetic and non-phonetic, the verbal and non-verbal, as well as the linguistic, paralinguistic, and non-linguistic. In recent decades, the significance of paralinguistic communication has gained recognition (Kraus, 2017). Thanks to advancements in measurement technologies, researchers can now quantitatively investigate what was once taken as conventional wisdom, namely that success or failure in communication often depends not just on the content of the message but at least as much on how it is expressed and delivered (Sanders, 1984; Zhou *et al.*, 2004). Furthermore, Won et al. examined the connections between communication and creativity, revealing a significant linear correlation between the synchrony of non-verbal communication and creativity (Won *et al.*, 2014).

2. Research methods

In this study, paralinguistic communication during co-creation was categorized into several patterns using time-series clustering from the viewpoints of silence and conversation balance. Then, among these paralinguistic communication patterns, those that characteristically appear during pre-resonance were identified by using the Decision Tree Analysis (hereafter DTA). With this approach, the authors explored the time-series characteristics of paralinguistic communication that occurs in pre-resonance during co-creative design. This study uses data collected during co-creative pair-work experiments conducted in a previous study, including video recorded during the work, and data on the transition of the creative state and the moment that resonance was felt during the work, which were recorded by examiners interviewing the participants (Figure 1). The data of 8 pairs of 16 participants were used for analysis, excluding those whose voices were not sufficiently audible to be used. For details of this experiment, see the previous paper (Matsumae *et al.*, 2022).

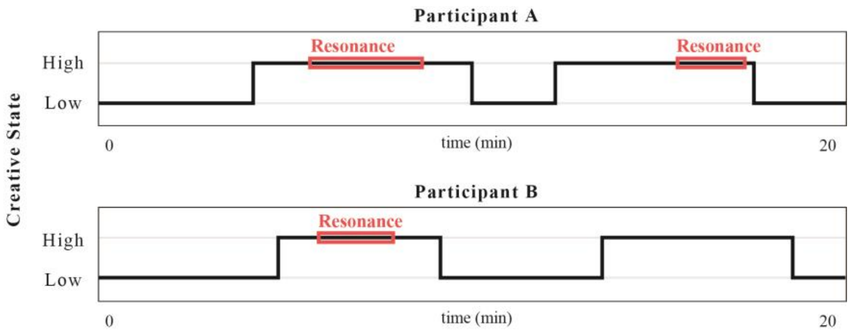

Figure 1. Examples of data on the transition of the creative state and the moment that resonance was achieved in a pair

2.1. Identification of resonance and pre-resonance

The resonant moments in this study were identified based on individual interviews in which participants indicated whether they felt resonance during the work. For this study, "resonance" was defined as an interval in which the two members of a pair felt resonance simultaneously. In addition, the study focused on paralinguistic communication in pre-resonance to gain insights into what kinds of conversation can lead to resonance. The authors identified pre-resonance as the 1.25 minutes preceding the onset of resonance, a span considered the minimum time needed for the onset of resonance. This figure was arrived at by comparing the lengths of time observed between occurrences of resonance and from the beginning of work to the first resonance.

2.2. Identification of paralinguistic communication

Paralinguistic communication was understood by observing silence and conversation balance in this study. Silence measures the density of interaction in the co-creation process, i.e., whether the process is marked by an individual or collective state, while conversation balance defines the balance of interaction, i.e., whether one participant is taking the lead or both participants are equally participating in the co-creative design process. "Silence" was defined as the total silent periods experienced by a pair of participants between each participant's utterances, with the ratio of silence per analysis unit evaluated to determine the silence ratio. A sliding window analysis was used to calculate the silence ratio. The analysis window size was set to 15 seconds, which was approximately the shortest duration of resonance and the shortest to allow a grasp of phonetic communication characteristics in this study. The width of the window shift was set to one second. "Conversation balance" was evaluated as a skewed ratio, which was an absolute value for the differences between each ratio, the ratios being the length of each participant's utterances divided by the total of all utterance lengths of the pair. The skewed ratio was also calculated using a sliding window approach. Both time-series datasets were smoothed by 15 intervals using a moving average method.

2.3. Analysis methods

The authors developed and proposed an analysis methodology used to understand time-series characteristics in paralinguistic communication patterns in pre-resonance in this study. First, to investigate conversational patterns during the co-creative design process, time-series datasets divided into equal time periods were clustered according to the similarity of their waveforms for each of the two perspectives of paralinguistic communication: silence and conversation balance. Then, these two perspectives of paralinguistic communication were categorized using time series clustering. Time series clustering is a method of clustering time series datasets according to trends in data transition (Petitjean *et al.*, 2011). In this study, time-series datasets on silence and conversation balance were clustered by wave similarity. The characteristics of the waves in each formed cluster were then used to grasp the time-series characteristics of each paralinguistic communication category, e.g., that 'silence gradually decreased', that 'only one person expressed utterances, but gradually both people started to express utterances equally'. For time-series clustering, the time-series datasets for silence and conversation balance were divided using a sliding window analysis. The window size was set to 1.25 minutes,

https://doi.org/10.1017/pds.2024.110 Published online by Cambridge University Press

referring to the length of pre-resonance time as defined above, and the width of the window shift was set to 15 seconds, which was the length of the smallest conversational turn. Time-series datasets divided here were then clustered according to the similarity of waveforms using the k-means method for silence and conversation balance. Soft dynamic time warping (hereafter Soft-DTW) was applied to evaluate similarity since it can consider phase shifts and generate a smooth centroid (Cuturi and Blondel, 2017). Then, these perspectives of silence and conversation balance were integrated into paralinguistic communication categories by reducing dimensionality using principal component analysis (hereafter PCA). PCA was performed on the time-series clustered datasets to contract the dimensionality of the datasets. PCA is a method of extracting principal components from multiple explanatory variables so that they can be explained by a smaller number of variables without sacrificing too much information. In this study, the principal components formed by dimensional contraction can be regarded as components that represent paralinguistic communication integrating the perspectives of silence and conversation balance. The time-series clustered datasets of analysis units of 1.25 minutes for silence and conversation balance are described as one-hot vectors. Following this, PCA was performed to generate new axes that integrated the two perspectives of silence and conversation balance, and all data were converted into the data on the new axes.

Finally, DTA was applied to the PCA datasets above to identify the set of classification criteria that determined whether the data would be classified as pre-resonance. DTA is a method that uses a tree-like model to generate classification criteria for datasets in which multiple covariates are included (Breiman *et al.*, 2017). In this study, after identifying the classification criteria of paralinguistic communication that leads to more pre-resonance, the paralinguistic communication identified can be considered as characteristic communication in pre-resonance. The classification and regression tree (CART) algorithm (Breiman *et al.*, 2017) was used to create decision trees. To prevent overfitting, the maximum depth of the decision tree was set to 3. Since the ratio of pre-resonance datasets out of total datasets was small (1.7%), non-pre-resonance datasets used for decision tree creation were balanced to distinguish those in which both members of a pair reached a creative state but did not express resonance. This enabled a better understanding of the characteristics of paralinguistic communication in the transition from a merely simultaneous creative state in a pair to a resonant state. To avoid the influence of transitional creative state analysis units, the 1.25-minute spans at the beginning and end of simultaneous creative states in a pair were excluded.

3. Results

3.1. Characteristics of paralinguistic communication: silence and conversation balance

The silence dataset during the co-creative design process was divided into five clusters, called silence_1-5 (Figure 2). From the centroid generated by the k-means time-series clustering, silence_1 refers to waves with a silence ratio in the range of 30%-50% and a half wavelength of about 20 seconds, silence_2 refers to waves with a silence ratio in the range of 40%-80% and a half wavelength of about 40 seconds, silence_3 refers to waves with a silence ratio in the range of 55%-95% and a half wavelength of about 75 seconds, silence_4 refers to waves with a silence ratio in the range of 35%-70% and a half wavelength of 20-35 seconds, and silence_5 refers to waves with a silence ratio in the range of 45%-75% and a half wavelength of 30 seconds. The conversation balance dataset was also divided into five clusters, called balance_1-5 (Figure 3). From the centroid generated by k-means time-series clustering, balance_1 refers to waves with a skewed ratio in the range of 20%pt-50%pt and a half wavelength of about 20 seconds, balance_2 refers to waves with a skewed ratio in the range of 25%pt-80%pt and a half wavelength of about 20-30 seconds, balance_3 refers to waves with a skewed ratio in the range of 30%pt-85%pt and a half wavelength of about 20-30 seconds, balance_4 refers to waves with a skewed ratio in the range of 20%pt-80%pt and a half wavelength of 15-20 seconds, and balance_5 refers to waves with a skewed ratio in the range of 10%pt-45%pt and a half wavelength of 75 seconds.

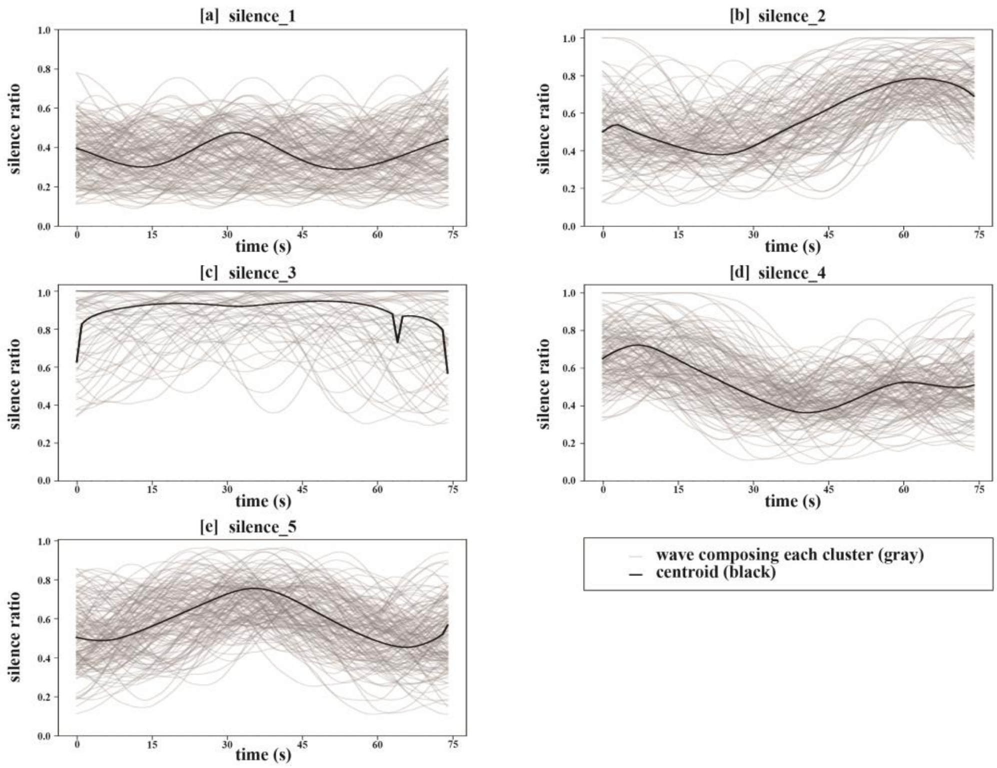

Figure 2. Clusters of silence; [a] silence_1; [b] silence_2; [c] silence_3; [d] silence_4; [e] silence_5: wave composing each cluster (gray), centroid (black)

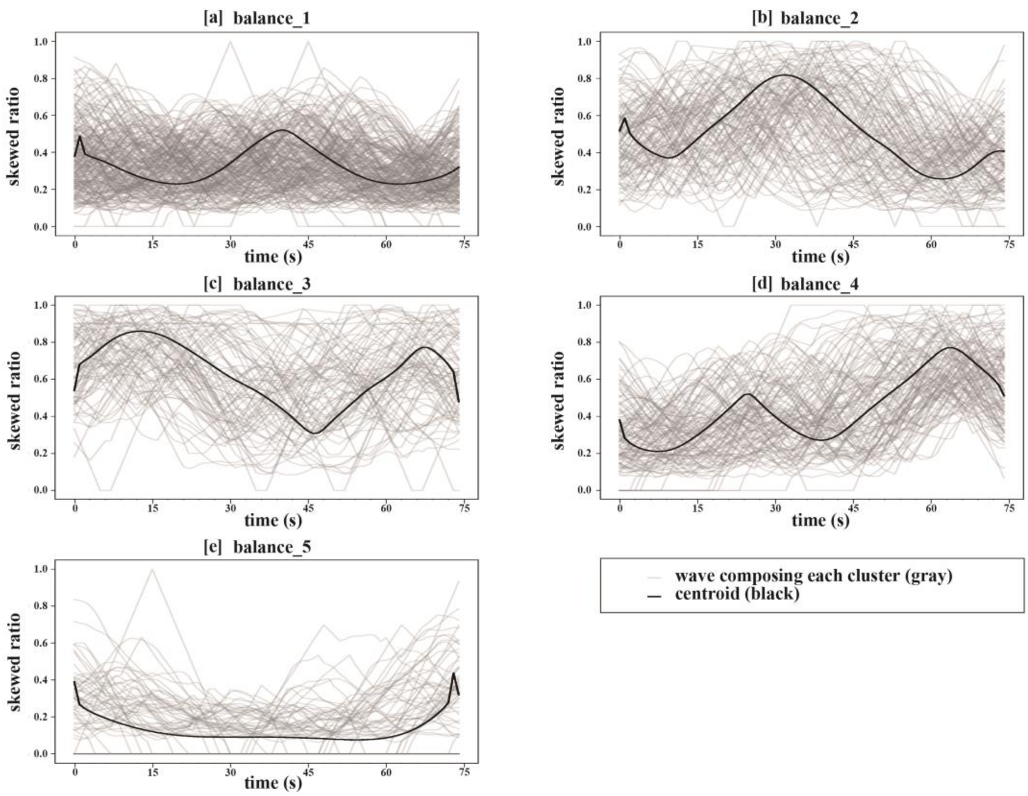

Figure 3. Clusters of conversation balance; [a] balance_1; [b] balance_2; [c] balance_3; [d] balance_4; [e] balance_5: wave composing each cluster (gray), centroid (black)

https://doi.org/10.1017/pds.2024.110 Published online by Cambridge University Press

3.2. Integration of the perspectives of silence and conversation balance into paralinguistic communication categories

PCA was carried out on the time-series clustered datasets processed above in 3.1 with six principal components set so that the cumulative contribution exceeded 80% (Figure 4). From the PC loadings, PC1 had a strongly positive correlation with balance_3, a negative correlation with balance_1, and little correlation with silence. PC2 had a strongly positive correlation with silence_3, a positive correlation with balance_1, and a weakly negative correlation with balance_4, silence_4, and silence_1. PC3 had a strongly positive correlation with silence_2, a weakly negative correlation with silence_3 and balance_5, and a weakly positive correlation with balance_1. PC4 had a strongly positive correlation with silence_4, a negative correlation with silence_1, and a weakly negative correlation with balance_4. PC5 had a positive correlation with balance_4, a negative correlation with silence_1, a weakly positive correlation with silence_3 and silence_2, and a weakly negative correlation with balance_3 and balance_1. PC6 had a positive correlation with silence_5 and balance_2, a negative correlation with silence_1, and a weakly negative correlation with balance_4.

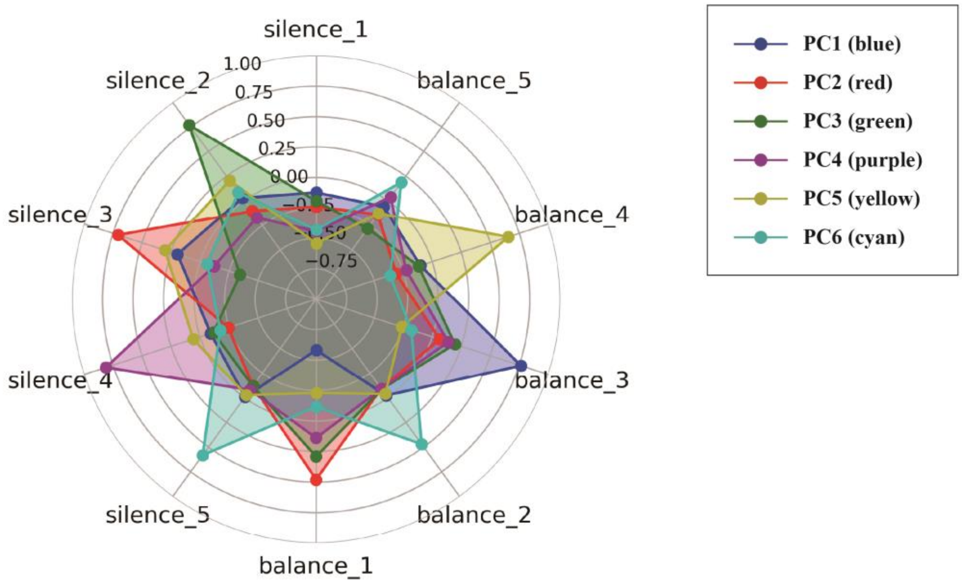

Figure 4. Principal component loadings: PC1 (blue), PC2 (red), PC3 (green), PC4 (purple), PC5 (yellow), PC6 (cyan)

3.3. Characteristics of paralinguistic communication in pre-resonance

The dataset used to create a decision tree was selected according to the criteria described in 2.1.3, resulting in a total of 30 data points: 11 for pre-resonance data and 19 for non-pre-resonance data. A decision tree of depth 3 was created with this dataset and the branching nodes were named a-e, starting from the upper left (Figure 5). As a result, node_a diverged depending on whether PC6 was less than or equal to -0.093, and more pre-resonance data were classified into node_b, which was less than or equal to -0.093. Node_b diverged depending on whether PC1 was less than or equal to -0.247, and more pre-resonance data were classified into node_d, which was less than or equal to -0.247. Node_c diverged depending on whether PC1 was less than or equal to -0.337, and more pre-resonance data were classified into node_e, which was less than or equal to -0.337. Node_d diverged depending on whether PC5 was less than or equal to -0.461, and more pre-resonance data were classified into the node that was less than or equal to -0.461. Node_e diverged depending on whether PC1 was less than or equal to -0.523, and more pre-resonance data were classified into the node that was less than or equal to -0.523. PC6 had the highest feature importance, followed by PC1 and PC5.

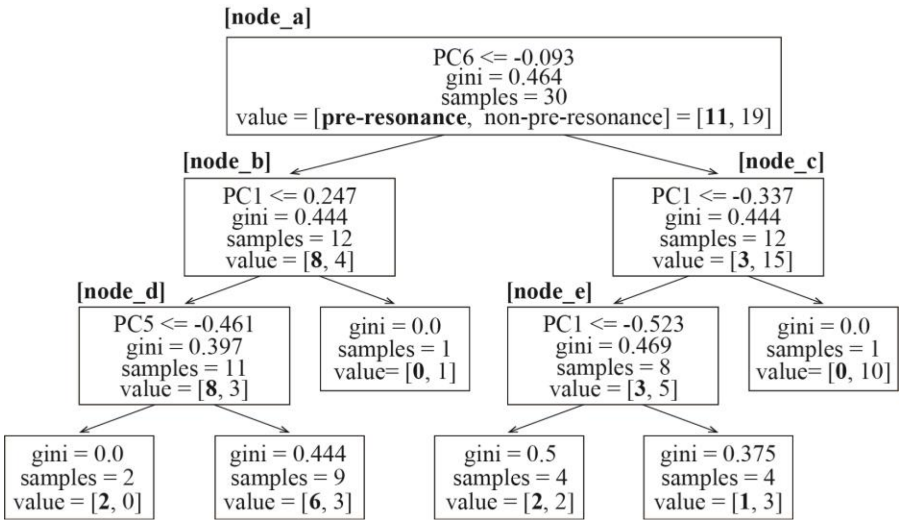

Figure 5. Decision tree separating pre-resonance and non-pre-resonance

4. Discussions

4.1. Characteristics of paralinguistic communication: silence and conversation balance

Silence_1 was a cluster of waves with a lower silence ratio than other clusters, suggesting that utterances were particularly active in this cluster. The short period of the waves compared to other clusters suggests that the development of topics was also rapid. Silence_2, silence_4, and silence_5 are clusters with similar amplitude and period of silence ratios. Since these had higher values than silence_1, they are considered to exhibit more silent time than silence_1, meaning the development of the topic was relatively slowly paced. However, these clusters have phase differences, with the peak silence ratios appearing at the end of silence_2, at the beginning of silence_4, and at the middle of silence_5. Therefore, it is suggested that silence_2 represents the gradual end of one topic, silence_4 represents the beginning of a new topic, and silence_5 represents the end of one topic and the beginning of the next topic. Silence_3 is a cluster of waves where the silence ratio maintains a high value such as 1, suggesting that both in a pair were silent and thinking.

Balance_1 is a cluster of waves with a lower skewed ratio than other clusters, suggesting that both participants expressed utterances in equal amounts. The short period of waves compared to the other clusters suggests that the development of topics was also rapid. Balance_2 and balance_3 are clusters with similar amplitude and period of skewed ratio. Since these values are higher than balance_1, the conversation balance was considered to be mainly one person expressing utterances and the other responding with short back-channel responses, and the topic development was slower than in balance_1. However, these clusters have phase differences, as balance_2 ends with the skewed ratio starting to rise from a low state while balance_3 ends with the skewed ratio starting to fall from a high state. Balance_4 is a transition in which the skewed ratio gradually increases, which can be considered to represent a transition from both participants expressing utterances in equal amounts to just one person doing most of the talking. Balance_5 is a cluster of waves that maintain low skewed ratios such as 0. This is considered to be a state in which neither participant in a pair expressed significant utterances, since the ratio calculation method means the skewed ratio is 0 when both participants in a pair have no utterances.

4.2. Integration of the perspectives of silence and conversation balance into paralinguistic communication categories

PC1 has a strong positive correlation with balance_3 and a negative correlation with balance_1. Thus, a large value for PC1 indicates mainly one person expressing utterances and a relaxed pace of topic development, while a small value indicates that both in a pair contributed utterances and the topic development was rapid. The values and periods of the silence ratio do not have much effect on PC1, as

https://doi.org/10.1017/pds.2024.110 Published online by Cambridge University Press

there is little correlation with silence. PC2 has a strong positive correlation with silence_3 and a positive correlation with balance_1. Thus, a large value for PC2 indicates that both participants in a pair remained silent and that the conversation balance was not skewed for this reason. Furthermore, PC2 has a weak negative correlation between silence_1 and silence_4 and balance_4. Thus, a smaller value for PC2 indicates less silence or, in an analysis unit of 1.25 minutes, that silence was decreasing (i.e., utterances were gradually increasing), and the skew in the conversation balance was initially small because both in a pair were silent but then gradually increased because mainly one person was expressing utterances. PC3 has a strong positive correlation with silence_2 and a weak positive correlation with balance_1. Thus, the large value for PC3 indicates that, in the analysis unit of 1.25 minutes, silence was increasing (i.e., utterances were gradually decreasing), and the skew in the conversation balance was small because both in a pair expressed utterances in equal amounts. Furthermore, PC3 has a weak negative correlation with silence_3 and balance_5. Thus, a small value of PC3 indicates that, in the analysis unit of 1.25 minutes, both participants in a pair remained silent and that the conversation balance was not skewed for this reason. PC4 has a strong positive correlation with silence_4. Thus, a large value for PC4 indicates that silence was decreasing (i.e., utterances were gradually increasing). Furthermore, PC4 has a negative correlation with silence_1 and a weak negative correlation with balance_4. Thus, a small value for PC4 indicates that utterances were particularly active and the skew in the conversation balance was initially small because both in the pair expressed utterances in equal amounts, but that the skew gradually increased because one person provided most of the conversation. PC5 has a weak positive correlation with silence_3 and silence_2 and a positive correlation with balance_4. Thus, a large value for PC5 indicates that, in the analysis unit of 1.25 minutes, silence was increasing (i.e., utterances were gradually decreasing), and the skew in the conversation balance was initially small because both in a pair expressed utterances in equal amounts but the skew gradually increased because one person provided most of the conversation. Furthermore, PC5 has a negative correlation with silence_1 and a weak negative correlation with balance_3 and balance_1. Thus, a small value for PC5 indicates that utterances were particularly active and the skew in the conversation balance was small because both in a pair expressed utterances in equal amounts or was large because one person provided most of the conversation. PC6 has a positive correlation with silence_5 and balance_2. Thus, a large value for PC6 indicates that, in the analysis unit of 1.25 minutes, one topic ended and the next began, and the skew in the conversation balance was large because one person provided most of the conversation. Furthermore, PC6 has a negative correlation with silence_1 and a weak negative correlation with balance_4. Thus, a small value for PC6 indicates a similar trend to that of PC4.

4.3. Characteristics of paralinguistic communication in pre-resonance

From node_a, more pre-resonance data were classified to a node where PC6 was smaller than a certain value. Thus, pre-resonance was characterized by a state in which there was little silence, utterances were particularly active and topics developed rapidly, and the conversation balance transitioned from a state in which both in a pair expressed utterances in equal amounts to a state in which one person provided most of the conversation. This suggests that, after both participants in a pair have experienced a state of active exchange of opinions, a change to a state in which one person actively expresses his or her opinion can lead to resonance. Observation of the experimental data showed that some resonance occurred after one person came up with an idea that was developed based on the opinions expressed by both in a pair and then shared that idea with the other person. From nodes b, c, and e, more pre-resonance data were classified to a node where PC1 was smaller than a certain value, whether or not PC6 was larger or smaller than that value (Figure 5). Thus, pre-resonance was characterized by a conversation balance in which both participants in a pair expressed utterances in equal amounts (Figure 4, Figure 3[a]). At the same time, it suggests that the pattern of silence in the pre-resonance state is difficult to define as one specific type (Figure 4). The above suggests that, rather than the amount of utterances or the conversational rhythm characterized by silence, the participation of both participants in a pair in discussion and the sharing of opinions and ideas leads to resonance, the creation of a shared image and the resonance of a creative state between them. From node d, more pre-resonance data were classified to a node where PC5 was smaller than a certain value when PC6 and PC1 were smaller than that value.

https://doi.org/10.1017/pds.2024.110 Published online by Cambridge University Press

This suggests that pre-resonance may be a state with even less skewed conversation balance and less silence than the state characterized by node_a.

5. Conclusion

First, this study introduced the development and proposal of a method to grasp the time-series characteristics of inter-personal communication. Second, the results of the study suggest the time-series characteristics of paralinguistic communication indicating pre-resonance during co-creation, whereby a state of pre-resonance is characterized by less silence, the rapid development of the topic, and a transition from both in a pair actively exchanging ideas to one person taking the initiative in conversation. This suggests that, after both participants in a pair have experienced a state of active exchange of opinions, a shift to a state in which one person mainly expresses his or her opinion can lead to resonance. Pre-resonance is also characterized by a conversation balance in which both participants in a pair express utterances in equal amounts rather than silence. This can be interpreted to mean that equal participation in the discussion and sharing of opinions can be a more important factor leading to resonance than the number of utterances or conversational rhythm woven by utterances and silence. These identified paralinguistic communication characteristics of pre-resonance can be considered as the signs or even the phases that evoke resonance during co-creative design. This research provides practical implications for the development of methods of enhancing communication that evoke resonance and contribute to the co-creative design process by elevating co-designers beyond a state of empathy and leading them to a resonant state, an essential creative moment in ideal pursuing design.

Resonance is essentially a gradational cognitive state that develops as individuals gradually stimulate each other through interaction, although the authors approximated resonance as a binarized creative status in this study. Because of this, resonance will be identified with greater precision by being treated as a gradational creative state, and this is one of the expected directions of future studies. Furthermore, the characteristics of paralinguistic communication in this study were grasped while focusing on the period immediately before resonance. While this period is predicted to have a significant effect that leads to resonance, studies focusing on longer periods may bring implications from different perspectives that will help us identify the communication that leads to resonance in the co-creative design process.

Acknowledgment

This work was supported by Graduate School of Kyushu University Research Skill Development Scholarship, JSPS Grant-in-Aid for Scientific Research JP20K20119 and JP22KK0220.

References

Antoniou, R., Dekoninck, E. and Bonvoisin, J. (2019), “Exploring the role of linguistic abstraction in idea-generation sessions”, Proceedings of the International Conference on Engineering Design, ICED, Vol. 2019-August, Cambridge University Press, pp. 329–338, https://dx.doi.org/10.1017/dsi.2019.36.

Bilda, Z., Edmonds, E. and Candy, L. (2008), “Designing for creative engagement”, Design Studies, Vol. 29 No. 6, https://dx.doi.org/10.1016/j.destud.2008.07.009.

Breiman, L., Friedman, J.H., Olshen, R.A. and Stone, C.J. (2017), Classification and Regression Trees, Classification and Regression Trees, https://dx.doi.org/10.1201/9781315139470.

Csikszentmihalyi, M. (2014), “Implications of a Systems Perspective for the Study of Creativity”, Handbook of Creativity, https://dx.doi.org/10.1017/cbo9780511807916.018.

Cuturi, M. and Blondel, M. (2017), “Soft-DTW: A differentiable loss function for time-series”, 34th International Conference on Machine Learning, ICML 2017, Vol. 2.

Depraz, N. and Cosmelli, D. (2003), “Empathy and Openness: Practices of Intersubjectivity at the Core of the Science of Consciousness”, Canadian Journal of Philosophy Supplementary Volume, Vol. 29, https://dx.doi.org/10.1080/00455091.2003.10717598.

Ehkirch, Q. and Matsumae, A. (2024), “Understanding the influence of interpersonal factors on interactions in co-design through intersubjectivity: a systematic literature review”, Design Science, Vol.10 No. e4, https://dx.doi.org/10.1017/dsj.2024.1.

Gonçalves, M., Cardoso, C. and Badke-Schaub, P. (2013), "Inspiration peak: Exploring the semantic distance between design problem and textual inspirational stimuli", International Journal of Design Creativity and Innovation, Vol. 1 No. 4, https://dx.doi.org/10.1080/21650349.2013.799309.
Kraus, M.W. (2017), "Voice-only communication enhances empathic accuracy", American Psychologist, Vol. 72 No. 7, https://dx.doi.org/10.1037/amp0000147.
Markou, M. and Singh, S. (2003), "Novelty detection: A review - Part 1: Statistical approaches", Signal Processing, Vol. 83 No. 12, https://dx.doi.org/10.1016/j.sigpro.2003.07.018.
Matsumae, A. and Nagai, Y. (2018), "The function of co-creation in dynamic mechanism of intersubjectivity formation among individuals", Proceedings of International Design Conference, DESIGN, Vol. 4, https://dx.doi.org/10.21278/idc.2018.0141.
Matsumae, A. Matsumae, S. and Nagai, Y. (2020), "Dynamic relationship design of knowledge co‑creating cluster: traditional Japanese architectural industry", SN Applied Science, Vol. 2 No. 443, doi.org/10.1007/s42452-020-2209-2
Matsumae, A., Shoji, K. and Motomura, Y. (2022), "An Attempt to Grasp Resonance during Co-Creation with Biosignal Indicators", Proceedings of the Design Society, Vol. 2, https://dx.doi.org/10.1017/pds.2022.94.
Nagai, Y. (2014), "A Sense of Design: The Embedded Motives of Nature, Culture, and Future", Principia Designae – Pre-Design, Design, and Post-Design: Social Motive for the Highly Advanced Technological Society, https://dx.doi.org/10.1007/978-4-431-54403-6_4.
Nagai, Y., Candy, L. and Edmonds, E. (2003), "Representations of Design Thinking- A Review of Recent Studies", Journal of the Asian Design International Conference, Vol. 1 No. 341.
Nagai, Y. and Taura, T. (2017), "Critical Issues of Advanced Design Thinking: Scheme of Synthesis, Realm of Out-Frame, Motive of Inner Sense, and Resonance to Future Society", https://dx.doi.org/10.1007/978-981-10-7524-7_8.
Park, J.R. (2007), "Interpersonal and affective communication in synchronous online discourse", Library Quarterly, Vol. 77 No. 2, https://dx.doi.org/10.1086/517841.
Patricia, A. St. John (2007), "Interactive and Emergent Processes: Possibilities and Problems in Group Creativity", Mind, Culture, and Activity, Vol. 14 No. 4, https://dx.doi.org/10.1080/10749030701623847.
Petitjean, F., Ketterlin, A. and Gançarski, P. (2011), "A global averaging method for dynamic time warping, with applications to clustering", Pattern Recognition, Vol. 44 No. 3, https://dx.doi.org/10.1016/j.patcog.2010.09.013.
Sanders, R.E. (1984), "Style, meaning, and message effects", Communication Monographs, Vol. 51 No. 2, https://dx.doi.org/10.1080/03637758409390191.
Sawyer, R.K. (2011), Explaining Creativity: The Science of Human Innovation, 2nd ed., Oxford University Press, New York.
Schuller, B., Steidl, S., Batliner, A., Burkhardt, F., Devillers, L., Müller, C. and Narayanan, S. (2013), "Paralinguistics in speech and language - State-of-the-art and the challenge", Computer Speech and Language, Vol. 27 No. 1, https://dx.doi.org/10.1016/j.csl.2012.02.005.
Shah, A., Huidobro Pereda, A. and Gonçalves, M. (2019), "Sprinting out of stuckness: Overcoming moments of stuckness to support the creativity flow in agile team settings", Proceedings of the International Conference on Engineering Design, ICED, Vol. 2019-August, https://dx.doi.org/10.1017/dsi.2019.241.
Shoji, K., Sawai, K. and Matsumae, A. (2023), "Creative States Estimation and Resonance Detection using Hidden Markov Models", Journal of Japan Creativity Society, Vol. 26 No. 1, pp. 118–136, https://doi.org/10.24578/japancreativity.26.0_118.
Taura, T. and Nagai, Y. (2009), "A Definition of Design and Its Creative Features", Iasdr2009.
Taura, T., Yamamoto, E., Fasiha, M.Y.N., Goka, M., Mukai, F., Nagai, Y. and Nakashima, H. (2012), "Constructive simulation of creative concept generation process in design: A research method for difficult-to-observe design-thinking processes", Journal of Engineering Design, Vol. 23 No. 4, https://dx.doi.org/10.1080/09544828.2011.637191.
Won, A.S., Bailenson, J.N., Stathatos, S.C. and Dai, W. (2014), "Automatically Detected Nonverbal Behavior Predicts Creativity in Collaborating Dyads", Journal of Nonverbal Behavior, Vol. 38 No. 3, https://dx.doi.org/10.1007/s10919-014-0186-0.
Woodman, R.W., Sawyer, J.E. and Griffin, R.W. (1993), "Toward a Theory of Organizational Creativity", Academy of Management Review, Vol. 18 No. 2, pp. 293–321, https://dx.doi.org/10.5465/amr.1993.3997517.
Zhou, L., Burgoon, J.K., Zhang, D. and Nunamaker, J.F. (2004), "Language dominance in interpersonal deception in computer-mediated communication", Computers in Human Behavior, Vol. 20 No. 3, https://dx.doi.org/10.1016/S0747-5632(03)00051-7.