Creativity Comes from Interaction

Multi-modal Analyses of Three-Creator Communication in Constructing a Lego Castle

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Abstract. We explored how three people communicate verbally (i.e. chatting, discussion) and nonverbally (i.e. gazes, gestures) in creating a Lego(R) castle collaboratively. We also investigated how such communication behaviors can be cues for a "better" and "more creative" castle. In Experiment 1, we asked a total of 30 students (3 people × 10 groups) to construct a castle fully in collaboration with the group members. In Experiment 2, we asked the other 27 students to assess the quality ("how good the castle is") and creativeness ("how creative the castle is") for the photographed castles. The verbal, gestural, and gazing behaviors of the creators were analyzed quantitatively. We conducted path analyses to identify parameters determining the quality and the creativeness, showing that the degree of communication behaviors was reflected in the evaluation of the created castle. In detail, the quality was enhanced by looking at the other group members as well as by discussing the content of the castle. The creativeness was determined by the degree of chatting and representational gestures. These results suggest the communication process in multiple-agent creation: Rapport can be constructed efficiently by chatting with the other members; creators can share divergent ideas; and they can construct a creative object.

Keywords: Communication · Creativity · Multiple-agent interaction · Multi-modal analysis · Lego(R)

1 Introduction

Creative activities, such as visual art, music, and building construction, are comprised generally of "communication" among creators, objects (i.e. works), and beholders (e.g. viewers, audiences) [3]. Creators' intentions are to be reflected in the object; beholders perceive such intentions by viewing the object; and they

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assess the quality and the creativeness of the object. Our focus in the present study is how creators communicate with each other in constructing a work collaboratively, and how the created work is evaluated in terms of the quality and the creativeness. By understanding how multiple creators' communication behaviors contribute to the quality and the creativeness of the work, we can provide novel knowledge about creativity in multi-party interaction.

We already know that communication behaviors among three or more people are different from those between two [2,5]. In two-agent conversation, if one person speaks, the other one is expected inevitably to speak next. In contrast, the next speaker is not identified uniquely in three-agent communication, so that the communication is to be more complex [5]. We can communicate smoothly by identifying the next speaker via verbal (e.g. specific phrases such as "What do you think, Professor?") and/or nonverbal cues (e.g. eye contact, bodily direction), even among three or more people [4].

Our focus in the present study is targeted at whether such multi-party communication generates "creativity" that is not produced individually. In the literature [6], the individual's creativity can be classified into two components: "divergent" and "convergent." Divergent thinking is a thought process used to generate creative ideas by exploring many possible solutions. In contrast, convergent thinking follows a particular set of logical steps to arrive at one solution. We can assume that collaborative creation is also composed of these two elements: producing many different ideas (divergent) and gathering them into one work (convergent). In this kind of activity, the members should construct "rapport," which is a state in which multiple people can communicate with one another and is usually based on shared interests, values, and other personal factors [1].

The group members' nonverbal communication is also an important factor in the collaborative task. A member's gaze at the other group members is important in role-sharing [13] and gestures among three people promote the completion of the task [8].

In the literature, the clear goal of the task (i.e. instruction about how to make an object) was provided to the creators [13]. In a real creative activity, however, creators sometimes create objects in an impromptu manner through a trial and error process without any instruction. In such a condition, each group member should present his/her own imagery accurately with the others and needs communication to understand the other members' ideas. In the present study, we set up a collaborative creation task, in which creators construct a "castle" by using Lego(R) bricks without any instruction. Pike [12] has shown that Lego is a useful tool for a creator to shape his/her imagery in the mind. McGraw et al. [9] showed that the "trial and error" process of including and excluding bricks helps creators express their own ideas. The task using Lego bricks enables us to visualize how the group members construct one object collaboratively by sharing their own ideas.

The purpose of the present study is to understand how three creators communicate verbally and nonverbally with each other as well as how such communication behaviors determine the quality and the creativeness of the work

(i.e. evaluation). These two evaluative axes, "quality" and "creativeness," are thought to be distinct as in, "This work is built well but not so creative" (e.g. [14]). We tested three hypothetical models (Fig. 1) in the present study. Figure 1a indicates that the verbal (i.e. discussion, chatting) and the nonverbal behaviors (i.e. gestures, gazes) would affect in parallel the quality and the creativeness of the work. If the verbal and the nonverbal behaviors are related to each other, we assumed that some causal relationships should be observed (as shown in Fig. 1b and c), so that we excluded the correlations between the verbal and the nonverbal behaviors in this diagram. Figure 1b indicates that the verbal behaviors would determine the nonverbal behaviors, both of which would explain the evaluation of the work. Figure 1c is a contrasting model of Fig. 1b in terms of the order of the verbal and the nonverbal behaviors. By understanding how creators' communication enhances the quality and the creativeness of the work, we would provide a basic perspective for multi-party interaction in a collaborative creation.

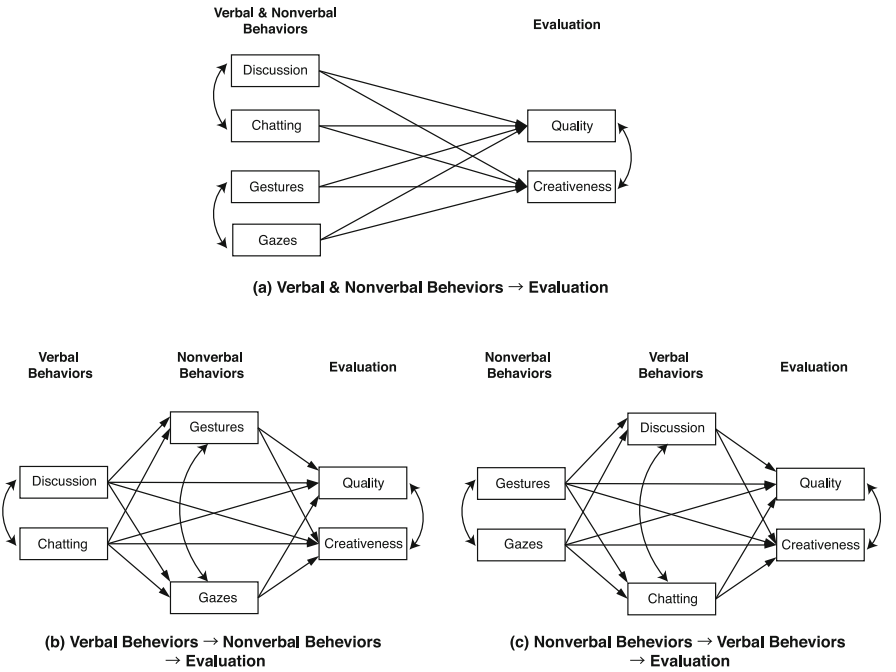

Fig. 1. Hypothetical models explaining evaluation by communication behaviors. Lateral and bilateral arrows indicate the causal and the correlational relationships between parameters, respectively.

2 Method

2.1 Experiment 1 (Collaborative Creation Task)

Participants. Thirty students (15 men, 15 women, $M = 20.03, SD = 1.81$) participated in Experiment 1, and were assigned to each of 10 same-sex groups (5 male groups and 5 female groups). The members of each group had never met each other before the experiment.

Procedure. Each experiment was conducted in a sound-proof room. Participants sat down at a circular table (top: radius 44 cm, height: 82 cm). Approximately 600–700 Lego bricks were placed in the groove on the edge of the table. The colors of bricks were white, red, blue, yellow, black, green, brown, lime, and orange. Participants were asked to create a castle collaboratively within 30 min by using the Lego bricks. The auditory and visual portions for each participant were recorded on a video camera, which was located in front of him/her (HDR-CX550V, Sony). We used a wireless microphone for the audio (ECM-AW3, Sony). Three cameras were synchronized by recording a flashing light simultaneously. An experimental snapshot is shown in Fig. 2.

Annotation. The second author annotated each participant's verbal and non-verbal behaviors using the EUDICO Linguistic Annotator (ELAN [7]). He annotated behaviors in three phases: "opening" (0:00–5:00), "middle" (15:00–20:00), and "ending" (20:00–25:00). We excluded the final phase of 25:00–30:00 because some of the groups completed the task at this phase. We analyzed the total of these 15 min in the present study. The following behaviors were annotated.

The *discussion* is defined as utterances related to the castle creation, e.g. "Let's make a gate with brown bricks!" and "Can I make this portion bigger?" Utterances irrelevant to castle creation were categorized as *chatting*, e.g. "Do you play baseball?" and "I feel like a kid again." We counted the number of *gazes*, or when a participant looked at another group member. We also identified the

Fig. 2. Snapshot of Experiment 1 (Color figure online)

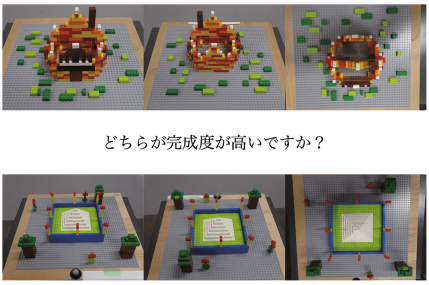

Fig. 3. Example of images in Experiment 2. The sentence in the middle means "which is better?" in Japanese.

number of *gestures* (representational gesture [10]), which is a body movement expressing a specific object spatially. As for the discussion and the chatting, we asked an expert in annotation with ELAN to decode all the behaviors, showing high reliability of the second author's annotation (Cohen's $\kappa = .96$).

2.2 Experiment 2 (Evaluation Task)

Participants. Twenty-seven students (7 men, 20 women, $M = 19.63$, $SD = 1.28$) participated in Experiment 2. No participants participated in Experiment 1.

Stimuli. We photographed the front, the back, and the top images of each of the works and arranged them side by side. We combined two out of 10 works (45 combinations in total) and placed them vertically (see Fig. 3).

Procedure. We conducted an experiment to assess the quality and the creativeness of the work using Thurstone's pairwise comparison method [15]. Each experiment was conducted using a computer with a monitor (PCG-21514n, Sony) and SuperLab4.5 (Cedrus). The participant sat 30 cm in front of the monitor, watched one of 45 stimuli (Fig. 3), chose which was better ("quality"), and chose which was more creative ("creativeness"). He/She repeated the task for all combinations, the order of which was randomized among participants.

3 Results

3.1 Basic Statistics

The data collected in the present study are plotted in Fig. 4. The basic statistics are shown in Table 1. Although we should acknowledge that variations among the individuals/groups were relatively high as shown in Fig. 4 and Table 1, we used all the samples in the following analyses to obtain enough samples.

3.2 Correlation Among Parameters

We computed Pearson's correlation coefficients (Table 2) among all the parameters shown in Table 1. The discussion correlated negatively with the gazes ($r = -.35$) and positively with gestures ($r = .46$). The chatting correlated positively with the gazes ($r = .50$) and the creativeness of the work ($r = .61$), both of which also correlated with each other ($r = .40$). In contrast, the quality of the work did not show any significant correlation with the other parameters. The two evaluation items (i.e. quality, creativeness) did not correlate with each other.

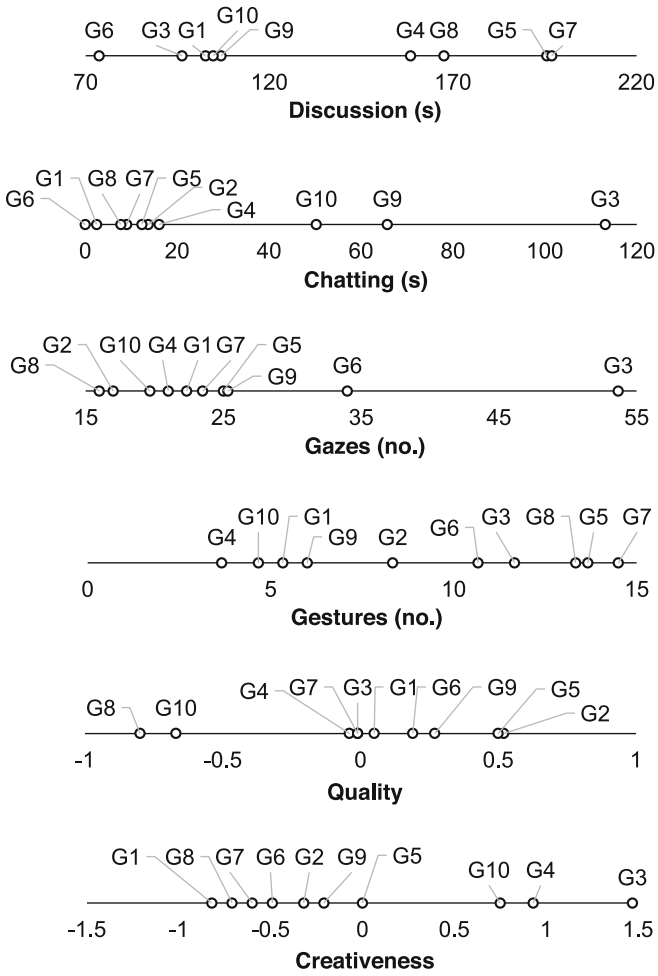

Fig. 4. Mean value per group computed for each parameter of verbal behaviors (i.e. discussion, chatting), nonverbal behaviors (i.e. gazes, gestures), and evaluations of the work (i.e. quality, creativeness). G1–G10 indicate group IDs. G1–G5 and G6–G10 are male and female groups, respectively.

3.3 Path Analysis Determining Quality and Creativeness by Communicative Behaviors

The aforementioned correlation analyses were useful to understand the relationship between any two items, but we have not understood the causality of how the creators' behaviors affect the quality and the creativeness of the work. We conducted path analyses (e.g. [16]) by which we can construct a model of the process from the creators' behaviors to the evaluation of the work.

Table 1. Basic statistics for each parameter. The values were computed for individuals in Experiment 1 ($N = 30$) and for groups in Experiment 2 ($N = 10$).

Parameter	*Mean*	*SD*	*Max.*	*Min.*
Verbal ($N = 30$)				
Discussion (in s)	140.47	65.80	317.49	32.77
Chatting (in s)	28.98	41.61	187.46	0.00
Nonverbal ($N = 30$)				
Gazes (no.)	25.70	14.34	73.00	6.00
Gestures (no.)	9.20	5.71	26.00	1.00
Evaluation ($N = 10$)				
Quality	0.00	0.42	0.52	−0.80
Creativeness	0.00	0.74	1.47	−0.82

Table 2. Correlation matrix for communication behaviors and evaluations ($N = 30$).

	Discussion	Chatting	Gazes	Gestures	Quality
Chatting	−.09				
Gazes	$-.35^{\dagger}$	$.50^{***}$			
Gestures	$.46^{**}$	.03	.08		
Quality	.19	−.06	.14	.04	
Creativeness	−.14	$.61^{***}$	$.40^{*}$	−.18	−.11

$^{***}p < .001, {}^{**}p < .01, {}^{*}p < .05, {}^{\dagger}p < .10$

In the present study, we installed three hypothetical models (Fig. 1). Path analyses were conducted for these models using the generalized least squares method, by which we computed the goodness-of-fit indices for each model (Table 3). Model c yielded the minimal AIC and BIC and the maximal CFI, indicating that Model c fit the best with the present data. AIC, BIC, and CFI stand for Akaike Information Criterion, Bayesian Information Criterion, and Comparative Fit Index, respectively.

By excluding the insignificant paths from the initial model (Fig. 1c), we found the final model in which all the paths were significant ($\alpha = .05$) or at least approaching significant ($\alpha = .10$) (Fig. 5). Based on the goodness-of-fit indices,

Table 3. Goodness-of-fit indices for three hypothetical models (Fig. 1).

Model No.	AIC	BIC	CFI
a	508.59	526.81	.42
b	496.37	520.19	.94
c	494.13	517.95	1.00

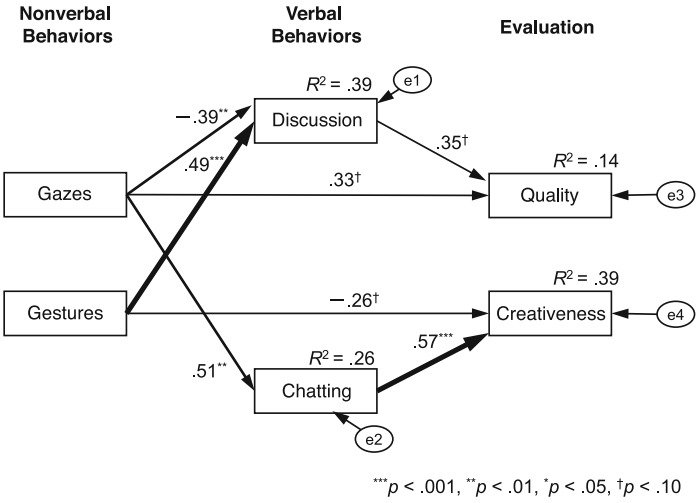

Fig. 5. Path diagram explaining evaluation by communication behaviors (values were standardized.) The boldness of the path was based on the significance of the value. e1-e4 indicate error variables. No correlation paths remained.

we confirmed that the present data fit the final model, $\chi^2(8, N = 30) = 4.26, p = .83, \mathrm{CFI} = 1.00, \mathrm{RMSEA} < .001$[1].

First, by gazing at one of the other creators, the chatting ($\beta = .51$) and the discussion ($\beta = -.39$) increased and decreased, respectively. The amount of gestures determined the amount of discussion ($\beta = .49$). As for the causality from the nonverbal behaviors to the evaluation of the work, the number of gazes enhanced the quality ($\beta = .33$) and that of gestures decreased the creativeness ($\beta = -.26$). According to the absolute values of β, the influences of the verbal behaviors seemed greater than those of the nonverbal. The amounts of discussion and chatting enhanced the quality ($\beta = .35$) and the creativeness ($\beta = .57$), respectively.

The final model shows that the nonverbal behaviors influenced the verbal behaviors, both of which influenced the quality and the creativeness of the work. The quality was determined by the amounts of gazing and discussion, whereas the creativeness was determined less by gestures and more by chatting.

4 Discussion

In the present study, we investigated effects of three creators' communication behaviors on the quality and the creativeness of the work in a collaborative creation task using Lego bricks. Results can be summarized as follows. First, the amounts of nonverbal behaviors determined those of verbal behaviors. Second,

[1] RMSEA stands for Root Mean Square Error of Approximation.

both verbal and nonverbal behaviors determined the quality and the creativeness of the work.

We found that more gestures generate more discussion. We focused in the present study on McNeill's "representational" gestures [10], which are bodily movements to shape an object spatially. In the present study, the creators' discussion was triggered by such gestures, implying that the creator's mental imagery is expressed spatially by the gesture, to be verbalized as discussion. McNeill suggested that a spatial aspect of a mental representation produces the gesture and that a verbal meaning of the representation produces the utterance [10]. According to this, the gesture takes an important role in the verbalization of the mental representation. In the path model (Fig. 5), the gesture and the discussion are not produced in parallel; rather, the creator's mental imagery is produced first, by which the conversation (discussion) can be promoted.

The amounts of discussion and gazing determined the quality of the work. In Suzuki et al. [13], three creators attempted to construct one large box like a jungle gym collaboratively. The presence of one "leader," who explained verbally how to construct the box, contributed to the quality of completion. Our finding in the present study is in line with this study. Our definition of "discussion" is "utterance related to creating the castle," which is equivalent to the "convergent" process in creativity [6]. This means that the convergent conversation (i.e. conversation toward the completion of the task) among three creators enhances the quality of the work. The more interesting thing is that the gazing behaviors among creators enhanced the quality of the work. Patterson [11] categorized gazing behaviors into several functions, one of which is "promoting the completion of the task," suggesting that the convergent function of discussion be obtained by "looking at the other members" as a nonverbal cue.

Furthermore, we showed that the amount of chatting determined the creativeness of the work. The chatting functions to construct rapport, which is a foundation of communication with each other [1]. Divergent ideas can be generated by chatting, with the result that highly creative work can be generated. In contrast, the use of the representational gesture decreases the evaluated creativeness. Such a gesture represents the spatial imagery of each member [10] being reflected in the work. This may cause the fixing of a particular member's imagery on the work, so that creators are unlikely to talk with each other divergently, resulting in non-creative work.

In the present study, we showed that the group creativity comes from the verbal and the nonverbal interactions among multiple creators. However, we have not understood yet effects of time-series characteristics of communication on the quality and the creativeness. We should examine the present data in depth in future study. The present study also suggests that creators' nonverbal skills in communication and/or personality (such as creativity, leadership) influence the work's quality and creativeness. Further experiments will be needed by incorporating personal and social factors of individuals and/or groups.

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