The Social Functions of Questions in Embodied Collaborative Work

Lucas M. Bietti¹

Federico U. Bietti²

Abstract

Researchers have been interested in the investigation of the social functions of questions in conversational contexts. However, limited research has been conducted on the social functions of questions in embodied collaborative work, i.e. work that involves the manipulation of physical objects. The aim of this study was to identify the social functions of questions in embodied collaborative work and to determine whether such functions correlate with performance outcomes. To do so, we conducted qualitative and quantitative analyses of a dataset of 1751 question-answer sequences collected from an experimental study where pairs of participants (N=134) completed a collaborative food preparation task. Qualitative analysis enabled us to identify three functions of questions: *Anticipation questions*, *exploration questions* and *confirmation questions*. Quantitative analyses revealed that there was no correlation between the types of questions and group performance. However, they showed that groups that contributed the most to performance presented a similar distribution of question types. The identification of such patterns is a first step towards the design and implementation of interaction-focused interventions aimed at increasing group productivity in embodied collaborative work.

Keywords: questions; functions; embodied collaboration; work; performance

¹ Department of Psychology. Norwegian University of Science and Technology

² Département de Sociologie. Université de Tours.

Introduction

Questions are one of the most important linguistic and embodied resources scaffolding social interactions, from human social interaction in everyday (Fox & Thompson, 2010) and institutional (Murtagh, Furber, Thomas, 2013) settings to human animal interaction (Mondémé, 2020) and human interactions with virtual agents (Vera Liao et al., 2018) and social robots (Pitsch, Gehle, Dankert, Timo & Wrede, 2017). Researchers have been particularly interested in the investigation of the social functions of questions in conversational contexts in WEIRD and non-WEIRD cultures (Enfield, Stivers & Levinson, 2010). Questions contain specific lexical, morphological, syntactical and prosodic features (Couper-Kuhlen, 2012) that vary depending on the particularities of language families investigated (Enfield et al. 2010), allowing their (almost) effortless identification in face-to-face conversations. Questions have specific social functions (Enfield et al. 2010), including requests for information (Drew & Couper-Kuhlen, 2014) and confirmation (Hayano, 2014), seek for help (Erkelens, et al. 2020) and agreement (Heritage & Raymond, 2005), perform assessments (Lindström & Mondada, 2009), make suggestions, proposals and offers to another (Stevanovic, 2012) and other-initiated conversational repairs (Schegloff, 2000). They also trigger the formation of interactional sequences, the goal of which is the achievement of interactional goals.

Questions embedded in embodied collaborative work rely on the coordination of bodily resources such as manual gestures, gaze, posture, and facial expressions to achieve shared goals. The joint accomplishment of shared goals goes beyond the coordination of verbal and non-verbal behaviors in synchronized fashion over time. Task-oriented collaboration involves taking the intentions, plans and goals of others into account (Knoblich, Butterfill, & Sebanz, 2011). Collaboration influences the action and planning of interacting partners and shapes interactive outcomes, such as when partner A asks “What should we do

with this (while pointing to a bag of flour)?” B replies: “we must put half of that in this bowl (while touching the bowl)”, and A acknowledges B: “Alright, I see it now”. This short question-answer sequence illustrates how each interacting partner’s intentions, plans and goals come into play in embodied collaborative work.

This study has two goals: 1) to identify the social functions of questions in embodied collaborative work; and 2) to determine whether such functions correlate with performance outcomes. To do so, we conducted qualitative and quantitative analyses of a dataset of 1751 question-answer sequences collected from an experimental study where pairs of participants completed a collaborative food preparation task. To our knowledge, no previous research has been carried out to date on the social functions of questions and how these affect performance outcomes in embodied collaborative work. First, we review the literature focused on the investigation of the social functions of questions in interactive and conversational contexts. Second, we describe the experimental task where the 1751 question-response sequences analyzed here were collected. Third, we present a detailed description of the methodological aspect of the study. We then identify the main types of questions observed in the question-responses sequences and show their distribution in the dataset. Fifth, we present illustrative examples of each of the type questions identified, including multimodal analyses of each question-response sequence. We then perform a Principal Component Analysis (PCA) on the kinds of questions in relation to performance outcomes. This exploratory statistical technique enabled us to discover the relative weight of each question type in high performing groups.

Background

Questions are recipient-designed and oriented towards interacting partners, i.e. the speaker who poses the question assumes that the recipient possesses the information requested. The study of adjacency pairs (e.g. Sacks & Schegloff, 1973; Sacks, Schegloff & Jefferson, 1974;

Schegloff, 2007) has enabled the systematic investigation of the social functions question-response sequences in conversations. Adjacency pairs are units of conversation composed of two turns or pair types (in the present case: Question => Answer); each pair type has to come from a different speaker (A and B), be placed adjacently (1. A: Question => 2. B: Answer) unless separated by an insertion sequence (1. A: Question => (2. B: Request for clarification => 3. A: Answer [turns 2B and 3A is the insertion sequence]) => 4. B: Answer) and the second pair type is identified as functionally related and relevant (Hutchby & Wooffitt, 2008) to the first pair type (e.g. A: “Where did we buy these glasses?” B: “At the flea market”). Questions (first pair type) impose special constraints on answers (second pair part). In engaging in such sequences, interacting partners impose constraints on one another, and hold each another accountable, to produce coherent and intelligible courses of action in relation to relevant actions and events. Adjacency pairs structuring question-response sequences may have multiple second pair parts, therefore preference is given to the most relevant answer (Pomerantz, 1984) which is then followed either by an acknowledgement from the partner who has initiated the sequence and/or a change in the topic of conversation.

Researchers have investigated the social functions of questions in everyday conversations (Bietti, 2010, 2013; Fox & Thompson, 2010; Goodwin & Cekaite, 2013; Tannen, Kendall & Cynthia Gordon, 2007; Rossano, 2010), children peer-to-peer conversations (Stivers, Sidnell, & Bergen, 2018), clinical populations (Anglade, Le Dorze, & Croteau, 2021; Antaki, 2013; Goodwin, 1995; Laakso, 2015), medical consultations (Heath, 1986; Heritage & Robinson, 2006; Mayor & Bietti, 2017; Murtagh, Furber, Thomas, 2013) police interrogations (Stokoe & Edwards, 2008; Van Charldorp, 2014), job interviews (Bangerter, Corvalan, & Cavin, 2014; Brosy, Bangerter & Mayor, 2016), classroom interactions (Drew & Piera, 2014; Hosoda, 2016; Ishino, 2017), service encounters (Fox, 2015; Lindström, Norrby, Wide & Nilsson, 2019; Mondada & Sorjonen, 2016), helpline

services (Butler, Potter, Danby, Emmison, & Hepburn, 2010), guided tours (Mondada, 2017), team meetings at the workplace (Svennevig, 2012), and political (Gialabouki & Pavlidou, 2019) and immigration (Channon, Foulkes, & Walker, 2018) interviews. Several of these studies adopted a multimodal perspective to the analysis of question-response sequences (e.g. Stivers & Rossano, 2010).

The study of the social functions have also been studied in embodied collaborative work involving the manipulation of physical and digital objects in a variety of contexts, including operating theaters (Bezemer, Korkiakangas, Weldon, Kress, & Kneebone, 2015; Hindmarsh & Pilnick, 2007), design (Bietti, Baker, & Detienne, 2016; Bietti & Baker, 2018a), and architectural (Bietti & Baker, 2018b; Murphy, 2004) studios, and radio stations (Risberg & Lymer, 2020). These studies have shown the multiple ways in which questions redirect team members' attention to objects and actions. For example, Bietti and Baker showed that questions acting reminders redirected professional designers' attention to objects (e.g. computer screens) and actions (e.g. product delivery to client) in the design studio. Bietti and Baker found that questions acting as reminders scaffolded future planning and collaborative decision-making among professional at the design studio. Research on the social functions of questions at the workplace has been conducted exclusively in real-world situations, and therefore, characterized by high ecological validity. To our knowledge, no research has been carried out to date on the social functions of questions in embodied collaborative work in experimental settings. This is essential if we are interested in gaining better understanding of the multiple ways in which different types of questions affect performance in small groups.

The Current Study

In this study we identify the social functions of questions in embodied collaborative work and analyze whether these functions correlate with performance outcomes. To do so, we

examined 1751 question-response sequences in dataset taken from an experimental study on the cultural transmission of cooking skills (Bietti, Bangerter & Mayor, 2017; Bietti, Bangerter, Knutsen & Mayor, 2019). Under two conditions (interactive vs. non-interactive), pairs of participants taught how to make ravioli to new pairs after completing the task themselves. While in the interactive condition, the transmission cooking skills occurred in face-to-face conversations, in the non-interactive conditions, pairs video-recorded their instructions for the new pairs.

The aim of this study was to determine the social functions of questions in embodied collaborative work involving the manipulation of physical objects. Thus, the 1751 question-response sequences were collected from the performance sessions only, that is, when pairs worked as teams in the process of ravioli-making, not when they transmitted their previous experience to the new pair.

Food preparation is a social activity taught and learned across cultures and societies that currently attracts a lot of media attention. This is reflected in the increasing number of cookbooks that are sold annually, TV shows, online courses and tutorials available on the subject. Food preparation is a meaningful real-world task with well-documented evolutionary benefits. It enhances survival and nutritional fitness by reducing harmful bacteria and increasing the digestibility of food (Aiello & Wheeler, 1995; Carmody & Wrangham, 2009). It can boost creativity (McCabe & de Waal Malefyt, 2015), and have a positive impact on people's self-esteem (Farmer, Touchton-Leonard K & Ross, 2018). When food preparation occurs collaboratively it strengthens social bonds by reinforcing family relationships, initiating, and underpinning friendship (Wrangham, Jones, Laden, Pilbeam & Conklin-Brittain, 1999). Longitudinal studies have shown that individuals who were able to develop sufficient cooking and food preparation skills by emerging adulthood tend to be healthier and have better nutrition (Utter, Larson, Laska, Winkler M, & Neumark-Sztainer, 2018). The only

constraint that the collaborative ravioli-making task was time duration (see description of Task below). Hence, group members could freely interact while making the ravioli, as it would occur in a comparable real-world situation.

Method

Participants

134 participants (67 pairs; 76 men) were recruited from the student population of the University of Neuchâtel (Age $M = 23.2$; $SD = 4.04$). They were fluent speakers of French and reported having limited previous cooking experience. They had previous practice of simple skills like combining and heating ingredients but had not mastered more complex skills (e.g., preparing a pie from scratch). Participants received 25 CHF compensation each for half an hour of their time along with an incentive of 0.25 CHF per pair for each produced ravioli of good quality (Fig 1).

Task

The task consisted of two kinds of sessions, performance sessions and transmission sessions. The question-response sequences analyzed here were collected from performance sessions only where participants prepared ravioli together in pairs. Their goal was to produce as many good quality ravioli as possible in 10 minutes. Each pair had at their disposal a ball of 150 grams of dough; 200 grams of filling made of ricotta cheese and concentrated tomato paste (for easy detection of leaks and imperfections when evaluating ravioli quality); a 24-hole ravioli mold with zigzag sealing for easy release; a pasta maker; a rolling pin; a cutting board; 2 pizza cutters; 2 knives; 4 teaspoons; 2 kitchen cloths and kitchen paper; 250 grams of flour; and a stopwatch. The collaborative food preparation task had ten consecutive phases: 1) divide the dough in two; 2) add flour to the dough; 3) use rolling pin to flatten the dough; 4)

use pasta maker to flatten the dough; 5) cut dough in half; 6) put the first layer of dough over the mold; 7) add filling; 8) cover with second layer of dough; 9) flip over the mold; and 10) cut ravioli. Immediately after the time was up, the ravioli were assessed by the experimenter.

Performance

Performance was measured as the quantity of good ravioli each pair produced. The criteria that experimenters applied to consider ravioli as “up to a satisfactory standard” were that they should contain filling and they were perfectly sealed. We chose the filling to be red so any leaks in the ravioli would be immediately visible to experimenters (Fig 1). Experimenters used their fingers to gently press each of them to confirm that ravioli did not contain any leaks when this was not evident at first sight. Ravioli with leaks were considered as low-quality ravioli and discarded. The rationale for having adopted these criteria was twofold: (i) ravioli should be perfectly sealed so that they kept their shape and filling during boiling; and (ii) adding no filling would have made the ravioli easier to manipulate and would have enabled pairs to save time during the adding filling stage of the task. In practice, it was easy to make the distinction between good and bad-quality ravioli.

[Fig.1. Examples of low quality (left) vs. high quality (right) ravioli. Only the number of high-quality ravioli was counted to measure performance in the collaborative task. Tomato concentrate paste was used to facilitate the detection of leaks in the dough.]

Coding

The identification of questions followed the coding scheme for question-response sequences in conversation developed by Stivers and Enfield (2010). Their coding scheme is empirically grounded in a comparative project on question-response sequences in ordinary conversation in 10 languages. Stivers and Enfield propose a basic differentiation between Content (Q-word) Questions (e.g., What did you eat for breakfast?), Polar Questions (e.g., Did you go to the movies yesterday?), and Alternative Questions (e.g., Are we going for a walk or do you prefer to stay at home?). Such initial differentiation responds to lexical, morphological, syntactical and prosodic features. The coding-scheme considers the social functions of questions as well; from information and confirmation requests, assessments and suggestions to other initiation of repairs (e.g. What?) and rhetorical questions. It also accounts for the question-response sequences in which the answer corresponds to a visible action (e.g. head shakes, nods, shrugs, pointing gestures, eyebrow flash, etc.) which is regarded as relevant response. This is essential feature for the throughout coding of question-response sequences in embodied collaborative work.

The data we collected was in French. In French, content (Q-word) questions include interrogative pronouns such as: *qui/who*; *que/what*; *lequel/which*; *où/where*; *quand/when*; *combien/how much*. They can be followed by noun phrases, which form a syntactic constituent. Polar questions can be accompanied by a finite verb, a negative adverb, adverb of frequency, a clitic, or a subject. In alternative questions each of the alternatives in the question is stressed. Any positive polar question can be turned into an alternative question by adding *ou/or* and the interrogative final particle *hein/not*. Declarative syntax ending with an interrogative intonation is the more frequent way in which questions are composed in French (Mondada, 2017).

Categorization

We used thematic analysis (Braun & Clarke, 2006) for the categorization of the social functions of questions in the dataset. This was a deductive and inductive process. We started the categorization procedure following well-established social functions of questions (e.g. request for information; request for confirmation; seek for help) reported in the literature. Data was transcribed in InqScribe™ for later synchronization with multimodal annotations in ChronoViz (Fouse, Weibel, Hutchins & Hollan, 2011). Transcriptions followed standard conventions in conversation analysis (Jefferson, 2004; Mondada, 2018). The synchronization of transcripts with multimodal annotations facilitated the familiarization with the data. This was essential for the generation of our initial codes, which mainly described what participants were doing while making questions. We grouped together codes into more general themes and reviewed them for coherence and consistency. Themes corresponded to the social functions of questions. This was an iterative procedure that enabled us to identify such functions in a systematic fashion.

Type of Questions in Relation to Performance

No previous study has investigated how different types of questions affect group performance in embodied collaborative work tasks. Thus, we conducted an exploratory quantitative analysis to investigate the specific features of questions in relation to group performance. We used Principal component analysis (PCA) for such purpose. PCA was useful to reduce complexity of the data set minimizing information loss (Jolliffe & Cadima, 2016). PCA was an adequate technique because it enabled the identification of associations between previously identified types of questions through thematic analysis and performance outcomes.

Results

The familiarization with the data and the initial coding resulted in the differentiation between questions related to the collaborative task and questions that were not. We found that 84% (n=1521) of the 1751 question-response sequences initially identified were task related. New rounds of coding and revision of codes led to the categorization of the questions opening the 1521 question-response sequences into three clearly distinguishable themes. Themes corresponded to the social functions of questions in the collaborative food preparation task, and these were: 1) anticipation questions; 2) exploration questions and 3) confirmation questions. Anticipation questions were requests for information about embodied actions that participants should perform in the next phases of the collaborative task while completing the present phase. Exploration questions were requests for information about embodied actions that the participant posing the question should execute to successfully progress in the ongoing phase of the task. Confirmation questions were requests for confirmation about embodied actions that were just performed or about to be performed in the ongoing phase of the task. Anticipation questions corresponded for the 26% (n=394), exploration questions for the 41% (n=618) and confirmation questions for the 32% (n=491) of all the task-related questions that initiated the 1521 question-response sequences that we analyzed. Twenty percent of the 1521 question-response sequences (n=304) were double-coded. Inter-rater agreement for the three types of questions was very good ($\kappa \geq .79$). Disagreements across coders were resolved through discussion.

Here, we present an example and description of each type of question-response sequence taken from the dataset to illustrate how they operated in practice.

Anticipation Questions

Example 1 shows the coordination of an anticipation question with embodied actions and transition phases in the collaborative task (see Methods for description of task phases).

1. P1: **Tu t'occupes de mettre la fa:rce? (.2) Y ont mis [un tou:t p'tit peu et pis**
Do you take care of the filling? They put a little bit and then
**presses the dough with two palms* Fig.2a*
2. P2: **[Là je comme:nce =**
I'm starting
3. P1: **= Moi (.2) du coup hum >je commence à r'faire un autre bout<**
So, I'm starting to do another part
pushes ravioli mold towards P2..... Fig.2b
changes gaze direction towards half ball of dough Fig.2c

[Fig 2. Example of anticipation question and coordination of embodied actions.]

P1 made a polar question (1) acting as anticipation question. This is the first element of the adjacency pair. He made it while pressing the first layer of the already flattened dough against the ravioli mold with his hand palms (Fig. 2 a). P2's response (2), accepting P1's request was the second element of the adjacency pair. Almost immediately P1 told P2 what he planned to do afterwards (3), in the next phase of the collaborative task. He did it while placing the ravioli mold closer to P2 (Fig. 2b). The goal of P1's embodied action was to place the ravioli mold in P1's visual attention field. P1's placing-for action (Clark, 2003) and change in gaze directions towards the half ball of dough (Fig. 2c) closed the question-response sequence initiated by the anticipation question (1). P1's change in gaze direction predicted what he planned to do next: to flatten the second layer of dough to cover the first layer, to which P2 was about to add the filling.

Exploration Questions

Example 2 presents an occurrence of an exploration question that one participant posed while performing an embodied exploration of the pasta maker. Dyads were instructed to carefully pass the dough through the pasta maker, which had two rollers that could be adjusted using the knob on the side. This allowed making the dough gradually thinner. Each time before passing the dough through the pasta maker, dyads had to turn the knob in order switch levels (6 levels, see Fig. 3c).

1. P3: Du coup après alors (.4) ils expliquent qu'il faut mettre sur 1 =
So then, they explain that you have to put it on 1
**changes gaze direction towards pasta maker* Fig.3a*
2. P4: = Oua:is
Yeah
3. P3: Alo:rs (5.2) comment on tourne ce tru:c? (1.4) a:: [comme ça] (.) sur 1 ok
So, how do we spin this thing? Ah like that, on 1, ok
leans forward.....
**tries to turn the knob.....* Fig.3b*
learns how to turn it
4. P4: [°Ok°]

[Fig. 3. Example of exploration questions while learning how to use tools.]

P3 changed gaze direction towards the pasta maker while making explicit what they should do in the next phase of the task (1). P3's change in gaze direction towards the pasta maker directed P4's attention towards the same object (Fig. 3a). P3's directing-to action (Clark, 2003) created a shared focus of visual attention and grounded mutual knowledge about the next phase of the task (Clark & Schaefer, 1989; Clark & Brennan, 1991). P4 agreed with P3's (2) and then P3 leaned forward to adjust the rollers of the pasta maker using the knob on the side (Fig. 3c). She spent more than five seconds trying to figure out how the knob worked (3). The problem was that the knob had to be slightly pulled out, otherwise, it

did not turn. P3's posed the content (Q-word) question because of having failed to learn how the knob worked (Fig. 3b). However, the eureka moment came after a short silence: trial and error enabled her to learn how to turn the knob. P4 acknowledged P3's solving the problem (4). Such acknowledgement overlapped with P3's embodied demonstration and response to her own exploration question (3).

Confirmation Questions

Example 3 illustrates a question-response sequence about joint decision-making that was initiated by a confirmation question. The sequence shows participants deciding where they should trim the excess dough so it could successfully cover the entire surface of the ravioli mold.

1. P5: Je coupe là?

Shall I cut there?

**is about to cut the dough* Fig.4a*

2. P6: °Eu:h ouais°=

Uh yeah

3. P5: = On est d'acco:rd? (.4)

Do we agree?

**lifts head and looks at P6* Fig.4b*

4. P6: Ouais (.2) >sinon on refera après<

Yeah, otherwise we will do it again after

nods

**P5 cuts dough.....* Fig.4c*

[Fig. 4. Example of confirmation question in joint decision-making.]

P5's polar question (1) acted as request for confirmation that opened the question-response sequence. P6 confirmed P5's decision to trim the excess dough where she had

previously planned. However, he did it quietly using reduced speech volume (2) which did not seem to be very convincing for P5. As a result, P5 made a second confirmation question (3) as she had to be completely sure about how much excess dough she had to trim off. Having removed too much dough may have resulted in a shorter layer of dough that did not cover the complete surface of the mold. After a short silence, she lifted her head and looked at P6 (Fig. 4b). P5's change in head position and gaze direction reinforced the accountability of P6 as he responded to her confirmation question (Bavelas, Coates & Johnson, 2002; Goodwin, 1994; Stivers & Rossano, 2010). P5 trimmed off the excess dough immediately after receiving P6's affirmative response (4). She was already removing the excess dough when P6 added that they could do it again later (Fig. 4c).

Principal Component Analysis

Principal component analysis (PCA) was performed to determine whether confirmation, exploration and anticipation questions correlated with performance outcomes. In the PCA we also included whether questions were task-related or not. PCA was computed using packages ggplot2, FactoMineR, factoextra, Factoshiny, and corrplot in the R statistical software. The first two dimensions accounted for 58.7% and 17.2% of the variance respectively (Fig.5), which allowed us to base our analyses on these dimensions only. The variables related to the interaction between group members formed the first dimension relevantQ (27.66%), nonrelevantQ (20.67%), confirmationQ (20.88%), explorationQ (17.49%) and anticipationQ (13.05%); whereas performance was the main variable that formed the second dimension (94.67%). This shows that the types of questions as well as whether they were relevant or non-relevant for the task were closely associated with each other (Fig.6). However, the results indicate that there was no link between such variables and performance, that is, the types of questions and their relevance for the task were variables that could not explain increased or

decreased performance in the groups. Thus, associations between confirmation, exploration and anticipation questions and performance were discarded in further analyses.

[Fig. 5. Exemplified variance by dimension in PCA]

[Fig. 6. Contribution of variables to dimensions 1 and 2 in PCA]

Then, we investigated the position of groups in the two dimensions according to the values of each variable. Each group (hence after individuals in PCA) occupies a location in the diagram (Fig. 7), allowing the association of anticipation, exploration and confirmation questions and their relevance for the task with low and high performing groups.

[Fig. 7. Positions of groups and performance outcomes in dimensions 1 and 2 in PCA.]

There were groups who contributed more than others in each of two dimensions. The five groups that contributed most to dimension 1 were group 65 (13.64 [0.16]), 33 (7.72 [0.09]), 32 (7.30 [1.66]), 31 (6.24 [1.10]), 54 (5.07 [0.04]). Their contribution to dimension 2 appears between brackets. In contrast, the five groups that contributed the most to dimension 2 were group 20 (6.36 [1.54]), 5 (6.13 [0.06]), 8 (4.11 [0.46]), 13 (3.47 [0.22]), 25 (2.99 [0.76]). Their contribution to dimension 1 appears between brackets.

PCA also determined the types of questions that contributed more to dimension 2 (performance). We established the relative weight of each type of question for the groups that influenced performance the most (Table 1).

Gr.	Perf.	Relevant%	non.R%	Conf.%	Explo.%	Anticip%	Total%
20	33	44.29	11.43	17.14	15.71	11.43	100
5	32	42.86	16.67	14.29	14.29	11.89	100
8	28	41.18	17.65	11.76	11.76	17.65	100
13	31	48.84	2.33	11.62	30.23	6.98	100
25	30	50.00	0.00	11.11	27.78	11.11	100
22	27	46.34	9.76	12.19	19.51	12.20	100
17	0	50.00	0.00	14.29	21.42	14.29	100
14	0	45.00	10.00	25.00	16.67	3.33	100
18	1	50.00	0.00	14.29	25.00	10.71	100
28	1	47.54	4.93	14.75	18.03	14.75	100

[Table 1. Relative weight of each type of question in the groups that most influenced dimension 2 (performance).]

We observed that the top three groups that contributed more to dimension 2 showed similar distribution of questions: group 20, relevantQ (44.29%), nonrelevantQ (11.43%), confirmationQ (17.14%), explorationQ (15.17%) and anticipationQ (11.14%); group 5, relevantQ (42.86%), nonrelevantQ (16.67%), confirmationQ (14.29%), explorationQ (14.29%) and anticipationQ (11.89%); and group 8, relevantQ (41.18%), nonrelevantQ (17.65%), confirmationQ (11.76%), explorationQ (11.76%) and anticipationQ (17.65%). As a result, these three groups presented five clear patterns regarding the distribution of questions: 1) 41-45% of relevant questions; 2) 11-17% of non-relevant questions; 3) 11-17% of confirmation questions; 4) 11-15% of exploration questions; and 5) 11-17% of anticipation questions.

Discussion

We investigated the social functions of content (Q-word) questions, polar questions, and alternative questions in a dataset of 1751 question-response sequences collected in an experimental study in which 67 pairs of participants completed an embodied collaborative task in the laboratory. This gave us the possibility to measure performance outcomes, which was provided by the number of good quality ravioli produced by each pair. We did it using a collaborative food preparation task. Food preparation is an everyday activity that is taught and learned across cultures and transmitted over generations in families and group. The kind of task chosen aimed at increasing the ecological validity of the experimental design. No previous observational or experimental study has examined the social functions of questions in embodied collaborative work in which the manipulation of physical objects played a central role and performance outcomes could be measured.

We made a distinction between task-related and non-task related questions (e.g. What do you study?) and observed that a significant proportion of questions were task-related. Then, we identified the social functions of task-related questions using thematic analysis (Braun & Clarke, 2006) and discovered that they had three main functions, i.e. anticipation, exploration, and confirmation. These are related to the social functions of questions that have been already documented in previous observational studies (Drew & Couper-Kuhlen, 2014; Erkelens, et al. 2020; Hayano, 2014; Heritage & Raymond, 2005; Lindström & Mondada, 2009; Stevanovic , 2012).

The three illustrative examples we presented showed the multiple ways in which the three types of questions were linked to the accomplishment of interactional goals: i) planification of future collaborative activities (example 1); ii) learning how an essential tool for the successful completion of the collaborative task works (example 2); and ii) decision-making about an embodied action that would negatively affect group performance if it were

done incorrectly. Interestingly, such goals referred to complementary temporalities in the activity. While example 1 (Fig. 2) referred to a future phase of the task (e.g. add filling to the dough), example 2 and 3 were related to the ongoing phase. Example 2 (Fig. 3) was linked to an action (e.g. turn the knob) that dyads must perform to progress in the task (e.g. to flatten the dough in the past maker). Example 3 (Fig. 4) was associated with an action, that if done inaccurately, would increase the risk of having a poor task performance (i.e. reduce the number of good quality ravioli produced). Questions presented in examples like 2 and 3 were coded differently because they reflected distinct levels of participants' certainty. In cases like example 2, participants used trial-and-error methods to solve task-related problems. Such methods were not successful at first, therefore, participants decided to seek for help from their partner by making exploration questions. On the contrary, in cases like example 3, participants requesting confirmation from partners knew what the preferred course of action was. They suddenly decided to interrupt what they were doing to invite their partners to participate in the decision-making process. Thus, exploration questions presented a lower degree of participants' certainty than confirmation questions. These results go beyond the findings reported in previous observational studies on the social functions of questions in multimodal interactions.

The experimental task enabled us to measure performance outcomes. Anticipation questions were used to plan future phases of the collaborative task while still working the current phase. On the contrary, exploration and confirmation questions often led to an interruption of the collaborative activities taking place within the task phase. However, the exploratory nature of the study did not allow us to define a priori hypotheses to test. For example, to have tested whether anticipation questions predicted higher performance in the number of good quality ravioli produced in comparison to exploration and confirmation questions would not have been appropriate considering that we did not have a condition for

each type of question to calculate how each affected performance individually. We used PCA to perform an exploratory quantitative analysis of how different questions affected group performance. Results showed that there was no correlation between the types of questions and performance. We then did additional analyses focused on the relative weight of each question type for performance. We found that the three groups that contributed most to performance in the PCA presented a similar distribution of anticipation, exploration and confirmation questions. Interestingly, they also showed similar distributions for task-related and non-task related questions. Such patterns revealed that exploration and confirmation questions played an important role in performance, even when they may have led to interruptions in the collaborative activities of the task phases. PCA indicated that non-task related questions presented similar relative weight of anticipation, exploration and confirmation questions. This revealed that showing interested in partners' life stories (who they were, where they came from, what they studied, whether they had children, etc.) positively affected group performance.

Qualitative and quantitative analyses enabled us to i) identify the social functions of questions in embodied collaborative work; and ii) determine the extent to which each question type contributed to group performance. Our results perfectly complement findings reported in ethnographic observations obtained through the careful analysis of video-recorded data in naturally occurring interactions. Future experimental studies will enable researchers to make predictions about what types of questions may lead to an increase in collaborative work performance. This is important if we want to propose interventions to augment work productivity in collaborative work that involves the manipulation of physical and digital objects.

Data Availability

The data and code that support the findings of this study are openly available at:

<https://osf.io/5wdgt/>

Competing interests

The authors have declared that no competing interests exist.

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