

# LET ME FINISH MY THOUGHT: PROCESS INTERVENTIONS TO CHANGE TEAM BEHAVIOR DURING REMOTE DESIGN COLLABORATION

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## ABSTRACT

This research investigates changes in team behavior and communication through interruptions and gestures, due to design process strategies in pre-formed remote teams for conceptual design tasks. Understanding creative remote team behavior is important due to the increase of remote communication in knowledge work. Teams were given a creative or analytical condition intervention to facilitate their conceptual design team process. The research contributes to the human-computing interaction literature by characterizing changes in distributed team behavior due to process method interventions. The creative condition exhibited a decrease in interruptions. The analytical condition exhibited a decrease in gestures and an increase in problem characterization at the cost of ideation discussion. Remote team members can better gauge which meetings or work tasks are best to be done in person or remotely by gauging not just the task but also the team behavior.

**Keywords:** Gesture, Communication, Remote Collaboration, Conceptual design, Design cognition

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## 1 INTRODUCTION

The increase of remote team collaboration impacts team behavior and performance. Previous studies of design teams have looked at in person in situ team interactions [Tang \(1989\)](#), distributed team interactions through interviews and surveys [Yang and Jin \(2008\)](#); [Hinds and Bailey \(2003\)](#), or distributed team interactions with hardware tools to facilitate collaboration [Sirkin \(2011\)](#); [Eris et al. \(2014\)](#). There is a gap for research on the impacts of process method interventions on in situ team behavior and creativity in remote design task (RDT) collaboration during remote team meetings. This research contributes to our understanding of how distributed design teams using design process method tools behave and communicate synchronously during conceptual RDTs through nonverbal gestures and verbal interruptions. Such research becomes increasingly important as remote collaboration becomes ubiquitous due to the demand for the flexibility for hybrid or remote work. Research is required to understand the impact on remote settings on team member behaviors in relation to creativity. Particularly, in situ studies will allow understanding moments-to-moments team interactions within remote settings. [Whillans et al. \(2021\)](#) conducted interviews with knowledge workers to study how the workplace changed in response to lockdown policies. Similar to the distributed team conflict model reported by [Hinds et al. \(2003\)](#), respondents reported through interviews differences between online team task, process, and relationship activities. Process interaction is time spent by teams to define and structure their work. Content interaction is time spent on activities that involved giving and receiving feedback and inquiring into and executing the core tasks [Whillans et al. \(2021\)](#); [Hinds and Bailey \(2003\)](#). Distributed teams experienced frustration when meetings focused on content interactions instead focused on process interactions. Task conflict can be good for teams, but process conflict is generally detrimental for teams [Hinds and Bailey \(2003\)](#). Team members can become frustrated when in-person or remote content/task-oriented meetings are diverted towards process focused topics. Remote workers reported the use of ‘huddle’ or informal interactions during in-person work settings to clarify process methods. Informal check-ins are reduced in remote work and so are subsequent informal opportunities to clarify or address potential process conflict. Without opportunities to clarify working processes, individual team members can inadvertently and efficiently complete the wrong tasks [Whillans et al. \(2021\)](#); [Robey et al. \(2000\)](#). By introducing a shared process, teams can reduce process conflict and improve team performance which we can observe and measure through changes in team behavior [Hinds and Bailey \(2003\)](#); [Tang \(1989\)](#). The objective of this study is to investigate investigate remote team behavior through an in situ control study with conceptual RDTs to understand how a creative or analytic methodological intervention impacts distributed design team behavior in terms of meeting focus, interruptions, and gestures. Our goal is to understand the impact of process methods in remote meetings on team behavior to improve both collaboration and communication. Our research questions are: How does remote design team behavior change with process intervention, in particular, their gestural and interruption behavior, during remote conceptual design collaboration tasks? Our goal is to understand how remote design teams can facilitate collaboration for hybrid and remote design work through process interventions by measuring team interactions, through interruption and gestures.

## 2 RELATED WORK

### 2.1 In person in situ design team studies

Past studies on design teams have shown that creative design teams utilize their shared workspace to engage in several non-verbal communication techniques such as listing, drawing/sketching, and gesturing [Tang \(1989\)](#); [Donovan et al. \(2011\)](#); [Tversky \(2019\)](#). These idea expression techniques are relevant for design teams to store information, express ideas, or mediate interaction. However, the shift from physical shared workspaces to digital shared workspaces also brings new challenges to team interactions.

How teams communicate and listen to each other during in-person meetings is different from that of distributed meetings [Sirkin \(2011\)](#); [Robey et al. \(2000\)](#); [Inkpen et al. \(2010\)](#). Humans are able to spatially distinguish ancillary side conversations during in person meetings through binaural unmasking [Schnupp and Carr \(2009\)](#); [Inkpen et al. \(2010\)](#); [Joris and van der Heijden \(2019\)](#). Interruptions can be disruptive in conversations and negatively impact team communication [Speier et al. \(1999\)](#). [Lande and Leifer \(2010\)](#) longitudinally studied student engineering design teams performance and found that

teams that evolved their projects through the design and engineering thinking phases the most tended to perform better. Understanding changes in design phases is relevant to characterize how teams problem frame and ideate. Creative design teams shifted more frequently between design phases tended to explore more ideas and reduced the risk of idea fixation.

## 2.2 Retrospective distributed team studies

Previous studies in distributed team work focus on the corporate context with varying team distribution architectures such as one-to-one, one-to-many, team-to-team, and/or hub-and-satellite [Sirkin \(2011\)](#); [Robey et al. \(2000\)](#); [Venolia et al. \(2010\)](#). Current research examining distributed team collaboration in remote settings frequently use interview or observational methods. The emergent themes that these studies report are essential to understanding how teams interact through conflict, goal orientation, and strategic use of time [Whillans et al. \(2021\)](#); [Yang and Jin \(2008\)](#); [Robey et al. \(2000\)](#). In-person and remote team work with 3 or 4 team members, follow different social rules of interactions as communication with several different parties can bring both diversity in ideas expressed and interpreted or mis-interpreted [Hinds and Bailey \(2003\)](#); [Horvat et al. \(2021\)](#). [Pacheco et al. \(2022\)](#) studied student design teams and found that students felt that their prototyping integration efforts were hindered due to communication limitations. [Farshad and Fortin \(2021\)](#) studied the cognition of a distributed engineering design team and report that the team adjusted their communication to be more explicit in day-to-day and digital documentation sharing. However, retrospective interviews or observational findings are unable to prescribe direct means for team performance improvement since participants are self-reflective on their team interactions and there is no comparison for control.

## 2.3 Distributed in situ team studies

Studies that focus on collaborative tool use of design students are often more appropriate for corporate environment settings where there can be collaboration tools such as robotic arms or tools for extending gesture [Sirkin \(2011\)](#), specialized communication systems [Inkpen et al. \(2010\)](#); [Yankelovich et al. \(2007\)](#), or collaboration sketching board systems [Tang \(1989\)](#); [Eris et al. \(2014\)](#); [Junuzovic et al. \(2012\)](#). Such devices are best used in a shared corporate context due to the cost for such devices. Collaboration tools that are bulky or expensive are less accessible for individual households.

This leaves a gap in the research to study the impact of design process methods in situ remote design teams. Design process method tools such as Brainstorming or 5-Why Analysis that facilitate in-person team performance can be taught and distributed at low cost to distributed teams to improve creative and problem framing team performance [Sutton and Hargadon \(1996\)](#); [Osborn \(1953\)](#); [Liker \(1997\)](#); [Ohno and Bodek \(2019\)](#). The remote team in situ conceptual design study presented here studies the influence of process methods interventions on team gesture, interruption, and performance.

## 2.4 Process intervention

Sufficient problem framing, ideation, and consideration of alternatives is important for teams to effectively and efficiently solve problems to avoid over-investing into less fruitful strategies. Process Tools such as Brainstorming or 5-Whys have been developed to facilitate conceptual design teamwork. This in situ control study introduces a process intervention in order to study changes in team behavior in remote tasks. By providing a shared process model, teams can reduce process ambiguity and conflict for how to execute a shared strategic process for completing a creative remote design task and can reduce process conflict where teams can then focus on task (or content) discussion instead. In practice, experienced design teams will utilize the divergent-facilitating Brainstorming and analysis-facilitating 5-Whys process method tools.

### 2.4.1 Creative condition

Brainstorming is a technique used in design teams to routinely, creatively produce new innovative designs. Brainstorming includes several guidelines to facilitate team interaction such as “Build on the Ideas of Others,” “Suspend Judgment,” or “One Conversation at a Time”. Brainstorming promotes collaborative team performance to enhance individual ideation contributions to teams by promoting the generation of novel or creative ideas [Osborn \(1953\)](#). Brainstorming primes teams to engage in a

divergent design process method tool which is associated with improved team performance [Sutton and Hargadon \(1996\)](#)

#### **2.4.2 Analytical condition**

The 5 Why Method facilitates teams to analyze the root cause of a problem for a deeper understanding that could inspire insightful problem framing and ideation that addresses root problems as supposed to symptomatic or superficial problems. Each potential cause of a problem can be linked to a preceding cause by having a team ask “Why?” Such problem analysis methods can help break down complex problems into more tractable problems. By analyzing a problem space to its root cause, can help teams identify a high impact problem to design a solution for that can effectively address ancillary sub-problems in an elegant manner [Ohno and Bodek \(2019\)](#); [Liker \(1997\)](#).

### **2.5 Team behavior**

#### **2.5.1 Interruptions**

Interruptions in video conferences are more spatially difficult to differentiate than interruptions during in person meetings and can be disruptive as a consequence. In-person team interactions enable individuals to filter and distinguish the location of speakers through binaural hearing where listeners are able to distinguish sound signals between both ears [Schnupp and Carr \(2009\)](#); [Inkpen et al. \(2010\)](#). The ability to focus one’s listening in the presence of several speaking parties is colloquially known as the ‘cocktail party effect’. Interruptions in video conferences overlay the voice signals of the speakers’ microphones and come out of the same speaker system that are difficult for listening parties to distinguish. Poor audio fidelity is psychologically unfamiliar and has impacts to attention to the media channel and memory from the audio information. Breakdowns in audio away from naturalistic characteristics, such as spatial quality, can result in listener frustration [Reeves and Voelker \(1993\)](#).

Interruptions in the work place can be disruptive (41%) resulting in the discontinuation of the interrupted task [O’Conaill and Frohlich \(1995\)](#). A nascent idea cut short and forgotten due to an interruption limits the breadth of alternatives explored. In our study, we measure the occurrence of interruptions in relation to process method interventions during RDTs to understand synchronous remote team communication.

#### **2.5.2 Gestures**

Gestures have been studied as an essential means for teams to communicate during the conceptual design process [Tang \(1989\)](#); [Tversky \(2019\)](#). Psychologists report that gestures help us think and preventing organic gestures can disrupt thinking and help communicate motor knowledge. [Aigner et al. \(2012\)](#) studied mid-air hand gestures for human-computer interaction where they found a prevalence in iconic gesturing and deictic gesturing. Deictic gestures (pointing) serve several roles during in person design activities such as helping support communication to check for shared understanding and team members fix attention. [Donovan et al. \(2011\)](#) found that design teams use deictic gestures to check or repair team understanding by calling attention to shared objects. However, since deictic gestures are often directed towards shared media in the physical space, we suspect that the frequency of deictic gestures will decrease during remote design collaboration tasks.

Iconic gestures depict and are used to create novel communication expressions in the absence of verbal descriptive vocabulary that express properties of objects or actions [Tversky \(2019\)](#). Gestures are natural actions that can be used to communicate ideas before the verbal vocabulary can exist for expression. Gestures can also be used to more accurately communicate ideas involve interactions or relationships in space [Goldin-Meadow \(2005\)](#). In our study, we manipulate process methods in remote design team collaboration and measure team behavior changes in conversation duration, interruption and gesture.

## **3 RESEARCH METHODOLOGY**

### **3.1 Research study design and data collection**

The online remote video meeting study is designed to investigate the immediate changes in team behavior and performance influenced by group process methods: (i) Brainstorming Creative Condition (CC) and (ii) 5-Why Analytical Condition (AC) through a controlled RDT experiment. We introduced a

shared process method model to enable teams to focus on completing the design task with reduced process conflict ambiguity.

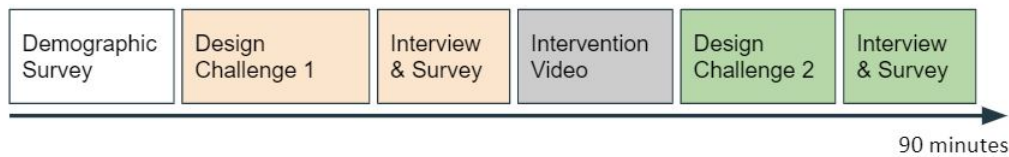


Figure 1. Timeline for the online design task study. The entire remote video meeting study took roughly 90 minutes for the pre-formed teams of three. Participant teams were given a randomly assigned intervention video between the control and post-intervention remote design tasks.

Both design challenge sessions were 15 minutes in length following the demographics survey and after both RDTs teams were interviewed and surveyed (Figure 1). The prompts were selected around a pandemic theme that was current and relevant to minimize the need for benchmarking or researching activities. The first design challenge helped serve as a control for comparison.

The prompt for the first RDT (pre-intervention) was as follows: *“Airborne viruses spread from person to person, mainly in droplets from when someone coughs or sneezes. Tiny droplets from a sick person move through the air and land on the mouths or noses of others nearby. People can also become infected by touching their faces and eyes. This is an unconscious process in which people touch their faces many times per day. Design a solution that will prevent people from infecting each other and themselves.”*

Teams were then randomly assigned either an intervention, which was presented as a two-minute recorded video between the control and post-intervention design challenge. Teams were not asked explicitly to use the method to let behavior occur organically and teams adopted the process method interventions to varying degrees. Participants were given a post-intervention RDT immediately after the video tutorial intervention. Teams used the Zoom: Video Conferencing platform for communicating remotely throughout the entire study. Participants were asked to focus their laptop video cameras on the participants head and shoulder angle during the study to capture gestures. The prompt for the second RDT (post-intervention) was as follows: *“Due to the tremendous increase in infected people, hospital resources have become limited. The development time to produce more hospital resources exceeds the mortality risk of sick patients. This leads to medical staff needing to decide whose life to save. Design a solution that saves lives in the short term.”*

### 3.2 Sample strategy

This study recruited seven pre-formed teams of three team members through online advertisements. Recruiting pre-formed teams with past working experience was necessary to minimize the need for new team culture formation. Participants were between the ages of 18-34. Participants were asked to sign a consent form and complete a demographics survey to capture age and perceived hierarchical relationship to team members.

### 3.3 Data analysis

The authors video coded all 14 RDTs (7 control, 3 CC intervention, 4 AC intervention) for frequency of interruptions, design phase changes and durations, and gestures. A sample video was re-coded with a one week gap to check for consistency in video coding by the first author with a consistency of 92%. Using verbal protocol analysis methods, the design phases were first parsed into process or content discussion. Milne and Leifer (2000); Goldschmidt (2014). We recorded the duration of design phase content discussion and parse for problem characterization (PC), ideation discussion (ID), or Mixed content discussion utterances by analyzing the time stamped transcripts. Within the content utterances, we sub-categorized PC, ID, or mixed (PC+ID) discourse utterances to quantify the number of content utterance design phase changes as a metric of team performance Lande and Leifer (2010). Mixed segments are when individual team members go back and forth between PC and ID where coding the transcript segments for the exact moments of switching is impractical.

Roger et al. (1988) developed an interruption classification scheme that was used to inform our interruption coding scheme. Videos were coded for overlap interruptions, unsuccessful interruptions, and successful interruptions. A summary with the descriptions of the interruption we coded for can be found in Table 1 Roger et al. (1988).

Table 1. Interruption coding scheme

Interruption Type	Description
Overlap	Simultaneous speech where speakers both attempt to take the floor.
Unsuccessful	The interruptor fails to take the floor before the interruptee has completed.
Successful	The interruptor prevents the interruptee from completing.

We focused on coding mid-air hand gestures by viewing the RDT video recordings and measured the number of each gesture types. Since deictic and iconic gestures are typically used during in-person communication to express semantic content, we wanted to see if there is a difference in gestural behavior as a result intervention condition. A summary with the description of the gestures coded for can be found in Table 2 Goldin-Meadow (2005); Aigner et al. (2012). Our coding scheme ignored gestures that did not utilize participants' hands such as nodding and we did not code for beat gestures, that help communicate conversational cadence, which frequently migrated off screen and did not have semantic relevance to the conversation.

Table 2. Gesture coding scheme

Gesture Type	Description
Deictic	Gestures that indicate objects, people, and locations in the real world.
Iconic - Static	Gestures that bear a close relation to the semantic contents of speech that are stationary.
Iconic - Dynamic	Gestures that bear a close relation to the semantic contents of speech that depict relations, interactions, or mechanisms.

## 4 FINDINGS

The total duration of time and distribution of time teams discussed content during the control RDT was similar across all seven teams. For the control RDT, teams spent, on average, 9 min. on content discussion during the 15 min RDT. The CC teams, on average, did not exhibit significant changes between the control and post-intervention RDT. The AC teams, on average, focused content discussion more on PC than on ID during the post-intervention RDT. The total duration of content discussion time between the control RDT or post-intervention RDT was similar for both conditions (Figure 2).

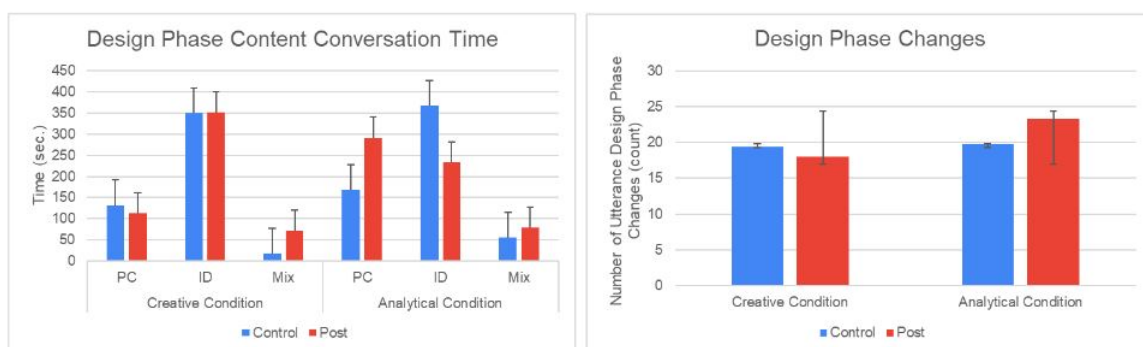


Figure 2. Duration of content conversation time and number of phase changes. The total duration of time spent discussing content and the changes in design phases were comparable for both conditions. The duration of time spent in problem characterization in the AC increased.

The frequency of content design phase changes which we capture through changes in utterances did not vary significantly between the two RDTs and we cannot conclude on aspects of team performance

change. Lande and Leifer (2010) longitudinal study looked at how these changes occurred in teams over the duration of 9-months as supposed to 15 minute RDTs. There were no noticeable changes in the number of design phase changes between interventions or the control and post-intervention RDT. For the CC, the total number of interruptions decreased on average with a particular decrease in occurrence of successful interruptions. Interruption behavior in the AC stayed roughly the same between both conceptual design tasks (Figure 3). The control RDT had an average of 28.82 interruptions during the 15 minute control RDT (1 interruption/31 sec.). Interruptions typically occurred between two team members. The most common interruption type were successful interruptions.

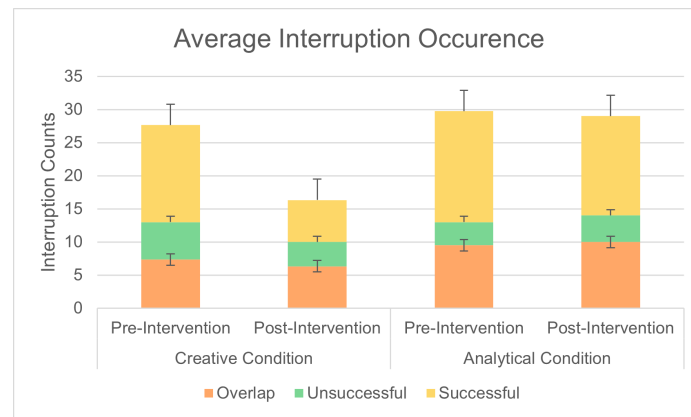


Figure 3. The distribution and frequency of interruptions for the AC were similar for both design tasks. On average, the frequency of successful interruptions decreased in the CC which also decreased the total number of interruptions between the control and post-intervention RDT.

The occurrence of deictic gestures during both RDTs were limited and the use of iconic gestures was prevalent for all teams. CC teams had a slight increase in occurrence of iconic gestures and AC teams had a decrease in iconic gestures between the control and post-intervention RDTs (Figure 4). Participants frequently used beat gestures when speaking often in tandem with iconic gestures which were occasionally lost off-screen out of the speaker’s camera view.

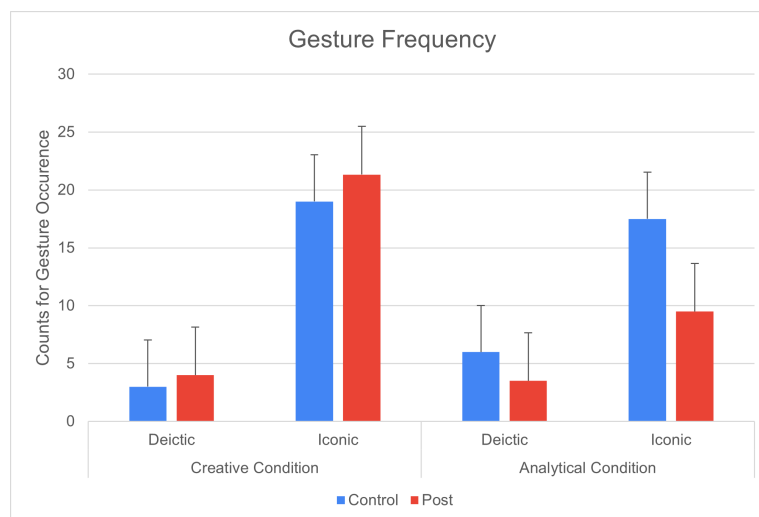


Figure 4. Changes in deictic and iconic gesturing between control and post-intervention RDTs. Gesture behavior was similar for the CC, however, there are decreases in gesturing for the AC.

## 5 DISCUSSION AND CONCLUSION

Teams in the CC behaved similarly during both RDTs but with a decrease in the number of successful interruptions during the post-intervention RDT. Teams in the AC increased in the amount of time

spent to discuss PC at the cost of ID which inhibited the production of novel ideas. The occurrence of gestures generally decreased for the AC teams suggesting that the verbal communication for expressing ideas during the AC team PC discussion was sufficient through verbal communication. CC teams would intentionally call out suggestions made by the video intervention such as “Build on the Ideas of Others” to help stimulate ideation. AC teams varied in the degree of adoption of the 5-Why method. One of the AC teams abandoned the suggested intervention early in the second RDT.

### **5.1 Design phase content conversation time duration and phase changes**

Our study looked at the effects of process method interventions on design phase duration, phase changes, and team communication behavior through interruptions and gestures. We characterize how teams focused their time based on how much time is spent on content discussion.

Work tasks can be categorized into well-defined tasks with clear metrics and specifications or ill-defined tasks that can be ambiguous, uncertain, or exploratory. Participants completed a conceptual design task which was open-ended and ambiguous in nature. Process method interventions can influence team performance by tailoring how the team strategizes on what to focus their finite meeting time on. To reduce process conflict, we introduced a process method intervention to enable teams to focus on task work. We observed more process conflict in the AC teams and participants abandoned the AC intervention when they felt the intervention hampered their ID. Our data shows that the amount of time spent on ID for the control and post-intervention task were similar for the CC. The AC intervention has an increase in the amount of time teams spent discussing PC between the control and post-intervention design challenge and a subsequent decrease in the amount of time spent on ID despite one of the AC teams abandoning the process method early in the post-intervention RDT. Our data suggests that the preclusion of one content focused activity over another during the task may contribute to team alignment. Neither intervention changed in design phase change team behavior which suggests that teams conceptually diverged from their initial ideas similarly for both RDTs. This limit can be due to the time limitations of the RDT from the study design.

### **5.2 Interruption - team behavior**

CC teams had a decrease in successful interruptions and AC teams had no noticeable change in interruption. We found that teams, on average, in our control condition had 28.82 interruptions during the 15 minute RDT. If the duration of an interruption is roughly 3.2 seconds every 32 seconds, then this can result in a loss of communication efficiency during verbal communication of 10%. It is difficult to gauge the experienced degree of disruptiveness of interruptions or the exact duration of time an interruption lasts from our data set. Team members or team managers can opt to suggest for teams to meet in person if team remote meeting behavior lean towards frequent interruptions. Not all in-person workplace interruptions are equally disruptive. 64% of in-person workplace interruptions can provide some benefit to the interrupted party [O’Conaill and Frohlich \(1995\)](#). The disruptiveness of interruptions varies with the complexity of task being interrupted, duration of interruption, and similarity of the competing tasks [Gillie and Broadbent \(1989\)](#); [Speier et al. \(1999\)](#). Interruptions due to the overlapping of sound through speakers during remote meetings can result in inefficiencies in team communication and efficiency contingent on task type.

### **5.3 Gesturing - team behavior**

Our focus on coding gestures was to understand how team gesturing can change in a RDT due to a creative or analytical intervention. Gestures are important in design since they help communicate novel ideas or analogies that may lack verbal words that can capture and communicate a team member’s concept [Kang and Tversky \(2016\)](#); [Goldin-Meadow \(2005\)](#). Deictic gestures in our study were an infrequent occurrence. The sparsity of deictic gestures in our study is possibly due to the lack of shared media or work space for teams to refer to which can result in teams having difficulties in building common ground [Donovan et al. \(2011\)](#). The CC teams did not appear to have changes in frequency of either gesture types. Further research can look at the mediating effects that the video meeting media may have compared to in-person shared workspaces for the same design teams. AC teams relied on verbal communication. The AC teams had a general decrease in the occurrence of both deictic and iconic gestures.



## 6 FUTURE WORK AND RECOMMENDATIONS

Sound designer engineers can continue to explore developing tools that allow remote meeting attendees to spatially differentiate meeting attendees during interruptions by using stereo audio and distributed individual laptop microphones to minimize disruptive voice overlap. This may enable listening parties in active conversation to hear and differentiate between two different speakers during simultaneous speaking. Future studies can include measuring cognitive load and task accuracy during controlled design tasks with two confederate participants with spatially tailored speaker systems.

Teams should be mindful of what process methods are used and for what tasks since mismatches in process method can result in process and affect conflict. Reminding teams to have 'one conversation at a time' might be sufficient in facilitating the reduction of successful interruptions. Reducing the occurrence of interruptions in online meetings is critical in minimizing overlapping speakers that cannot be differentiated by tertiary listeners. The appropriateness of interruptions, however, varies with the type of task and future work should look at the relationship of task type with team behavior in remote collaborative settings.

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