The influence of workstation orientation and task complexity on the underlying factors of efficient team collaboration

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Content

Abstract

Team collaboration is an important strategy for modern organizational problem solving.. Previous research has shown that the orientation of a work station and the complexity of the team task influence the outcome of a team collaboration. However, not a lot is known about how the underlying factors (team leadership behavior, mutual performance monitoring, closed loop communication and backup behavior) of effective team collaboration are affected by the orientation and complexity. This study investigates how orientation and complexity influence effective team collaboration based on the mentioned underlying factors. In an experiment, three member teams needed to execute team tasks. The results showed that the orientations of workstations influence mutual performance monitoring and backup behavior in the teams to a significant extent, whereas task complexity had no significant influence on the factors underlying team collaboration. Based on existing literature the results imply that the orientation can lead to decreased uncertainty regarding fellow team members actions and a faster development of interpersonal trust.

Introduction

Team collaborations are an important part of modern organizational problem solving. According to Salas, Cooke, and Rosen (2008, p.1) "[t]eams are used when errors lead to severe consequences; when the task complexity exceeds the capacity of an individual; when the task environment is ill-defined, ambiguous, and stressful; when multiple and quick decisions are needed; and when the lives of others depend on the collective insight of individual members.". The statement implies, that team collaborations are needed for conducting a variety of different tasks.

Therefore, ongoing research is focused on how the outcome of team collaborations can be improved (Bolstad & Endsley, 2003; Buljac-Samardzic, Dekker-van Doorn, Van Wijngaarden, & Van Wijk, 2010). One crucial factor for the improvement of team collaborations is the orientation of the workstations where the collaboration takes place (Elsbach, & Pratt 2007). The authors state that the orientations of workstations include the physical setup of a workplace (e.g. the arrangement of furniture at the workplace) and whether it hinders direct face to face communication or not. Whereas, it is generally known that the orientations of workstations influence the outcome of team collaboration, not a lot is known about how the underlying factors of effective team collaboration are influenced by the orientation of the workstation and the type of the team task. The goal of the present study is to investigate the influence of the workstation orientation and the type of the team task on the underlying factors of effective team collaboration.

One research field which focuses on the underlying factors of effective team collaboration is called team effectiveness. Research in this specific field revealed a variety of underlying factors which influence how effectively a team collaborates. Some of the important findings of this research field are presented in the next paragraphs.

Team effectiveness: The identified underlying factors of effective team collaboration

According to Sims, Salas, and Burke (2004) one important factor of team effectiveness is team leadership. The authors state that a team leader has the ability to assess the process of the team and assign tasks to the various team members. In addition to the abilities of the team leader, Sims, Salas, and Burke (2004) found communication patterns associated to these abilities, which lead to successful leadership. The authors state that the team leader needs to show behavior that

facilitates the team problem-solving (e.g. team motivation speeches), but also evaluate and discuss ineffective team performance. Furthermore, the team leader should assign task related roles to the fellow team members.

Another factor that was identified by McIntyre and Salas (1995) is mutual performance monitoring. Mutual team performance monitoring can be defined as the ability to "keep track of fellow team members' work while carrying out their own role […] to ensure that everything is running as expected and [...] to ensure that they are following procedures correctly" (McIntyre & Salas, 1995, p. 23). Salas, Rosen, Burke, Nicholson, and Howse (2007) identified communication structures of the team members, that indicate successful mutual performance monitoring. The authors state that team members have to monitor the actions and communication of fellow team members, recognize when a fellow team member makes a mistake and offer other team members important information without any request.

A third underlying factor according to Salas, Rosen, Burke, Nicholson, and Howse (2007) is loop communication. This factor can be seen as a form of communication where all team members express a shared awareness of task goals, situational understandings and plans for problem solving. The authors state that in teams where closed loop communication can be observed, the communication is concise, terminology is standardized and the team members engage in cross checking and confirming communication patterns (Salas, Rosen, Burke, Nicholson, & Howse, 2007).

The last underlying factor that is discussed here is called backup behavior. Backup behavior is defined "as helping other team members [to] perform their role [in the team]" (Porter, Hollenbeck, Ilgen, Ellis, West, & Moon, 2003, p.391). The authors also mention behavioral patterns that underly the construct of backup behavior. They state that all team members need to understand the other team members roles and tasks. Furthermore, all team members must be willing to accept or search assistance when a task or role specific mistake happens (Porter et al., 2003).

Orientation of workstations

As mentioned before, past research identified that the orientation of a workstation influences the effectiveness of a team collaboration significantly (Elsbach, & Pratt 2007; Mishra, Mishra, & Ostrovska 2012) Nevertheless, research in that area has mainly focussed on overarching differences in team collaborations when team tasks are executed within different

workstations, without an investigation on how these differences arose. An example of such a study was conducted by Mishra, Mishra, and Ostrovska (2012). The study investigated how team collaboration is influenced by the orientation of different workstations. In one condition the researchers let the teams execute a team task within a workspace that encourages face to face contact, whereas in the other condition the teams collaborated in a workspace where this face to face contact was absent. The results of that study showed that teams which collaborated within a workplace that encourages direct face to face contact, communicate more efficiently compared to teams which executed the team task within a workstation, where face to face contact was absent (Mishra, Mishra, & Ostrovska 2012). However, this study did not investigate how the orientation of the workstation influenced the underlying factors of effective team collaboration, such as team leadership behavior, mutual performance monitoring, closed-loop communication or backup behavior. Based on that identified lack in literature the first research question of the present article was developed:

RQ_1: Does the orientation of a workstation which encourages face to face contact, lead to an improvement of the team collaboration mediated by changes of the factors underlying team effectiveness?

Type of task

Past research investigated how the type of the task influences an effective individual and team performance (Liu & Li ,2012; Stewart, & Barrick, 2000). Liu and Li (2012) state that especially the complexity of a task influences performance. The authors define task complexity as the "number of elements of which the task is composed of and the relationships between those elements" (Liu & Li, 2012, p. 554). Based on that statement the present study aims to find out which influence the complexity of a task has on the underlying factors of effective team collaboration. Additionally, the current study investigates whether the complexity of a task influences the underlying factors of effective team collaboration to a different extent, when the team task is executed in workstations which differ in orientation. Therefore, the following research question was developed:

RQ_2: How are the factors underlying team collaboration influenced by the complexity of the team task, when the task is conducted in different orientations of workstations?

An experimental design was developed, where teams performed team tasks that differed in complexity in two different orientations of workstations.

Method

Participants

The sample consisted of 30 participants (20 male, 10 female). These 30 participants were grouped into teams of three. The mean age of the teams performing the tasks in the first workstation orientation was 22 (SD = 2,88). The mean age for teams performing the tasks in the second workstation orientation was 35 (SD = 13,59). In the teams, which performed the experiment in the first work station orientation six participants were Dutch and nine participants were German. In the teams, which performed the experiment in the second work station orientation, all 15 participants were German. The participants were allocated to the different teams and workstation orientations based on the availability of the participants. The participants within the different teams knew each other before the experiment. Three of the 30 participants were familiar with the tasks they needed to carry out for the experiment. Two of the three experienced participants were allocated to different teams which needed to execute the tasks in first workstation orientation. One participant was allocated to a team that needed to carry out the tasks in the second workstation orientation. No specific exclusion criteria were defined. The participants were recruited based on availability sampling from the personal environment of the researchers. The study was approved by the ethics committee of the University of Twente.

Design

A between groups design was used.. The two independent variables were the task complexity and the orientations of workstations. As dependent variables team leadership behavior, mutual performance monitoring, closed loop communication and backup behavior were used.

Team Task

The computer game “Keep talking and nobody explodes” was used as a team problem solving task. The goal of this game was to defuse a virtual bomb through interpersonal communication of the team members. The participants had to solve bombs with different levels of complexity. To defuse the bomb the participants had to occupy two different roles, namely one

participant had to defuse the bomb, whereas the two remaining participants provided the bomb defusing participant with rules on how to defuse the bomb. In order to defuse the bomb, riddles with different defusing rules needed to be solved. These riddles were called modules. During the game, only the participant who was defusing the bomb could see it, whereas the instruction givers had to rely on a verbal description of the bomb and its various modules provided by the defusing participant. The bomb was defused successfully, when all modules on the bomb were solved within five minutes or less (for detailed instructions, see. Appendix 1)

Module pool: All modules which could appear on the bombs

For this experiment not all by default available modules were used for the experiment. The used modules are given below: “on the subject of wires”, “on the subject of button”, “on the subject of keypads”, “on the subject of Simon says”, “on the subject of memory”, “on the subject of mazes”, “on the subject of who's on first” and “on the subject of passwords” The excluded modules were: “on the subject of complicated wires”,” on the subject of wire sequences”, “on the subject of Morse code”. These modules were excluded because they were deemed too complicated to solve for novice participants (for further explanations of the modules see. Appendix 1)

Simple task: Bombs with a low level of complexity

The computer game “Keep talking and nobody explodes” included various levels, which differed in complexity. As the simple task, a level named “first bomb” was used. In this task the bomb consisted of three different modules, which had to be defused within five minutes. These modules were “on the subject of wires”, “on the subject of keypads” and “on the subject of button”. These modules appeared during every experimental trial in different configurations. To solve these modules not a lot of interpersonal communication was needed. Additionally, during every trial of the experiment the participants had to solve the same kind of module just in different versions, which consequently led to a low level of required task adaptation.

Complex task: Bombs with a higher level of complexity

As the complex task another level of the game was used. This level was called “one step up”. In order to defuse the bomb successfully the participants had to solve four modules compared to three modules, which needed to be solved in the simple task condition. Whereas the participants had to solve the same three modules throughout all executed trials during the conduction of the simple task condition, in the complex task condition the bomb consisted of a different variation of four modules from trial to trial. These four modules were randomly chosen from all available modules in the module pool by the algorithm of the computer game. Thus, the participants had to solve a larger number of modules within the same time frame and additionally adapt to a new setup of the bomb from trial to trial. These factors made the “one step up” level more complex than the level “first bomb”.

Orientation of workstations

In order to replicate different orientations of workstations two different table setups were built. In one table setup, a direct face to face communication between the bomb defusing participant and the instruction providers was absent; the second setup encouraged face to face communication between all team members. The different table setups are explained below.

Divided tables setup

The first environment consisted of two rows of tables, where one row was located behind the other row. The participant who was defusing the bomb was located in the back row, whereas the instruction providers were sitting in the front row with their backs turned to the bomb defusing participant (see. Fig. 1). To ensure that no direct face to face communication between the defusing participant and the instruction providers was possible, a sight blocking construction was located between the rows of tables.

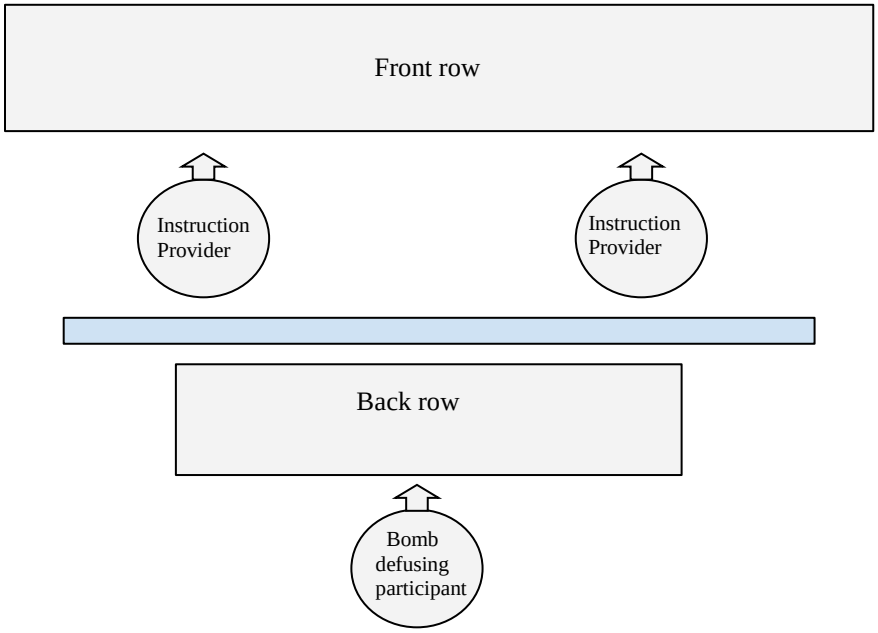

Figure 1: divided tables setup

Round table setup

The second environment consisted of a round table around which the participants were seated. Thus, they could engage in face to face communication (see Fig. 2)

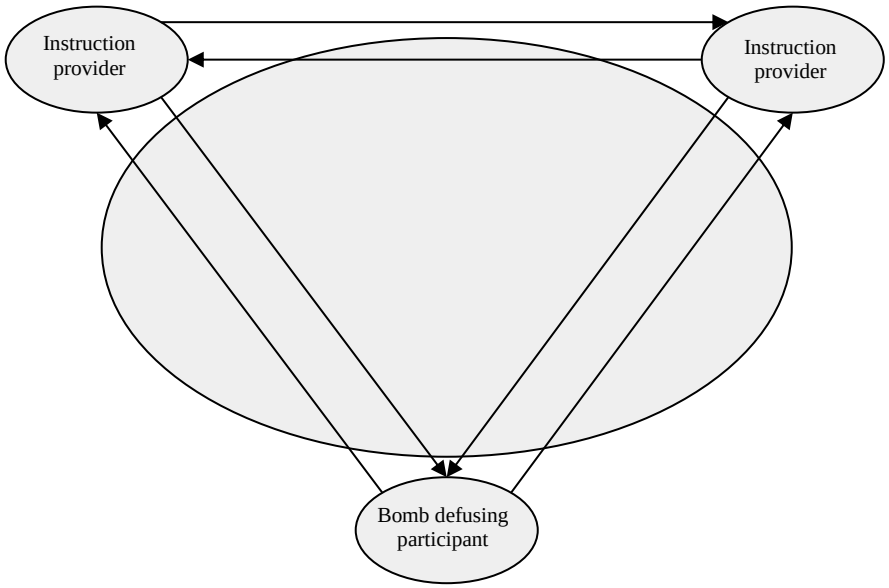

Figure 2: round table setup

Materials

The computer game “Keep talking and nobody explodes” was installed on a Lenovo V320 laptop, which was given to the participant who was defusing the bomb. The game manual, which includes the rules on how to solve the modules, was printed twice and provided to the instruction givers. The Dutch teams received an English game manual, whereas the German teams received a game manual in the German language. This was due to the circumstance that no Dutch version of the manual exists. Furthermore, notepads and pens were given to all participants in order to take notes which were helpful for the solving of specific modules.. For data analysis purposes, the teams were video recorded. For these recordings two cameras were used. One camera recorded the instruction providers, whereas the other camera recorded the bomb defusing participant.

Procedure

Before the start of the experiment, an informed consent was handed to the participants. This informed consent included written information about the process of the study, possible risks, data privacy and the information that they participate voluntarily and could withdraw at every point of the study or even afterwards (see Appendix 2). The informed consent was handed to the Dutch participants in English, whereas German participants received an informed consent in the German language, based on the missing English skills of the German participants.

However, the purpose of the study was not mentioned in the informed consent or verbally in order to keep the participants blind to the research questions until the end of the experiment. The participants were informed about the purpose of the study after the experiment was over. After they signed the informed consent, the game “Keep talking and nobody explodes” was explained to the teams. All of the teams had to watch videos that explained the different modules which could occur on the bomb. The Dutch participants watched a series of English tutorial videos on YouTube. The German participants had to watch a video-explanation in German, which was recorded by the researcher. After the teams watched the videos, they were allowed to ask comprehension questions regarding the different modules. The comprehension question round was included to assure that all teams have a similar level of understanding regarding the team task. No formal assessment of comprehension was carried out. Subsequent to the explanation, the teams conducted two test trials for the simple task bombs and two test trials for the complex task bombs. During those test trials they were able to ask questions about technical

issues that arose (e.g. How can I turn around the bomb?). No comprehension question about the modules were answered. After the test trials were completed, the teams had to solve five simple and five complex bombs. Five teams had to conduct this task in the divided tables setup and five teams executed the task in the round table setup. The Dutch teams conducted the experiment in English, whereas the German teams executed the experiment in German. After all trials were conducted the experiment ended. They were thanked for their participation and contact information of the researchers were given to every participant. This was needed, to assure that they could contact the researchers after the study is over in order to receive additional information or to withdraw from the study, which would lead to a deletion of the collected data.

Data Analysis

The recorded video data of the experiment was transcribed using the software InqScribe Version 2.24. After the transcription of the video data, the test trials of each group were coded according to a coding scheme (see. Table 1) using ATLAS.ti Version 8.4.15. Only the test trials for each team were coded, caused by time related issues. Furthermore, the transcriptions revealed that the most interesting communication behaviors were observable during the test trials. Every sentence of the test trials was first literally transcribed and subsequently coded according to the coding scheme described in Table 1. Additionally, the test trial transcripts of one group were coded by a fellow researcher to calculate an estimate of the inter-rater reliability. Krippendorff´s alpha was used for this estimate ($\alpha = 0.882$). For the analysis of the raw data SPSS 23 was used. For analysis purposes the behavioral codes were merged into the variables based on the identified factors of team effectiveness. To answer the first research question a one-sided non-parametric independent samples Mann-Whitney U test was conducted. To answer the second research question a two-sided non-parametric independent samples Mann-Whitney U test was used. The non-parametric tests were chose, because the data was not normally distributed.

Table 1: coding scheme based on the underlying factors of an effective team collaboration

Behavioral code	Definition	*Example from the transcripts*
Accepts help	The team member is willing to accept help from fellow team members if needed	*"Yes, I see it "* *"Ohhh, okay. Now I see it, yes"*

Assess process of the team	Realizes the progress of the team and communicates it towards the other team members	*"Well, we'll continue now. We can almost see these signs again"* *"3, 2, 1. Yes, now I have the word game"*
Assigns roles to team members	Different task related roles are assigned to specific team members	*"you take over with the cables and I make the button"* *"Take over the leading part in communication"*
Concise communication	Task related information is communicated precise between the team members	*"How many blue wires are there?"* *"One red, one yellow, one red, and one white"*
Cross checking and confirming	Team member ask questions to check whether the communicated information by another team member was correct; confirms communicated information of fellow team member	*"Okay, so it is yellow right?"* *"Yes, it is yellow and it says HOLD on it".*
Evaluates performance	Teams evaluate their performance during or after a trial	*"yes, we still have to agree on the symbols. I was confused by your shower [symbol]"* *"there was a vowel in there where is the error?"*
Monitors actions and communication of team members	Individual team member tries to monitor the actions or communication of another fellow team member	*"we need the serial number [to the defusing participant] ... is there a vowel in there?"* *"Then we have to take that down here [to fellow team member] What is blinking?"*
Motivational speech	Team member motivates fellow team member/s through motivational speech	*"so, we can handle it already. We also do it together"* *"Okay, very good!"*
Offers important information	Task related information is offered by a team member without the request of another team member	*"Alright, there is no Button, four wires"* *"So, button is hold and it is white. There are [also] six wires "*
Realizes when an error occurs	The team realizes when an error already occurred or is going to occur	*"Ooops I miss clicked "* *"The second, right? Oh no"*
Searching for assistance	Team member is asking for help when it is needed	*"How do I get this cut?"* *"What do I have to do now?"*
Standardized terminology	The team uses same terminology to communicate about the task	*"Okay. Copyright, chin, x, 3"* *"Okay, symbols. There is a 3 with an extra curly in the end, smiley, bt and paragraph"*

Understanding team members roles	The team understands the roles of each individual team member	*"That's yours "* *"I do not have the instructions here; you have to look"*
Discussing team members task	The team discusses what fellow team members have to do in order to solve the task	*"This is the first column, so now you have to press the order"* *"Would not he have to press that ?"*

Results

Results for the different orientations of workstations

Two significant differences were revealed for the influence of the orientations of workstations on the underlying factors of efficient team collaboration. The mutual performance monitoring behavior was significantly higher in the divided tables setup (Mdn = 10,667) than in the round table setup (Mdn = 5,167), U = 21,00, p = 0.013. Additionally, teams which conducted the team task in the divided tables setup (Mdn = 5,250) showed significantly more backup behaviors than teams which conducted the task in the round table setup (Mdn = 3,250) U = 24,50, P = 0,027.The orientations of the workstations had no significant influence in the remaining underlying factors of efficient team collaboration (see. Table 2)

Table 2: Comparison of communication behaviors based on the underlying factors of team effectiveness during the execution of the tasks in the two table setups. Number of groups, medians, Mann Whitney U and exact significance level (1-sided test). Tested at p < 0,05

	round table setup		divided tables setup		U and p-value	
	N	Median	N	Median	Mann-Whitney U	Exact Sig.
Team leadership behavior	10	3,625	10	4,625	39,00	0,209
Mutual performance monitoring	10	5,167	10	10,667	21,00	0,013
Closed loop communication	10	32,500	10	40,333	35,00	0,136
Backup behavior	10	3,250	10	5,250	24,50	0,027

Results for the different orientations of workstations under the consideration of task complexity

The analysis revealed that task complexity had no significant influence on the underlying factors of efficient team collaboration (see. Table 3; Table 4)

Table 3: Comparison of underlying factors of an efficient team collaboration during the execution of the simple task trials across the table setups. Number of groups, medians, Mann Whitney U and exact significance level (2-sided test). Tested at p < 0,05(0.025 upper-tail; 0.025 lower tail)

	Simple task; round table setup		Simple task divided tables setup		U and p-value	
	N	Median	N	Median	Mann-Whitney U	Exact Sig.
Team leadership behavior	10	3,500	10	4,500	15,500	0,548
Mutual performance monitoring	10	4,667	10	9,333	22,000	0,056
Closed loop communication	10	28,00	10	36,333	20,500	0,095
Backup behavior	10	2,500	10	6,250	21,000	0,095

Table 4:Comparison of underlying factors of an efficient team collaboration during the execution of the complex task trials across the table setups. Number of groups, medians, Mann Whitney U and exact significance level (2-sided test). Tested at p < 0,05 (0.025 upper-tail; 0.025 lower tail)

	Complex task; round table setup		Complex task; divided tables setup		U and p-value	
	N	Median	N	Median	Mann-Whitney U	Exact Sig.
Team leadership behavior	10	3,750	10	4,750	10,00	0,690
Mutual performance monitoring	10	6,000	10	12,000	8,00	0,421
Closed loop communication	10	43,667	10	47,333	10,00	0,690
Backup behavior	10	4,000	10	5,250	9,00	0,548

Discussion

The goal of this research was to find out, whether workstation orientations which encourage face to face contact influence the underlying factors of team effectiveness and lead to a better team collaboration consequently. Additionally, an aim was to determine, which influence the complexity of a team task has on the underlying factors of efficient team collaboration, when the task is performed within different orientations of workstations. The results showed that the orientations of workstations influence the underlying factor of mutual performance monitoring and backup behavior significantly. All other factors were not influenced to a significant extent. Unexpectedly, the independent variable of task complexity had no significant influence on the factors underlying team collaboration.

The results of the present study imply, that monitoring of the behavior and communication of fellow team members, which manifests mutual performance monitoring, occurred more often in the divided tables setup compared to the round table setup. An explanation for the significant difference of mutual performance monitoring was revealed by past research. According to Wilson, Straus, and McEvily (2006), the absence of a direct face to face interaction in distributed groups can lead to an uncertainties about the actions of fellow team members. The authors argue that these uncertainties develop, because context cues like non-verbal communication patterns are not present in collaborations, where no face to face contact is present. Additionally, they state that this inhibition of non-verbal communication leads to difficulties for the various team members to interpret the behaviors of their communication partners. Thus, the higher levels of mutual performance monitoring behavior within the divided tables setup can be explained by the absence of a direct face to face communication, which lead to uncertainties regarding the actions of the fellow team members.

Furthermore, the authors state that these uncertainties can lead to a slower development of interpersonal trust between the different team members. This assumption is consistent with the higher amount of backup behaviors that was observed within the teams which conducted the tasks in the divided tables setup. Past literature implies that teams with a lower level of interpersonal trust tend to spend more time backing up other team members (Ashforth & Lee, 1990).

These findings of a higher mutual performance monitoring and more backup behaviors imply, that in the development of new workplaces, the orientation of a workstation should be taken into consideration. Caused by the result that face to face communication can enhance the certainty in other team members actions and the development of interpersonal trust consequently, a workstation orientation which facilitates this communication can influence the outcome of team collaboration.

Unexpectedly, the task complexity had no influence on the underlying factors of team collaboration. This result is contrary to findings that task complexity influences performance (Maynard, D. C., & Hakel, M. D., 1997; Liu & Li, 2012). However, Maynard and Hakel (1997) state that the complexity of a task depends to a large extend on the subjective perception of the task complexity instead of the objective complexity of a task. The authors argue that differences in cognitive abilities and the motivation of the individuals performing the task influences the subjective perception of task complexity. Furthermore, Wood and Bandura (1989) related the social environment to the development of cognitive abilities and behavior. In the present study the participants were exclusively recruited in the personal environments of the researchers which led to a low variance between the social environments of the participants, who conducted the experiment. Thus, future research should use a sampling approach, which encourages the participation of individuals from different social environments.

Additionally, past literature revealed that not only the complexity of a task influences performance to a large extend, but also the type of the task (Stewart, G. L., & Barrick, M. R., 2000). In this study, the teams had to conduct the same task in different levels of complexity. Thus, it can be the case that the complex and the simple task were to similar types of task to assess a difference only based on the complexity level. Therefore, it can be stated that future research should choose more distinct tasks with different complexity levels to investigate the influence of task complexity and the type of task on underlying factors of efficient team collaboration.

Besides the already mentioned limitations and suggestions for future research, other factors which influenced the outcome of the study were identified. One factor was the small sample size (N = 10 teams) which led to limitations for the statistical power of the analysis. Furthermore, only the first four trials of each group were coded and used for the statistical analysis. This led to a decreased level of insight into the occurrence of team communication behaviors. Additionally, the groups might have experienced a learning effect throughout the

conduction of the first four trials, although they received an extensive explanation of the task they were going to perform. Future research should choose a higher sample size to achieve a higher power of the statistical analysis. Furthermore, the whole transcripts should be coded and analyzed in order to achieve better reliability of the data and to cancel out the possible learning effects during the first trials.

To conclude it can be stated that the findings of this study showed that the orientation of a workstation can influence the mutual performance monitoring behavior and backup behavior in team collaboration. Unexpectedly, the task complexity had no influence on the underlying factors of team collaboration. The findings should be taken into consideration when new collaboration spaces are developed. The research showed that when a face to face communication is encouraged by the orientation of a workstation, the teams can lower uncertainties regarding the actions of fellow team members and can build an atmosphere of trust more efficiently than when the face to face communication is absent.

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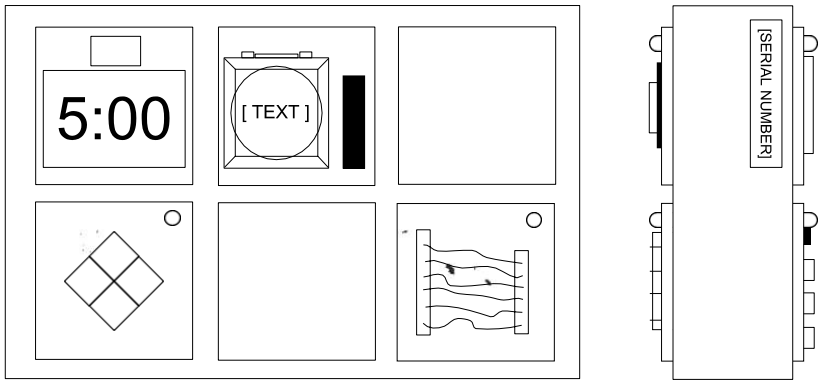
Defusing Bombs

A bomb will explode when its countdown timer reaches 0:00 or when too many strikes have been recorded. The only way to defuse a bomb is to disarm all of its modules before its countdown timer expires.

Example Bomb



Front Side

Modules

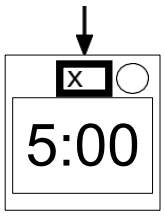
Each bomb will include up to 11 modules that must be disarmed. Each module is discrete and can be disarmed in any order.

Instructions for disarming modules can be found in Section 1. "Needy" modules present a special case and are described in Section 2.

Strikes

When the Defuser makes a mistake the bomb will record a strike which will be displayed on the indicator above the countdown timer. Bombs with a strike indicator will explode upon the third strike. The timer will begin to count down faster after a strike has been recorded.

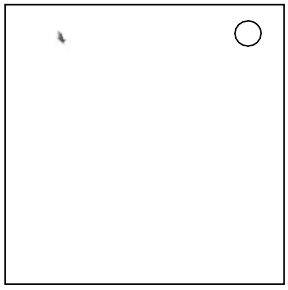
Strike Indicator



If no strike indicator is present above the countdown timer, the bomb will explode upon the first strike, leaving no room for error.

Gathering Information

Some disarming instructions will require specific information about the bomb, such as the serial number. This type of information can typically be found on the top, bottom, or sides of the bomb casing. See Appendix A, B, and C for

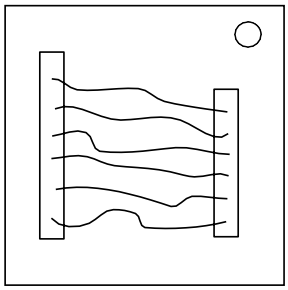


Section 1: Modules

Modules can be identified by an LED in the top right corner. When this LED is lit green the module has been disarmed.

All modules must be disarmed to defuse the bomb.

On the Subject of Wires



Wires are the lifeblood of electronics! Wait, no, electricity is the lifeblood. Wires are more like the arteries. The veins? No matter...

- A wire module can have 3-6 wires on it.
- Only the one correct wire needs to be cut to disarm the module.
- Wire ordering begins with the first on the top.

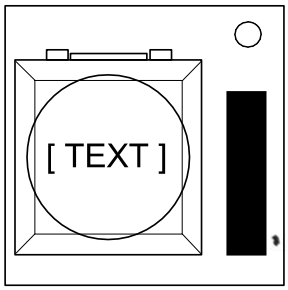
3 wires:
If there are no red wires, cut the second wire.
Otherwise, if the last wire is white, cut the last wire.
Otherwise, if there is more than one blue wire, cut the last blue wire.
Otherwise, cut the last wire.

4 wires:
If there is more than one red wire and the last digit of the serial number is odd, cut the last red wire.
Otherwise, if the last wire is yellow and there are no red wires, cut the first wire.
Otherwise, if there is exactly one blue wire, cut the first wire.
Otherwise, if there is more than one yellow wire, cut the last wire.
Otherwise, cut the second wire.

5 wires:
If the last wire is black and the last digit of the serial number is odd, cut the fourth wire.
Otherwise, if there is exactly one red wire and there is more than one yellow wire, cut the first wire.
Otherwise, if there are no black wires, cut the second wire.
Otherwise, cut the first wire.

6 wires:
If there are no yellow wires and the last digit of the serial number is odd, cut the third wire.
Otherwise, if there is exactly one yellow wire and there is more than one white wire, cut the fourth wire.
Otherwise, if there are no red wires, cut the last wire.
Otherwise, cut the fourth wire.

On the Subject of The Button



You might think that a button telling you to press it is pretty straightforward. That's the kind of thinking that gets people exploded.

See Appendix A for indicator identification reference.
See Appendix B for battery identification reference.

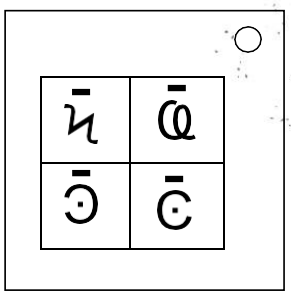
Follow these rules in the order they are listed. Perform the first action that applies:

1. If the button is blue and the button says "Abort", hold the button and refer to "Releasing a Held Button".
2. If there is more than 1 battery on the bomb and the button says "Detonate", press and immediately release the button.
3. If the button is white and there is a lit indicator with label CAR, hold the button and refer to "Releasing a Held Button".
4. If there are more than 2 batteries on the bomb and there is a lit indicator with label FRK, press and immediately release the button.
5. If the button is yellow, hold the button and refer to "Releasing a Held Button".
6. If the button is red and the button says "Hold", press and immediately release the button.
7. If none of the above apply, hold the button and refer to "Releasing a Held Button".

Releasing a Held Button

If you start holding the button down, a colored strip will light up on the right side of the module. Based on its color you must release the button at a specific point in time:

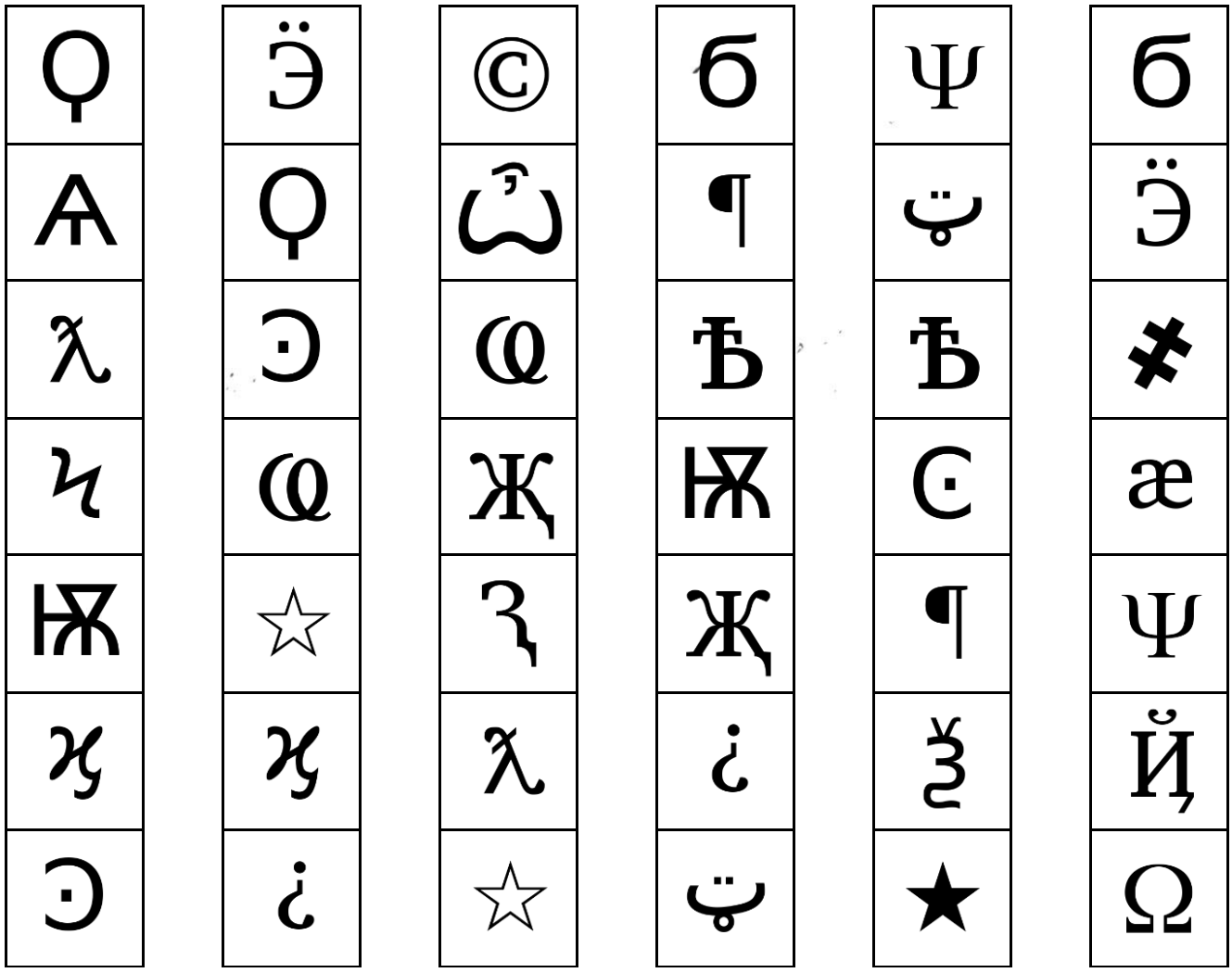
- Blue strip: release when the countdown timer has a 4 in any position.
- White strip: release when the countdown timer has a 1 in any position.
- Yellow strip: release when the countdown timer has a 5 in any position.
- Any other color strip: release when the countdown timer has a 1 in any position.



On the Subject of Keypads

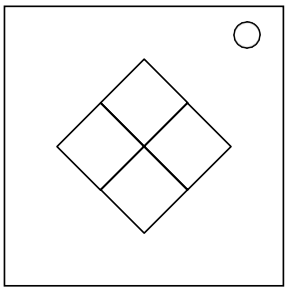
- *I'm not sure what these symbols are, but I suspect they have something to do with occult.*

Only one column below has all four of the symbols from the keypad.
Press the four buttons in the order their symbols appear from top to bottom within that column.

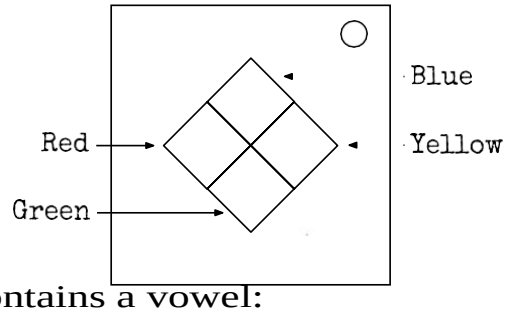


On the Subject of Simon Says

This is like one of those toys you played with as a kid where you have to match the pattern that appears, except this one is a knockoff that was probably purchased at a dollar store.



1. One of the four colored buttons will flash.
2. Using the correct table below, press the button with the corresponding color.
3. The original button will flash, followed by another. Repeat this sequence in order using the colormapping.
4. The sequence will lengthen by one each time you correctly enter a sequence until the module is disarmed.



If the serial number contains a vowel:

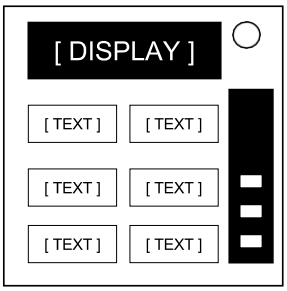
		Red Flash	**Blue Flash**	**Green Flash**	**Yellow Flash**
Button to press:	**No Strikes**	Blue	Red	Yellow	Green
	1 Strike	Yellow	Green	Blue	Red
	2 Strikes	Green	Red	Yellow	Blue

If the serial number does <u>not</u> contain a vowel:

		Red Flash	**Blue Flash**	**Green Flash**	**Yellow Flash**
Button to press:	**No Strikes**	Blue	Yellow	Green	Red
	1 Strike	Red	Blue	Yellow	Green

	2 Strikes	Yellow	Green	Blue	Red

On the Subject of Who's on First

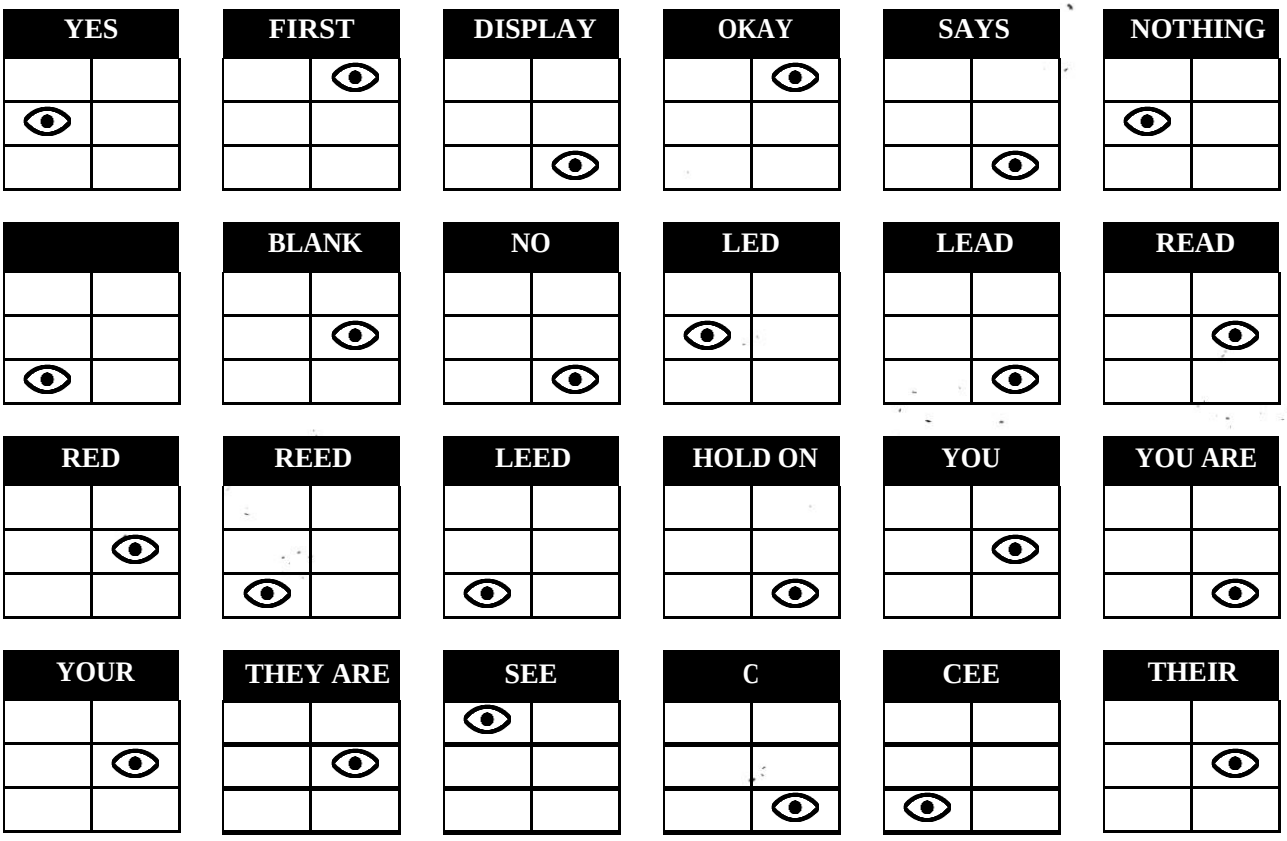


This contraption is like something out of a sketch comedy routine, which might be funny if it wasn't connected to a bomb. I'll keep this brief, as words only complicate matters.

1. Read the display and use step 1 to determine which button label to read.
2. Using this button label, use step 2 determine which button to push.
3. Repeat until the module has been disarmed.

Step 1;

Based on the display, read the label of a particular button and proceed to step 2:



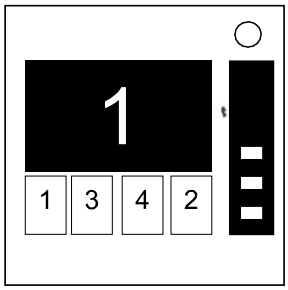
Step 2:

Using the label from step 1, push the first button that appears in its corresponding list:

"READY":	YES, OKAY, WHAT, MIDDLE, LEFT, PRESS, RIGHT, BLANK, READY, NO, FIRST, UHHH, NOTHING, WAIT
"FIRST":	LEFT, OKAY, YES, MIDDLE, NO, RIGHT, NOTHING, UHHH, WAIT, READY, BLANK, WHAT, PRESS, FIRST
"NO":	BLANK, UHHH, WAIT, FIRST, WHAT, READY, RIGHT, YES, NOTHING, LEFT, PRESS, OKAY, NO, MIDDLE
"BLANK":	WAIT, RIGHT, OKAY, MIDDLE, BLANK, PRESS, READY, NOTHING, NO, WHAT, LEFT, UHHH, YES, FIRST
"NOTHING":	UHHH, RIGHT, OKAY, MIDDLE, YES, BLANK, NO, PRESS, LEFT, WHAT, WAIT, FIRST, NOTHING, READY
"YES":	OKAY, RIGHT, UHHH, MIDDLE, FIRST, WHAT, PRESS, READY, NOTHING, YES, LEFT, BLANK, NO, WAIT
"WHAT":	UHHH, WHAT, LEFT, NOTHING, READY, BLANK, MIDDLE, NO, OKAY, FIRST, WAIT, YES, PRESS, RIGHT
"UHHH":	READY, NOTHING, LEFT, WHAT, OKAY, YES, RIGHT, NO, PRESS, BLANK, UHHH, MIDDLE, WAIT, FIRST
"LEFT":	RIGHT, LEFT, FIRST, NO, MIDDLE, YES, BLANK, WHAT, UHHH, WAIT, PRESS, READY, OKAY, NOTHING
"RIGHT":	YES, NOTHING, READY, PRESS, NO, WAIT, WHAT, RIGHT, MIDDLE, LEFT, UHHH, BLANK, OKAY, FIRST
"MIDDLE":	BLANK, READY, OKAY, WHAT, NOTHING, PRESS, NO, WAIT, LEFT, MIDDLE, RIGHT, FIRST, UHHH, YES
"OKAY":	MIDDLE, NO, FIRST, YES, UHHH, NOTHING, WAIT, OKAY, LEFT, READY, BLANK, PRESS, WHAT, RIGHT
"WAIT":	UHHH, NO, BLANK, OKAY, YES, LEFT, FIRST, PRESS, WHAT, WAIT, NOTHING, READY, RIGHT, MIDDLE
"PRESS":	RIGHT, MIDDLE, YES, READY, PRESS, OKAY, NOTHING, UHHH, BLANK, LEFT, FIRST, WHAT, NO, WAIT
"YOU":	SURE, YOU ARE, YOUR, YOU'RE, NEXT, UH HUH, UR, HOLD, WHAT?, YOU, UH UH, LIKE, DONE, U
"YOU ARE":	YOUR, NEXT, LIKE, UH HUH, WHAT?, DONE, UH UH, HOLD, YOU, U, YOU'RE, SURE, UR, YOU ARE
"YOUR":	UH UH, YOU ARE, UH HUH, YOUR, NEXT, UR, SURE, U, YOU'RE, YOU, WHAT?, HOLD, LIKE, DONE
"YOU'RE":	YOU, YOU'RE, UR, NEXT, UH UH, YOU ARE, U, YOUR, WHAT?, UH HUH, SURE, DONE, LIKE, HOLD
"UR":	DONE, U, UR, UH HUH, WHAT?, SURE, YOUR, HOLD, YOU'RE, LIKE, NEXT, UH UH, YOU ARE, YOU
"U":	UH HUH, SURE, NEXT, WHAT?, YOU'RE, UR, UH UH, DONE, U, YOU, LIKE, HOLD, YOU ARE, YOUR
"UH HUH":	UH HUH, YOUR, YOU ARE, YOU, DONE, HOLD, UH UH, NEXT, SURE, LIKE, YOU'RE, UR, U, WHAT?
"UH UH":	UR, U, YOU ARE, YOU'RE, NEXT, UH UH, DONE, YOU, UH HUH, LIKE, YOUR, SURE, HOLD, WHAT?
"WHAT?":	YOU, HOLD, YOU'RE, YOUR, U, DONE, UH UH, LIKE, YOU ARE, UH HUH, UR, NEXT, WHAT?, SURE
"DONE":	SURE, UH HUH, NEXT, WHAT?, YOUR, UR, YOU'RE, HOLD, LIKE, YOU, U, YOU ARE, UH UH, DONE
"NEXT":	WHAT?, UH HUH, UH UH, YOUR, HOLD, SURE, NEXT, LIKE, DONE, YOU ARE, UR, YOU'RE, U, YOU

"HOLD":	YOU ARE, U, DONE, UH UH, YOU, UR, SURE, WHAT?, YOU'RE, NEXT, HOLD, UH HUH, YOUR, LIKE
"SURE":	YOU ARE, DONE, LIKE, YOU'RE, YOU, HOLD, UH HUH, UR, SURE, U, WHAT?, NEXT, YOUR, UH UH
"LIKE":	YOU'RE, NEXT, U, UR, HOLD, DONE, UH UH, WHAT?, UH HUH, YOU, LIKE, SURE, YOU ARE, YOUR

On the Subject of Memory



Memory is a fragile thing but so is everything else when a bomb goes off, so pay attention!

- Press the correct button to progress the module to the next stage. Complete all stages to disarm the module.
- Pressing an incorrect button will reset the module back to stage 1.
- Button positions are ordered from left to right.

Stage 1:

If the display is 1, press the button in the second position. If the display is 2, press the button in the second position. If the display is 3, press the button in the third position. If the display is 4, press the button in the fourth position.

Stage 2:

If the display is 1, press the button labeled "4".

If the display is 2, press the button in the same position as you pressed in stage 1. If the display is 3, press the button in the first position.

If the display is 4, press the button in the same position as you pressed in stage 1.

Stage 3:

If the display is 1, press the button with the same label you pressed in stage 2. If the display is 2, press the button with the same label you pressed in stage 1. If the display is 3, press the button in the third position.

If the display is 4, press the button labeled "4".

Stage 4:

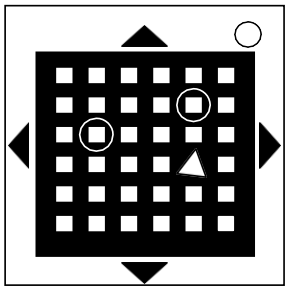
If the display is 1, press the button in the same position as you pressed in stage 1. If the display is 2, press the button in the first position.

If the display is 3, press the button in the same position as you pressed in stage 2. If the display is 4, press the button in the same position as you pressed in stage 2.

Stage 5:

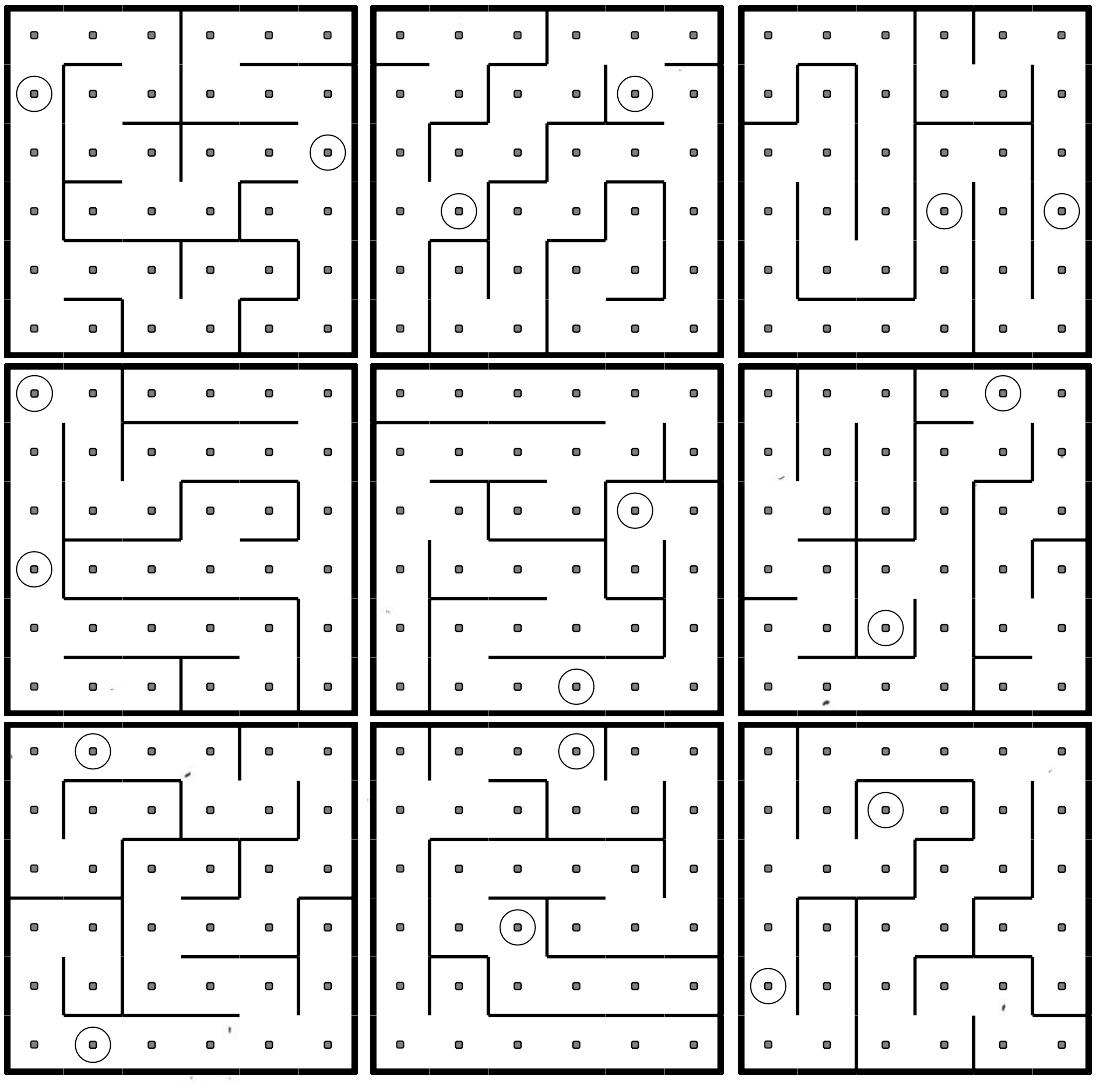
If the display is 1, press the button with the same label you pressed in stage 1. If the display is 2, press the button with the same label you pressed in stage 2. If the display is 3, press the button with the same label you pressed in stage 4. If the display is 4, press the button with the same label you pressed in stage 3.

On the Subject of Mazes



This seems to be some kind of maze, probably stolen off of a restaurant placemat.

- Find the maze with matching circular markings.
- The defuser must navigate the white light to the red triangle using the arrow buttons.
- **Warning:** Do not cross the lines shown in the maze. These lines are invisible on the bomb.



Appendix A: Indicator Identification Reference

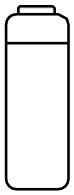
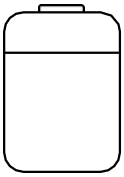
Labelled indicator lights can be found on the sides of the bomb casing.

Common Indicators

- SND
- CLR
- CAR
- IND
- FRQ
- SIG
- NSA
- MSA
- TRN
- BOB
- FRK

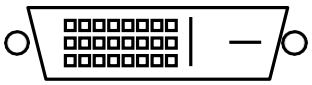
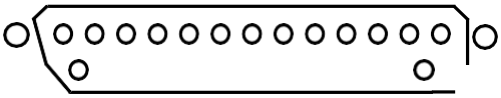
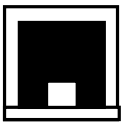
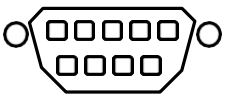
Appendix B: Battery Identification Reference

Common battery types can be found within enclosures on the sides of the bomb casing.

Battery	Type
	AA
	D

Appendix C: Port Identification Reference

Digital and analog ports can be found on sides of the bomb casing.

Port	Name
	DVI–D
	Parallel
	PS/2
	RJ-45
	Serial
	Stereo RCA

Appendix 2: informed consent

Information sheet Enschede, 15th of April, 2019

Dear participant,

In this experiment you are going to play the computer game "*Keep Talking And Nobody Explodes*". The purpose of this game is to solve a virtual bomb with your team within a time period of five minutes. The virtual bomb consists of three different small riddles, which you need to solve in order to defuse the bomb successfully. You will occupy one of two roles which are needed to defuse the bomb, namely you are either the participant who is defusing the bomb or one of the instruction providers, also known as experts.

The participant who is defusing the bomb can see the bomb on the screen, but does not know how to defuse it. The experts will receive a manual, which includes rules on how to solve the small riddles on the bomb and defuse the bomb consequently. These rules will be communicated by the experts to the participant who is defusing the bomb in a verbal manner. Thus, you need to communicate to defuse the bomb.

The playing of the game could lead to stressful reactions of some participants, caused by time pressure. The experimental setup which also includes the stress factor was reviewed and approved by the BMS Ethics Committee. The participation in this study is voluntary and you have the right to withdraw from the study at any point in time during the process of the study or afterwards. If you want to withdraw after the study is over you can contact us via email. If you decide to withdraw from the study during the experiment or afterwards, the collected data will be deleted and will not be used for any publication purposes.

Before the start of the experiment basic demographic information will be collected. This information includes age, gender and nationality. The data will be collected in an anonymized manner. During the experiment other data will be collected. The sessions will be video recorded for retrospective analysis purposes. The video data will be stored on a hard drive which is secured by a password. This password is only known to the researchers themselves. When the study is finished, the video material will be deleted. Additionally, after each trial of the experiment the task completion time of your team will be transcribed. The

transcribed completion times will not include any personalized data. This data will be stored for a retention period of five years after the submission of the thesis. The collected data will be used for the publication of a bachelor thesis. The video data will be coded and analysed afterwards. The task completions times are used for statistical analysis.

You have the right to inspect the collected data from the experiment where you participated at any time point. Even after the experiment has ended you can contact us in order to schedule an appointment for inspection purposes.

Contact information:
b.glinski@student.utwente.nl
l.vanwijk@student.utwente.nl

Ethics committee:
ethicscommittee-bms@utwente.nl

Enschede, 15th of April, 2019

Consent Form for “Keep Talking And Nobody Explodes”: The influence of team communication on successful bomb defusing

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [15/04/2019], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves a video recording of the session and the transcription of task completion times. The video recordings will be coded and deleted when the study is finished. The task completion times will be stored for five years after the submission of the thesis.	○	○
I understand that taking part in the study involves the following risks: time pressure, which could lead to stressful reactions	○	○
Use of the information in the study		
I understand that information I provide will be used for publication purposes of a bachelor thesis.	○	○
I understand that personal information collected about me that can identify me, such as the video recordings and demographic data, will not be shared beyond the study team.	○	○
I agree to be video recorded.	○	○
Future use and reuse of the information by others		
I give permission for the task completion times and video recordings that I provide to be archived in an anonymized excel table and on a secured hard drive respectively so it can be used for future research and learning	○	○

Signatures

_____ _____

Signature of participant Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

Study contact details for further information:

Benedikt Glinski: b.glinski@student.utwente.nl

Lara van Wijk: l.vanwijk@student.utwente.nl

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl