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THE RIG: A LEADERSHIP PRACTICE GAME TO TRAIN ON DEBIASING TECHNIQUES

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ABSTRACT

Cognitive biases such as myopic problem representation, group think, the conjunction fallacy, and confirmation bias impair effective decision making. Therefore, successful leadership should be able to spot and mitigate circumstances that promote cognitive biases. To understand and experience the consequences of cognitive biases and to teach and train on adequate countermeasures (debiasing techniques), this article presents a serious game for leadership practice. In a round-based game, a group of participants works as a team to make decisions constrained by time, uncertainty, lack of information, and conflict. The game simulates the last stages of finalizing deep sea oil exploration. While the game focuses on behavioral learning outcomes, the final debriefing emphasizes emotional aspects to achieve a long-lasting learning effect. The debriefing reveals that the game is not artificial but mimics exactly the stages that led to the real catastrophe at the Deepwater Horizon rig in the Gulf of Mexico in 2010.

1 INTRODUCTION

Human decision making in daily life or professional business is subject to lack of information, processing time, and limited resources. Kahneman and Tversky (1973) demonstrated that humans use shortcuts to cope with these constraints and that these cognitive representations and heuristics are prone to a systematical discrepancy to objective reality. A famous example is group think, an error that occurs in teams when the desire for harmony outweighs rational decision making. Janis (1982) showed that even high-performance teams are subject to severely flawed decisions due to the subconscious importance of team conformity.

The research field of cognitive biases in decision making bears endogenously entertaining applications and experiments that can be used in education. Particularly in a student-centric curriculum involving activity-based learning, psychological experiments highlighting cognitive biases are complementary didactics. An extensive theoretical overview of cognitive biases is presented in Kahneman et al. (1982) and Gilovich et al. (2002). The advantage of such an experiment is the individual experience of being actively part of a situation and observing one’s own limitations in decision making. Such an experiment is best suited to introduce and explain a certain concept in leadership-oriented courses.

After the concept has been introduced, such an experiment is often too limited in its real-world application context to use in training for and deducting useful skills, because it focuses primarily on an isolated concept. Serious games come in handy in this situation, because they inherit the dynamic and experience-based characteristics from experiments, and provide a situated and problem-based context (Boyle et al. 2011; Conolly et al. 2012). Lopes et al. (2013) provide an extensive list of serious games on leadership practice. Further, specific games that address the importance of cognitive biases in leadership, such as *Missing: The Pursuit of Terry Hughes* (Symborski et al. 2014; Barton et al. 2016) or *Everest 2* (Roberto and Edmondson 2017), exist in the market.

Although serious games have proved to be an effective didactic, Lopes et al. (2013) cautiously deduct, in their literature review, three areas of improvement: (1) use of advanced computer techniques, (2) a closer link between theoretical approaches and business games, and (3) guarantee of long-lasting learning outcomes.

This article describes a serious game to raise the awareness of cognitive biases in decision-making and training debiasing techniques. It picks up on the work by Roberto and Edmondson (2017) and Symborski et al. (2014), focusing on myopic problem representation, group think, the conjunction fallacy, and the confirmation bias. However, instead of setting up an artificial context, like climbing a mountain (*Everest 2*) or searching for a person (*Missing*), this serious game is based on the real case of the Deepwater Horizon catastrophe in the Gulf of Mexico in 2010. The participants are grouped and set into an environment in which they have to make several decisions to finalize the exploration of a deep sea oil exploration rig. The team members have to organize themselves to work their way through the game.

To start, the team is equipped with some background information on deep sea oil exploration to get familiar with the context-specific wording. During the game, the team must communicate effectively and share any presented information before solving a problem and making decisions to proceed to the next round. As in reality, information needed to solve the problem and make decisions is asymmetrically distributed among the team members. Further, the game is subject to time and resource constraints that are represented as conflicting goals among team members and a common objective of the entire team. Before and during the game, the participants do not know that the simulation mimics the real Deepwater Horizon case and that each team role, including the individual objectives and information, is linked to one of the real protagonists involved in the catastrophe.

The critical moment of learning occurs during the debriefing of the game, when the real case of Deepwater Horizon is presented. This highlights that the participants go through the exact decision stages as the managers of BP (formerly British Petroleum) on the Deepwater Horizon rig. The participants realize that their thought process is also subject to cognitive biases, as was the case in reality. From our experience, this moment attaches strong emotions to the learning outcomes (being aware and able to mitigate cognitive biases in decision making) that lead to a long-lasting learning effect.

The article is structured as follows: First, the educational structure and learning outcomes are presented, followed by the structure of the game and the game flow; a debriefing summary is presented at the end of the article.

2 EDUCATIONAL STRUCTURE AND LEARNING OUTCOMES

The presented game, henceforth referred to as *The Rig*, is a serious game to teach the importance of cognitive biases in impairing effective decision making and to provide training on debiasing techniques in a real-world scenario. Optimally, participants are grouped into teams of five, with each team member assigned a particular role. If the number of participants cannot be split into groups of five, two individuals can share a role. *The Rig* can handle 1 to 40 groups playing the game simultaneously.

The game consists of three elements and can be conducted fully in class or partially remotely within a time frame of 90 to 120 minutes: (1) A short pre-reading familiarizes participants with the appropriate wording for deep sea oil exploration; (2) the participants are grouped and play the game online in five rounds within a given time frame (75 to 90 minutes); and (3) the instructor debriefs the participants on the results during the lecture (15 to 30 minutes). The learning outcomes are as follows:

Learning Objective 1: *The participants should organize themselves and establish a leadership structure for effective decision making to handle information and interest asymmetries under constraints.*

Learning Objective 2: *The participants should identify circumstances and thought processes that are prone to cognitive biases such as myopic problem representation, group think, the conjunction fallacy, and the confirmation bias.*

Learning Objective 3: *The participants should apply group elicitation techniques such as brainstorming, focus group, and process modeling to overcome the myopic representation bias.*

Learning Objective 4: *The participants should apply the concept of psychological safety and the devil's advocate as debiasing techniques for group think.*

Learning Objective 5: *The participants should use adequate risk value calculation to mitigate conjunction fallacy bias.*

Learning Objective 6: *The participants should use probability theory and expert opinions as countermeasures for confirmation bias.*

In many cases, when teams work together on a common goal, each team member has private information that is not accessible by other members, whether this is context-specific knowledge, non-context-specific knowledge, or information about intrinsic motivations within the team. Individual goals can conflict among team members, without being explicitly stated. These information and interest asymmetries exist because individuals have incentives not to disclose all private information, because they are not aware that their private information is valuable (they take their knowledge for granted), or because they are not aware of their intrinsic preferences. Edmondson et al. (2003) highlight that these information and interest asymmetries impair effective decision making. However, these asymmetries can be transferred into win-win situations through multi-part negotiations and information pooling (Lax and Sebenius 1986 in Roberto and Edmondson 2017).

Despite a well-established communication culture and multi-part negotiations, individuals and teams may be subject to cognitive biases.

Myopic problem representation occurs when problem representation is oversimplified and important variables are overlooked (Legrenzi 1993; Jargowsky 2005). Specifically, in stressful situations decision-makers tend to focus on single objectives or states (Eisenhardt 1989) instead of considering the full picture. Along with making decisions under time pressure and information overload, humans are affected by emotions (in relation to peers) and selfish behavior (Song et al. 2016). Debiasing techniques are explicitly used to think about alternatives using group elicitation techniques such as brainstorming, focus groups, and process modeling. Critical thinking should be encouraged by making individuals responsible for thinking about at least two alternatives to any decision.

Group think is a cognitive bias that occurs if striving for harmony within the group outweighs critical thinking. Group think is a consequence of the information-sharing problem. Stasser and Titus (1985) point out that teams spend more time discussing information that is common to all team members than they do explicitly for privately held information. Team members might hesitate to share private information to comply with the team conformity (Janis 1982) and not to risk the common group objective. Teams and specific leaders can effectively account for this bias by establishing a culture of psychological safety and a climate safe for interpersonal risk taking (Edmondson 1999). Team members are, based on social norms within the group, free to speak up. In order to enforce non-conformity, teams can also include the role of a devil's advocate.

The conjunction fallacy is based on a misjudgment in which the conjunction of two events is perceived to be more likely than a constituent event (Tversky and Kahneman 1983). The more detailed information an individual has about a specific event, the more plausible this event is perceived to be, although it might be less probable. Debiasing techniques are an appropriate assessment of risk values, probabilities, and conditional probabilities.

The confirmation bias is a result of focusing more on information that confirms existing belief and mental models (hypotheses) and neglecting disconfirming evidence (Morewedge and Kahneman 2010). Mitigation techniques are the usage of expert opinions in the decision process and challenging the assessment of probabilities by including negative alternatives.

3 GAME STRUCTURE

3.1 Theoretical Background of Deep Sea Oil Exploration

Deep sea drilling is a tough and expensive business spanning multiple companies. Deep sea drilling has two phases: (1) explorative drilling, and (2) production. During the explorative phase, the borehole is drilled and cemented for later production. Before separating the (explorative) drilling rig from the wellhead, the annular space (lower end of the borehole) is sealed with cement to avoid any outflows of gas or liquids. After sealing, the production platform is attached to the wellhead to start its work. The game is about the last step of explorative drilling: Cementing the well casing.

The seabed is located about 1.5 kilometers below sea level. The borehole starts at the seabed and goes until it reaches the oil or gas field at a depth of about 4 kilometers. When the drilling head penetrates the sea floor, dissolved rock known as drilling mud (drilling fluid) wells up continuously. It needs to be pushed downwards and then upwards in between the drill pipe and the borehole wall. It is critically important to apply the appropriate pressure on the drilling mud. If the pressure is too low, then there will be no circulation, and dissolved rocks will not be pushed upwards and out of the borehole. If the pressure is too high, the drill pipe, the pipe casing, or the surrounding rock may be damaged.

As various layers of rock are penetrated, different combinations of pressure levels and drilling mud mixtures have to be employed to adapt to the changing realities of the rock layers. After the drilling head has been advanced, a well casing is lowered. To construct a segment of the well casing, three single casings of about 30 meters are combined using casing joints. The 90-meter well casing is then lowered into the borehole. Drilling mud is used to push the casing downward. At the bottom, the casing segment is hooked into the deepest well casing already introduced. Because every casing is lowered through an already existing one, this process creates a narrow, shrinking tube. The entire process of introducing 90 meters of casing takes approximately 12 hours. Thus, the maximum drilling depth per day is about 180 meters.

To avoid ascending drilling mud spillage onto the sea floor, a wellhead is installed. It ensures that the mud is directed back to the rig, closing the loop of circulating drilling mud. A security element called the blow-out preventer (BOP) is implemented on top of the wellhead on the seafloor to safeguard it. The BOP consists of several valves to monitor the up-flow of drilling mud and control for possible gas intrusions to the riser (a pipe from the seafloor/wellhead to the rig). If anything goes wrong, the BOP can seal the wellhead and avoid any unexpected gas or liquids in the riser. It is important for any issues to be solved either below the BOP or on the rig itself, because once any liquid or gas is in the riser, it cannot be controlled during the 1.5-kilometer ascent.

For the drilling mud to circulate properly, the return flow must be checked continuously (flow returns). Any volume of mud pushed down at a certain speed (pressure) must have exactly the same volume to be returned to the rig. If drilling mud is lost, then the pressure is too high and rock might be damaged and percolate there. An artificial toxic foam has to be deployed to seal the damaged region (where mud flows into the rock).

After drilling is done, the sealing process begins. A special final casing is used to terminate the borehole at the very bottom. The final casing must be well cemented and anchored with the wellbore so that no liquids or gas can rise upwards. Therefore, the cement must be appropriately mixed and pushed down with proper pressure. The final casing has to be centered precisely in the final well segment, so that the cement will evenly distribute around the outer casing. If the cement is not evenly distributed, "channeling" might occur. This means gas might rise through the mud that is not replaced properly by cement or if the cement is not properly compressed. Once gas rises unnoticed into the riser, there is no way to stop it until it reaches the rig. While cementing the final casing, so-called centralizers are used as auxiliaries. Centralizers are like gauntlets and are pulled over the pipe. Centralizers are pushed down with mud to keep the pipe centered in the borehole. The number and position of the centralizers plays an important role and also affects how the cement must be mixed later.

Once the final casing is fully cemented, no further circulation should take place. Mud that is pushed down the tube should flow up in the same tube and not between the outer casing and wellhead. Mud that is pushed down between the outer casing and wellbore should also rise up in the same way. If the return flows do not match, the cement job has failed. If returns flows are larger than expected, then gas or oil rises through the cement. If return flows are below expectations, then mud intrudes into the spongy cement. If the cement is spongy, gas and liquids will enter the riser after the mud is replaced by light seawater as a process for separating the drilling rig to give way to production.

A set of pressure and reflux tests can be used to determine whether the cement job has been successful. As the tests are always associated with fluctuations in pressure, they put strain on the wellbore. Too many tests are not good; neither are too few. If the tests are successful, the drilling mud will be replaced by lightweight seawater. The valves on the BOP will be closed and the exploration platform disconnected, and the production platform can be docked.

3.2 Game Setup

The game consists of five rounds (or phases) modeling the different stages of the final cementing job to be mastered by a team. Optimally, a team consists of five members, and each is assigned to one of the following roles: project manager, well manager, engineer manager, tool pusher, and engineer. The team goal is to get the cementing job done on time, with the lowest possible cost, while maintaining the safety of the rig. Safety means that the risk value of gas ignition in the riser, mainly due to channeling, does not exceed a certain threshold.

Each team member has individual goals and an individual task to solve during the game. The individual objectives are prioritized differently depending on the role. The roles and objectives directly represent the persons and intentions that were involved in decision making on the Deepwater Horizon. Each individual task, henceforth called the *challenge*, reflects the actual work the respective person on the Deepwater Horizon was involved with.

The five rounds simulate the five steps of finalizing the cement job and separating the exploration rig from the wellhead:

- Phase 1: Determine the final casing type and number of centralizers.
- Phase 2: Determine the cement mixture, circulation, and pressure parameters for the cementing job drilling mud.
- Phase 3: Deploy centralizers.
- Phase 4: Push down the cement using the mud, and, optionally, use a specific toxic foam as a spacer to decrease costs by $1 million.
- Phase 5: Replace the drilling mud with seawater and prepare the separation of the rig.

At the beginning of each phase, participants receive information about the current situation and their objectives. The dashboard is shown in Figure 1.

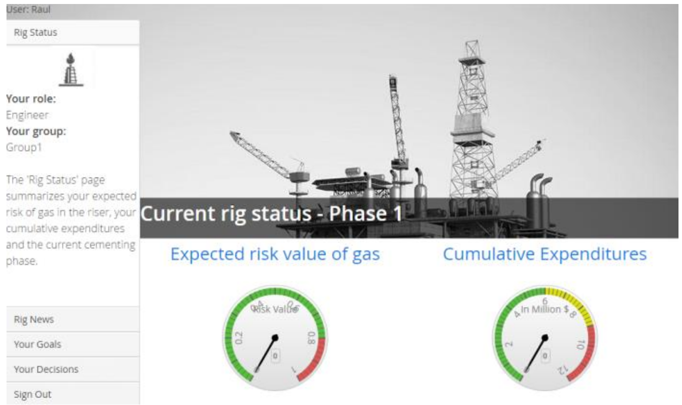

Figure 1: The dashboard shows the current status of the rig: Expected risk value of gas, cumulative expenditures, and access to information and decision sections.

The team must decide whether it makes sense in the current situation to delay further processes and inspect the well (opt for safety) or to proceed to the next phase (opt for cost efficiency). Figure 2 shows such a decision form. The delay is called *check* and comes at a cost. If a *check* is performed, the actual status of the rig will be reported, and possible countermeasures will be implemented automatically. However, a *check* is not necessary for every phase. An unnecessary *check* can even put a strain on the well and increase the risk of gas ignition. The information required for the decision *check* or *no check* can be derived from the information given in each phase. In summary, each team member has to decide individually in each phase, whether to

- Proceed to next phase (*no check*): Cost of $1 million
- Proceed to next phase and *check*: Cost of $2 million

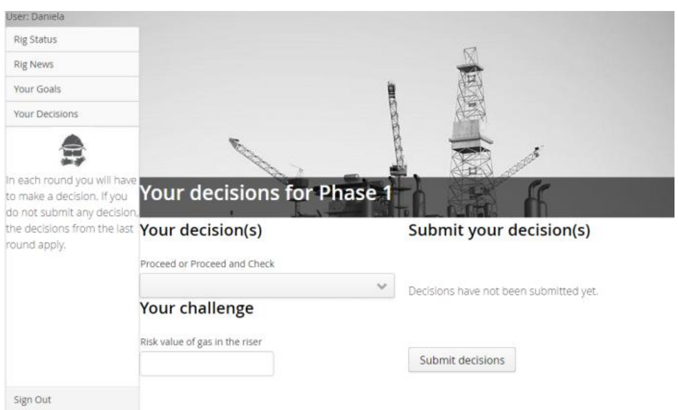

Figure 2: Decision form with three action items: (1) Decision on *check/no check*, (2) individual *challenge,* and (3) Submit Decisions button.

The final decision is based on a majority vote. If two team members select *no check* while three opt for *check*, the team proceeds to the next phase and executes a *check*. The project manager initiates the move to the next phase after everyone submits his/her decision. The team performance is measured using three factors:

- The group's ability to complete the five phases with the lowest cost while keeping the risk level below a certain threshold.
- Individual performance in achieving personal goals and solving the *challenge*.
- The group's conformity in decision-making.

An important factor when deciding whether a *check* is necessary is to assess the risk of gas ignition in the riser correctly. The risk value is assessed in intervals from 0 (no risk) to 5 (very high risk). Every decision in a particular phase is associated with a certain risk. The risk value can be calculated based on the probability that gas will enter the riser, multiplied by the severity of the issue, on a scale of 0 (no damage) to 5 (very severe damage).

4 GAME FLOW AND RESULTS

The Rig is played in five rounds. After the pre-reading, the instructor briefs each team separately on just one of the four following debiasing techniques:

- Group elicitation techniques
- Psychological safety
- Risk value calculation and conditional probability
- Negative alternatives and challenge of probability assessment

If the number of groups is less than four, the instructor can also brief groups on multiple techniques. The purpose of this briefing is to draw attention to cognitive biases and let the participants figure out when to apply them properly during the five rounds.

Before the game starts, each member is assigned a specific role, and gets his/her brief role background and individual login credentials for the game (username/password). Ingersoll et al. (2012) provide an organizational chart of the different roles. The background information, as listed in Table 1, is kept very brief, because participants should not pretend to act but rather be themselves. However, the information provided should create some tension based on authority coming from experience, because this was also the case in reality (Safina 2011).

Table 1: Roles, background information, and goals summarized from Safina (2011). Low cost: equal to or less than $7m expenditures; medium cost: equal to or less than $8m expenditures; high safety: 4 checks; medium safety: 3 checks; low safety: 1–2 checks.

Role	Background Information	Goal Priorities
Project Manager	10 years of work experience	1. Low cost 2. Medium safety
Well Manager	Very new on the Deepwater Horizon, primary experience in land drilling	1. High safety
Engineer Manager	25 years of work experience	1. Medium cost 2. High safety
Engineer	Working on the Deepwater Horizon for 3 years	1. Medium safety
Tool Pusher	Working on the Deepwater Horizon for 9 years	1. Medium cost 2. Low safety

For each round, every team member gets some private and common information about the current decision. The team should pool all private and common information to assess the current situation, solve the individual challenge, and decide correctly whether a *check* is necessary. The risk value and expenses are calculated based on the majority *check/no check* decision, and the new round begins with new information on the current phase. After round 5, the game ends, and if the risk value exceeds a certain threshold, the rig blows up. The game flow is depicted in Figure 3. The debriefing starts with collecting feedback from the participants, regarding:

- What was challenging?
- How did you organize decision making?
- How did you exchange and pool information?
- When and how did you use any of the debiasing techniques?
- Did you sense that the group or some individuals might run into a wrong direction (cognitive bias)?

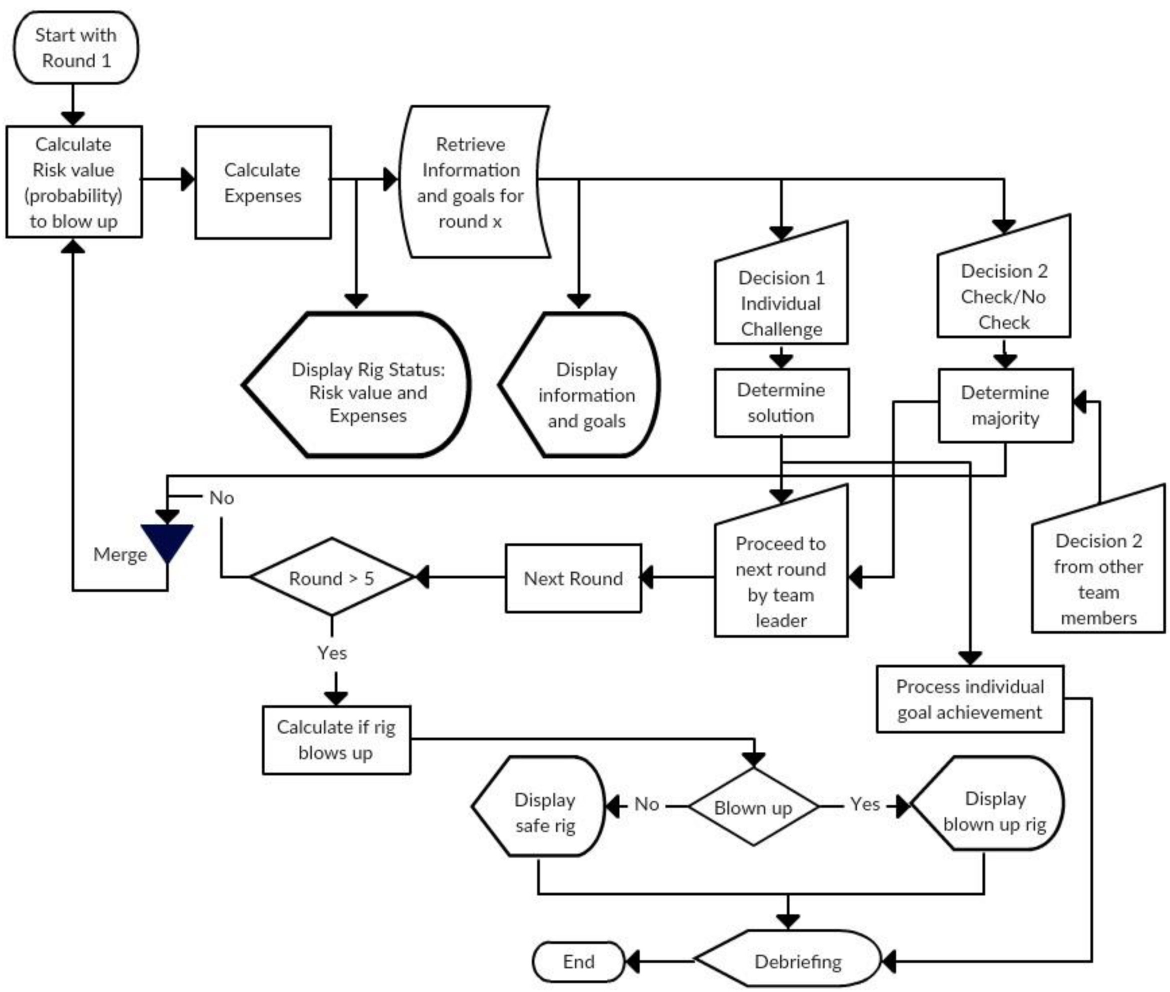

Figure 3: The flow chart of the game.

After the feedback, the instructor reveals each team's score. Typically, teams blow up the rig and only very few teams manage to survive the last round. Because competition creates excitement in the classroom the instructor should celebrate the winners. However, he or she should not focus on particular mistakes teams might have made. The instructor should increase the excitement by revealing that this game is not an artificial game. The instructor should show a short video or facts about the disaster and highlight that the participants went through the exact states of nature as in the real case. This leads to an emotional state within the classroom where students are curious and shocked at the same time. This moment creates a psychological anchor, and the students are eager to know about why and how it happened. The instructor takes this opportunity of full attention and continues the debriefing with the real case.

The disaster was mainly due to six factors: (1) fewer barriers to gas flow at well bottom owing to the casing model, (2) fewer centralizers to keep cement even, (3) no bond log to test cement integrity, (4) pressure test misinterpreted, (5) mud barrier removed early, and (6) blowout preventer failed (Halliburton 2017). If one of the factors could have been mitigated, the catastrophe could have been prevented. However, the cause of factors (1) to (5) can be mainly attributed to false management decision making. The sixth factor comes from the chain reaction but is mainly due to insufficient operational processes.

In phase 1, the team gets information about the final casing and the number of centralizers used. The probability and severity of gas ignition and information about the risk value threshold to opt for a *check* are distributed among the participants. By pooling all the information, they should be able to calculate the combined risk value and determine if a *check* is needed. This round serves as a warm-up round, and no cognitive bias situation is enforced.

In phase 2, the information on the probability and severity of gas ignition due to the chosen cement mixture and mud circulation parameters is also distributed. Again, information sharing is key in this phase. However, to calculate the correct risk value, the team must also incorporate the risk value from phase 1. Typically, teams do not account for the combined risk of phases 1 and 2, because they oversimplify the model or just ignore important variables (myopic representation bias).

The chief counsel's report states, "BP's management processes did not force the Macondo team to identify and evaluate all cementing risks and then consider their combined impact" (CRC 2011, page 102). The responsible team on the Deepwater Horizon did not consider an overall risk assessment of all cementing steps but rather treated each step as a separate factor. This could have been mitigated by a focus group that looks only at risk values or brainstorming that allows for an alternative perspective on what could go wrong.

In phase 3, the team is informed that only half of the centralizers are available. However, the team members get contradicting information on the risk probabilities and severity when using only half of the centralizers. Thus, they cannot rely on the information given and should perform a *check*. Nevertheless, teams typically opt for *no check*, because data on low risk severity and probability is given to the roles with high experience (authority) and strong cost focus. This creates a situation of tension, where group think appears, and critical voices are neglected for the sake of harmony. The chief counsel's report notes, "communication of centralizer decisions hampered risk identification and management" (CRC 2011, page 105). Indeed, there was a lot of back and forth on the decision to use fewer centralizers than initially simulated. Additional centralizers were ordered at the last minute, but the team worried that those were not the right ones and could delay the cementing process. After the decision to use fewer centralizers despite the risk of channeling, one BP engineer wrote to another team member, "But who cares, it is done, end of the story, [we] will probably be fine, and we will get a good cement job" (CRC 2011, 103). Fostering a climate of risk-free information sharing (psychological safety) would have helped to incorporate critical voices in the decision-making process.

In phase 4, the team can decide to use a toxic foam as a space between circulation mud and cement to push the cement down to the final casing. Using the toxic foam would save $1 million. Information on channeling probability or severity is not provided, except that this method has never been used before. Therefore, the team should opt for a *check* if they use the toxic foam. In reality, it is assumed that the toxic foam somewhat clogged the valves of the wellhead. The team increased and decreased the circulation pressure several times and finally, "personnel then tried to explain away concerns about lower-than-predicted circulation pressures by blaming faulty pressure gauge" (CRC 2011, page 106). The team is exposed to the conjunction fallacy and neglects any disconfirming evidence just to confirm their belief. This situation could have been resolved by taking an outside-in perspective and conducting a proper risk assessment.

In the final phase, phase 5, the drilling mud is removed by the lighter seawater, and the rig is prepared for separation. No information is given on probability and severity of gas ignition. The decision to run a *check* depends only on the assessment of whether return flows are a good indicator that the cementing process has been successful. During the previous periods, the wording "return flows" has been repetitive to create an anchoring effect. In phase 5, information is distributed that return flows are reasonable, suggesting that the cementing job has been successful. However, four other data points are given that directly contradict the idea that the cementing job has been reasonable. Typically, teams tend to rely more on the causality attributed to return flows, because this has been a known indicator in the past. However, assuming an equal weighting of data points, four out of five indicate that the cement job has failed and that a *check* should be performed. The chief counsel's report states, "BP focuses excessively on full returns as an indicator of cementing success. […] The Macondo team's approach to cement evaluation at Macondo was flawed. Because the team focused its attention so heavily on the risk of lost returns, it overemphasized the significance of full returns as an indicator of cementing success. Receiving full returns showed that cement had not flowed into the weakened formation but provided little or no information about: (1) the precise location where the cement had ended up; (2) whether channeling had occurred; (3) whether the cement had been contaminated; or (4) whether the foamed cement had remained stable" (CRC 2011, page 107). Using expert opinions or challenging the risk assessment, including negative alternatives, would have helped to minimize the confirmation bias.

5 SUMMARY

A leadership practice game is presented that can be used to train on debiasing techniques for myopic representation bias, group think, the conjunction fallacy, and confirmation bias. The Deepwater Horizon catastrophe is used as the context for this serious game. Participants undergo the final stage of decision making that led to the disaster. A long-lasting learning effect is created by creating an emotional peak in the debriefing, when the students realize that this was not a game, but that it really happened, and the causes were management and leadership problems that can appear in any other context. The link between the game rounds and what happened in reality is illustrated by real case examples from the chief counsel's report and team member quotes in court. The debriefing highlights the circumstances subject to cognitive biases and emphasizes countermeasures.

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