Play It Safe; Subliminal Learning Through a Situational Occupational Safety Game

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Play it Safe: a situational game for occupational safety

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Abstract This chapter describes the design choices and theoretical constructs that lead to the development of an occupational safety game, going by the name Play it Safe. Play it Safe is a tower defender game that uses situational data collected by the employees during their daily work to impact the parameters of the video-game. This data is gathered through a safety-campaign named count yourself lucky wherein the employees are asked to carry around a tally counter that, asks them to count an safe/unsafe aspect of their daily work process or the times they used the supplied safety technique Stop Think Act Review (STAR). Though far from a simulation play it safe creates the parameters for similar decision-making encountered in the work environment and subliminally reinforces the training of the STAR-protocol and conservative decision-making. Th-sly improving employees situational awareness as well as creating a shared mental model, which improves their shared safety behaviours.

1 Introduction

Every company with employees at some point experiences accidents. The Incident frequency rate (IFR) varies among sectors, as do the risk factors inherent to certain jobs. Measures to maximize safety (knowledge, protocols, conditional safety structures and safety interventions) contribute to lowering IFR. Not all companies are pro-active when it comes to safety, however even companies at the top of the safety culture-ladder whom have taken ample precautions, can only bring down their IFR to a certain level. Even when equipped with all the right tools in the correct environment the human factor enables employees to fail; as routine kicks in vigilance checks out. To bring safety awareness to the next level serious gaming might have a role to play in occupational safety.
1.1 Occupational Safety

After physiological needs the second step in the hierarchy of needs on the pyramid of Maslow [11] is safety. Occupational safety has been a priority in the workplace since the beginning of the 19th century. The last decade safety structures placed great emphasize on rule-based and behaviour-based safety. This approach has been described as Model 1[8] and is predominantly a top-down approach. In Model 1 workers attain knowledge, skills and act as rule-based operators that never break golden rules which are strictly enforced top-down. In Model 2 these same rules apply, however they are seen as guidelines for the competent professional [8]. They are reinforced bottom-up and dynamically, this results in safety solutions coming from the employee instead of the management. Whichever Model is used the safety climate and culture of the company implementing the safety intervention has been found as a key indicator for the attempted safety intervention [9]. Besides the safety climate and culture in around the company a large part of safety science also focus on the conditional safety. Conditional safety focuses on making the environment as well as the equipment used as safe as possible. This is realised by providing instructions, use of warning signs, protective gear to make the equipment and the work environment as safe as possible.

The primary cause of error and (almost) accidents is the human operator. Therefore in safety science Human Error [16] modelling based on the underlying strengths and limitations of the human operator is used to design protocols, rules, machinery and overall resilient systems to minimize accidents. Unsafe acts can be divided into execution error (correct plan, wrong execution) and planning errors (incorrect plan). Execution errors can be divided into slips (attention failure) and lapses (memory failure), planning errors can be either rule-based or knowledge-based mistakes (unintentional decision to act against rules or standards) and violations (deliberate decisions to act against rules or standards). To further understand human error Rasmussen [15] developed the human performance model, consisting of the following levels.

- **Skill based behaviour**: an automatised sensory-motor performance that one can perform without conscious control.
- **Rule based behaviour**: based on stored procedures, gained through experience and learning. It works through recognition, association of state/task and then using the stored rule for the task
- **Knowledge based behaviour**: when confronted with unfamiliar situations, where explicit thinking is necessary to develop a plan and try it and see if it works. It works through identification, decision of task and planning

The different levels of the model aren’t alternatives and therefore can be accessed at the same, however they get triggered for different situations. The mental model workers have of the situation around them, i.e. Situation Awareness (figure 1) [6], and the decision making depending on that situation are highly influenced by the performance levels used by the operators. SA came from military aviation [5] but since then has been used and researched in a far range of contexts and fields.
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Sley's definition of SA is: "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" [6].

This process is automatic, however perception, comprehension and projection of how an situation will evolve depending on the action a worker is planning to undertake is vital in planning to and undertaking action. When making a decision to perform a task, it is vital to base that decision on a correct state of the necessary elements in the environment around you. Therefore a review of the taken action and possible deviations of the projected state of the environment are important learning moments. Besides individual SA, there is also Team/Shared SA, the understanding between team members of their mental model of the situation. A high level of shared SA between team members, provides an work environment wherein the needs and way of approaching tasks and situations of others is understood and taken into account [19][18]. Therefore a high SA is a vital part of safety on the work-floor and, individually as well as in a team, will make it a safer place.

1.2 Play it safe

The Play it Safe project was established to address the needs of several small large companies working in high-risk and highly dynamic task-environments. All of them where faced with the same dilemma; specific rule-based behaviour and the specific task-related knowledge was available and being reinforced, accidents however still happen. Therefore new safety programs/interventions can give short or a maintain-
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ing boost to the employees safety awareness and are welcomed. Play it safe aims at creating top of mind safety awareness for workers in the construction and maintenance industry. The workers work in small teams with variable constitution and at varying locations. Obviously these workers know the safety rules, but in the heat of the moment slips, lapses and errors occur. Play it safe focuses on preventing accidents using a cognitive intervention called STAR (stop, think, act, review), for procedural tasks, focussing on the context outside the game rather than the content within the game.

This chapter describes the trials and tribulations of the design and development process of a serious game with the goal of behavioural change towards occupational safety aspects belonging to dynamic high risk environments. The introduction focuses on a short outline of occupational safety trends and related work in the field of serious gaming, as well as a short outline of the focus of play it safe. In the Design For Safety Section the design process is outlined, where the concept of situational gaming is explained, STAR and the surrounding safety concepts are explained and the implementation plan and model is explored. The Play it Safe the video-game describes the video game play it safe and the Game-model behind the game-play and game-mechanics as well as the transformational and subliminal learning in the game. The discussion section describes the possibilities of situational games and the initial experiences with Play it Safe and the count yourself lucky campaign.

2 Designing for Safety Awareness

Occupational Safety Games have predominantly been simulation games. Simulations for safety training depend heavily on a high match between content and context, a high level of fidelity and a low level of play (or no play at all). Issues with these simulations are that they:

- Almost automatically create a mismatch between the desired blend of entertainment and learning [17] within the game, missing out on the positive effects of entertainment on learning [7].
- Require extensive training needs analysis (TNA) methodologies [2].
- Can only be used for specific goals and situations. A created scenario within a simulation will only be useful for a specific target group and will only encompass limited tasks and environments. In an occupational safety game it would be impossible to simulate and program every possible accident or near accident inherent to the particular task in the particular work sector/industry.

Therefore, instead of focusing on the specific outcomes of specific risks of specific task-related accidents, the more practical and achievable goal might be to intervene in the mental model an employee applies to approach general tasks, environments and situations.
2 Designing for Safety Awareness

2.1 Situational Gaming

Situational games are games wherein real-life data is used to effect the parameters of the game, often through the use of cross and trans-medial applications. The idea is to gather situational data and play the game in close proximity or on the location or in the context were the initial problems arise.

The basic conjecture of the effectiveness of a situational games for serious purposes is that situation provides an authentic setting that engages a player, that helps to realise the logic, and that triggers the player into action. The authenticity provides the necessary meaning and appreciation. The situation plays a role in multiple dimensions of persuasion, i.e., striving to persuade players to change their behaviour. The framework helps to make the role and possibly the impact of situation explicit during the design of serious games. Situation contributes in a positive way in reaching the underlying objective of the game. Our framework consists of four basic elements: pervasive, simulation, eventing, and gamification.

For Play it safe we are using sitgames to increase safety awareness amongst workers. Eventing, thus taking real life events into the game play, is suggested to be a good starting point for any sitgame. Finally, situation determines the effect of a trigger. Triggers, when carefully timed and carefully chosen, provides the spark to truly activate a change in behaviour. By adhering to a persons situation, triggers become authentic and actions become meaningful. The subject can identify itself with the matter.

2.2 Play it Safe; Count yourself lucky with STAR

The videogame Play it Safe isn’t a stand-alone intervention, it needed a second vehicle to create the situational input and also a system to gather this input. Through the project, state of the art sensors and other elaborative options were proposed, however they proved to be infeasible in a highly dynamic high-risk work environment. For instance many companies didn’t allow smart phones because of the digital disruptions could prove dangerous during work hours. Therefore an analogue solution was found.

Play It Safe uses the safety intervention STAR combined with situational aspects, i.e. events from the work floor are integrated to have effect in the game. STAR (Stop, Think, Act, Review) is a mental protocol to facilitate safety awareness. This mental protocol attributes the creation of awareness of a situation to three entangled processes: perception, comprehension, and projection. These processes attribute the enclosing environment, the physical context. The mental model is completed with a decision making process and an effectuation of an intended action. The action obviously affects the state of the immediate environment. STAR is and has been used in several fields and is closely modelled after SA (see figure 4).

STAR has different modes of use (see figure 2);
1. As a **standard protocol** to be used with every task (skill-based behaviour)
2. As a **critical task protocol** to be used only with tasks that are deemed to be a risk and require full attention (rule-based behaviour)
3. As a **emergency protocol** to be used when something goes wrong and one finds oneself in an unfamiliar situation. (knowledge-based behaviour)

In the implementation of Play It Safe STAR was utilised and integrated in all of the aforementioned modes. STAR was also used to detect deviations from the projected outcome of situations and record these with a tally counter (CYL), that amount was then used as an in-game reward.

Uses Outside of the game (see figure 2):

- As a **safety protocol** to work with and after practice be part skill-based behaviour, rule-based behaviour and knowledge-based behaviour and enhance the communication culture and Team/Shared Situation Awareness, through mere learning on a leaflet and demonstrations.
- As a **detection tool** for situations that deviated from the projected outcome of an action (through the Review in STAR), of oneself or others. Which was the input of the CYL score, keeping score per day on a tally counter.

The core motivation to use one’s tally counter in the CYL-campaign is to gain an in-game advantage the use of an EMP in the game that makes it possible to get further in the game. The EMP however is a gamified STAR protocol that lets the player subconsciously do two things, in the game;

1. **Asses** when the in-game situation becomes too dynamic to project a clear outcome, i.e. being unable to project the situation state after the action is undertaken.
2. While using the EMP players are forced to **Review** the situation and reorder the elements in the situation.

![Fig. 2](image_url) Shows the ubiquitous workings of the STAR-protocol as a. situational safety detection tool b. a game-mechanic and c. a textual intervention

The ubiquitous implementation of STAR (see figure 2) trains players outside outside of the game to use a mental protocol to integrate into their daily working be-
haviour, while at the same time being a detection tool for situations that deviate from their projected outcome. This facilitates the players to take a closer look at their daily working environment and the boundaries to safe work within them, as well as noticing the limitations or shortcomings of conditional safety structures. The CYL is motivated by the in-game reward system while in the game the STAR is subliminally reinforce the already learned protocol in unrealistic situations that require and train the players SA.

Because the Game is played during lunchbreaks on the workplace the workplace situations become more tangible and the implantation of the CYL score can become an easy opener to discuss workplace safety amongst collegues. Furthermore because all collegues are using the same protocol the Shared/Team SA is trained and barriers in individual SA can be discussed as requirements for a high Team SA, creating an open communication culture where top-down initiatives are harnessed.

3 Play it safe

Play it safe(see figure 3) is a touch-screen tablet-based video game of the Tower Defence genre, the objective of a tower defender is to protect ones base against an enemy that wants to steal the supplies stored in that base. To succeed in this objective the player builds towers, tactically placed around the area to kill the stream of enemies. Play it Safe differs from traditional tower defence games, with the addition of workers that build and fix the towers and the possibility to use an Electro Magnetic Pulse (EMP) as a strategic advantage. The story behind the game is that a spaceship has crashed upon a distant planet that is inhabited by bug-like aliens that are attracted to you energy cores that you need to power and repair the ship. To defend your crew and ship against the bug-like aliens you build guard towers that automatically shoot the bug-like mechanised aliens.

3.1 Game objects

Energy Cores

The energy cores are the main assets in the game. Workers try to defend it and the enemies attempt to steal them. They are kept in the base spaceships.

Base

The home base of the game avatars is a spaceship wherein the energy cores are stashed. Members from the workforce enter the game through the base when the player starts to build.
Fig. 3 Shows a screenshot of Play it Safe being played

Enemies

There are two kinds of mechanized bug-Like Aliens. Both types can steal energy cores however the Eaters will attack towers and workers on their way whereas the collectors will go straight for the energy cores.

1. Eaters, their main objective is to destroy towers, by gnawing on them.
2. Collectors, their main objective is to walk into the base pick up an energy core and walk away with it.

Workers

To build Turrets it is necessary to have workers to build and restore the before mentioned turrets. There are 3 types of workers.

1. Builders build towers and repair towers
2. Firemen extinguish towers when they are on fire.
3. Mechanics fix mechanical damage in the towers.

The player can distinguish between the 3 types by the visual appearance of the workers. Your entire workforce has a single primary objective, and a fitting suit to perform this task. It is possible to assign tasks to avatars that are not there primary objectives; the avatars will however be slower and less successful in performing these
3 Play it safe

Fig. 4 Shows the proposed schematic behavior and attitude changing model.

non-primary tasks and are in more danger. When either enemies or fire/radiation from a tower hurts a worker, their health declines or they eventually die. To heal your workers you can direct them into a tower in a normal state, where they are healed.

Towers

Before building a tower you have to check the integrity of the ground you want to build it on, the higher the integrity of the ground the more resilient your tower will be against enemy attacks. Towers can be placed anywhere on the map and shoot intruding enemies at sight. Whenever enemies damage towers, their states deteriorate and markers (electricity sparks or fire) are visible before they eventually collapse or get repaired. The workers can hide in the tower when enemies are close.

3.2 Game Mechanics

Count yourself lucky score

In the start screen of the game the player is asked to fill in the day score of the previous working day of the CYL score. This score is used to determine the amount of EMPs available to the player in the game.

Courtesy of the Serious Gaming group, NHL University of Applied Sciences.
**Ground inspection**

To build towers the integrity of the ground can be checked with a special option to use a looking glass that gives the percentage of the ground-integrity. This integrity influences the towers deteriorating process.

**Electro Magnetic Pulse (EMP)**

The EMP can be used either to freeze all enemies as well as the workers or to just freeze your enemies, depending on successfully using the touch screen hold mode on the intended icon. In either situation it gives the player time to STAR and gain a new oversight in the game that was lost due to the pace in the game.

### 3.3 Gameplay

When the player starts the game he can build as many towers as time allows before a first wave of enemies arrives. The arrival of enemies is usually preceded by an alarm but as with any action in the game there are exceptions that keep players on their toes. Building towers can be done with workers, when chosen workers with their primary objective to build, towers will be finished quicker. When towers are build you can put your workers in the towers so they wont get hurt by the alien robots. After or during these attacks you can take them out to fix broken towers, however there is the risk that they will get hurt.

Enemies approach in waves, so usually there is time after a first wave there is time to regroup and fix or build extra towers. During waves pressure builds and it get harder and harder to keep control over your workers while keeping track of the states of the environment as well as your enemies. It is possible to use the EMP mechanic to regain control over the game environment and regain situational leadership over your workforce.

If you keep energy cores in the game, you win as soon as your lose all of them you lose. Extra points and badges can be won for using workers for their primary objectives as well as using the EMP or not letting your workforce get hurt.

### 3.4 Transformational and Subliminal Learning

Play it Safe uses a figural transfer to create a metaphorical low-fidelity game-world wherein less explicit and extensive parameters apply compared to the workplace through the use of, i.e. a metaphorical re-contextualisation [10]. In the Game-world there is observable (enemies) and non-observable (ground-integrity) danger and time-pressure, which force the player to keep reasseessing their plans and the environment. Not to recognize specific or realistic threats, but to gain insight and
perspective on the need for an oversight into the aspects of a situation, i.e. normal situation awareness and the necessity of conservative decision making within a dynamic environment.

Mitgutsch [12] distinguishes three stages of learning through serious games aligning with Bateson [1] stages of learning; (1) in, (2) through and (3) beyond the game. In case of Play it Safe the transformational learning process is.

1. In the game the player carries out random tasks at hand and leads a workforce that can change into various states. Through trial and error the player reacts to the game environment and learns to play the game.
2. Through the game learning the player will subconsciously learn what the limits and barriers of their situation awareness is and when they reach these parameters.
3. Beyond the game learning at this stage, is expanded to real life contexts outside of the game. The player learns the barriers for high situation awareness in their working environment. And is subliminally learning how to use STAR in skill-rule- and knowledge-based behaviours to reduce errors, slips and lapses and ultimately the companies IFR.

SA and STAR are used to overcome the in-game challenges without being explicitly thought, creating an implicit training tool that can be used for competition and entertainment.

4 Conclusion

This Chapter explored the possibility of using situational aspects in a video game. Play it safe focuses on preventing accidents using a cognitive intervention called STAR(stop, think, act, review) a tool used to focus attention when performing routine but important procedural tasks, focussing on context rather than specific content within the game. Preliminary trials show that the safety-leaders on site of the respective companies, noticed more interaction and respective tally counters scores when group activities took place then when solitary tasks were performed. The CYL campaign increased the communication culture about safety during these group activities, implicating a grow in Shared SA. This may implicate that the simple task of making a conscious note (although it just being the act of adding a click), can be tangible trigger to enhance situated cognition through situated play [14].

Play it Safe harnesses the motivating and rewarding aspects of in-game rewards for out-game actions (CYL), as well as subliminally reinforcing the outside game actions in the game. Creating a cyclical back and forward training tool, not to create high vigilance at all moments, but to recognize the barriers that make recognition of and incomplete view of the situation unsafe. Performing knowledge-based behaviour while wrapped up in other tasks can be dangerous at any time [20], therefore a insight in cognitive overload can be a powerful tool for safety awareness. As a Situational game the environment becomes a trigger in and outside of the game; safety
on the work floor, gaming on the work floor and safety in the game and outside of the game.

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