Approaches to Strengthen Behavioral Prevention in a German Medium-Sized Enterprise

Lisa Rücker and Johannes Brombach

Abstract

The improvement of working environment and in particular behavioral prevention has a long tradition in the maintenance of industrial health and safety standards in Germany. Despite further automation of the value process accompanying industry 4.0, human behavior and its impacts in terms of occupational health and safety must not be neglected. In the context of safety regulations and "unsafe behavior", this contribution deals with targeted analysis, the development of practical implementation measures for the reunification of behavioral and situational prevention, as well as the involvement of employees in the continuous improvement process.

Keywords

Behavior-based work safety • Maintenance of industrial health and safety standards • Continuous improvement processes (CIP) • Behavior based safety (BBS)

1 Introduction

Occupational safety continually gets more attention in industry during the last few years. In the age of automation, the fallacy arises that machines and robots are mainly responsible for producing products and services. However, even today, still 70 % of the national product are generated by manpower [12]. So "health and safety" is an intensely discussed topic and not only under cost-related aspects.

L. Rücker (✉) • J. Brombach
Faculty of Engineering and Management, Munich University of Applied Sciences, Munich, Germany
e-mail: ruecker.lisa@hm.edu; johannes.brombach@hm.edu

© Springer-Verlag Berlin Heidelberg 2016

B. Deml et al. (eds.), *Advances in Ergonomic Design of Systems, Products and Processes*, DOI 10.1007/978-3-662-48661-0_10

Especially for today's company, occupational safety has become a fundamental basis for successful enterprises.

A majority of work accidents are based on "unsafe behavior" of the employees (also called unsafe acts) [10]. Already in Loafman [9] talked about as much as 94 %. According to the German Federal Statistical Office, in 2013 almost 90 % of all work accidents could be explained by unsafe behavior of the employees [8].

► Unsafe behavior is defined as the performance of a task or other activity that is conducted in a manner that threatens health and safety of workers or other people.

Germany traditionally focuses on the technical and organizational occupational safety and health (OSH) [11], driven continuously by activities of legislators, companies, trade unions and accident insurances. The English space, however, is marked by behavioral-based prevention approaches [2]. One of these approaches is the "Behavior Based Safety—BBS".

2 Methodology

"Men act upon the world, and change it, and are changed in turn by the consequences of their action." [13, p. 1]. In the first instance the question is considered, why do people show a certain behavior. For this purpose, the Antecedent-Behavior-Consequence model (ABC-model, Fig. 1) by Skinner [13], which he used in the linguistic behavior analysis, can be consulted. People are influenced directly or indirectly by events in their environment.

This model describes that the behavior ("B"), i.e. an act or omission, is triggered by the "antecedents" ("A", preliminary conditions). Antecedents take place prior to the behavior. Relating to the occupational safety these preliminary conditions are e.g. trainings, manuals or the working environment [2]. However, preliminary conditions have only a low impact on behavior (share of approx. 15 %).

On the other side are the "consequences" ("C"), which occur as a result of a certain behavior. They can have a reinforcing or weakening effect and influence the behavior up to approx. 85 %. If a behavior is reinforced by its consequences, the likelihood of recurrence of this displayed behavior increases. Conversely, in the case of a weakening, the likelihood that a displayed behavior will be repeated, declines [2].

Possible consequences include, i.a., punishment, positive or negative reinforcement. While a behavior decreases by punishment, it increases by positive or negative reinforcement. By negative reinforcement, the individual is encouraged to a certain behavior in order to prevent something undesirable (e.g. adherence to the road traffic regulations in order to avoid fines). In contrast, by positive reinforcement, an individual shows a certain behavior for being recognized, praised or rewarded materially [4].

Fig. 1 The Antecedent-Behavior-Consequence-model

While most consequences only have temporary effects, positive reinforcement can sustain a certain behavior permanently. The method "BBS" is based on these principles of positive reinforcement [10].

BBS orientates itself on the security pyramid of H.W. Heinrich, which describes that an accident at work is preceded by a variety of unsafe behaviors. This method is promoted by employees. Its aim is to draw attention on safe and unsafe behavior by mutually observing and giving feedback. Thereby, on the one hand, safe behavior is encouraged by positive feedback, on the other hand, unsafe behavior can be reduced through specifically derived measures. In the long term accidents and injuries can be prevented. While most approaches are guided by supervisors, BBS focusses on the employees steering this method (bottom-up). Employees accept responsibility for their own occupational safety as well as those of their colleagues. They are supported by their superiors.

2.1 The Five Steps of BBS

A founder of behavioral safety, E. Scott Geller, ascertained: "It is much more cost-effective to 'act' an employee into safe thinking than it is to 'think' a person into safe acting." [6, p. 309].

As a continuous improvement process BBS is divided into five steps, in the form of a circuit (Fig. 2).

In the first step, a behavior is defined, which should be displayed by an employee in a certain situation. There are special requirements for the definition of a behavior, e.g. clarity, measurability, observability etc. [5] (e.g. "The employee wears safety glasses while drilling"). Information to define a behavior may be found in accident reports, first-aid books, near-accidents and employee interviews etc. Afterwards, these defined behaviors are summarized in the form of an observation card (cf. Fig. 5) [10].

In the second step, the corresponding behavior is observed by using the observation card. It is individually designable when observations are made, whether there are specific fixed periods or typical situations in use. There are moments, for example, where an employee has to wait for the work process of a machine. The observations are documented (anonymously) in the form of a tally sheet (cf. Fig. 5),

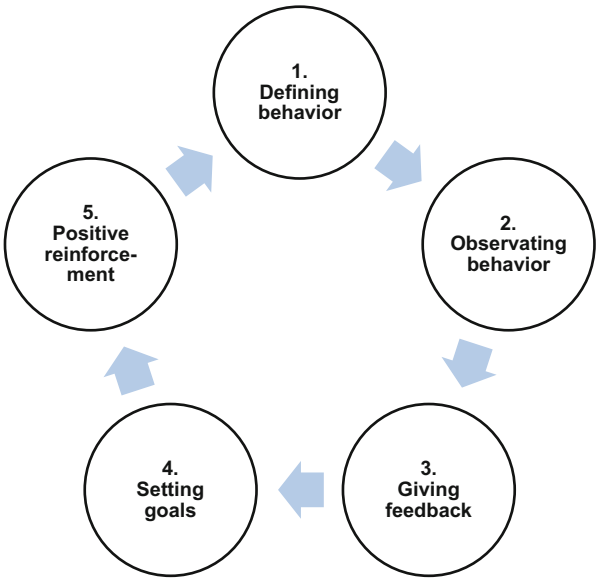

Fig. 2 The five steps of BBS

e.g. there is no name on the tally sheet, neither of the observer nor of the observed person. Through this we can avoid the distress of possible negative consequences [2].

Besides observing the employees, feedback is given about the observed behavior (third step). Depending on whether a safe or unsafe behavior has been observed, they get a positive or a constructive feedback including an explanation. Examples: "I saw that you were wearing protective clothing while deburring. I like that, keep it up."; "I saw that you weren't wearing protective gloves while handling raw material. Please use them next time, so you do not cut yourself on the sharp ridges and edges."). The most common form is an oral feedback, which should occur straight after the observation and is only intended for the observed person. There is also the possibility of graphical feedback, often depicted as line graphics. Here, however, are only published results of groups, departments or the entire company, but not of an individual. In very rare cases written feedback is also used [2].

In the fourth step, goals or interim targets are set, which should be reached in a certain period (e.g. increase of the share of safe behavior by 20 %). Thus, the basis for determining the objective is the current situation, i.e. the current share of safe behavior [5, 10].

Finally, positive reinforcement is placed in the fifth step. It is a key aspect of the BBS and differentiates this system from most traditional approaches. An event is seen as a positive amplifier, if according to BBS a safe behavior occurs frequently in the future. This phenomenon is called "law of effect" [14], i.e. "responses that produce a satisfying effect in a particular situation become more likely to occur again in that situation, and responses that produce a discomforting effect become less likely to occur again in that situation." [7, pp. 108–109]. When correctly used,

giving feedback is often already a positive reinforcement. With the positive feedback (as a result of shown safe behavior) having a satisfying effect, this consequence will contribute to a continuous occurrence of safe behavior. In this context, also setting goals and interim targets can be used as a further amplifier [2]. In addition, a variety of studies indicates that employees receiving positive reinforcement are more communicative, performance oriented and creative [3]. Besides these described social amplifiers (e.g. praise, recognition, achievement of objectives), in some cases material amplifiers (e.g. food voucher) exist. However, the focus of the BBS lies on social amplifiers [2, 5].

2.2 Implementation of the BBS in a Medium-Sized Enterprise

As shown in Fig. 3 the possibility of introducing the BBS in a German medium-sized metalworking company has been explored in three phases within a period of 6 months.

2.2.1 Safety Assessment

Within a safety assessment (phase 1), the corporate and occupational safety culture of the enterprise are analyzed.

The analysis of the results of an employee survey in 2013 (participation rate 74.5 %) showed, i.a., that current working conditions are considered to be very good (e.g. all required tools are available). Furthermore, open and trustful communication, as well as mutually given feedback, are frequently used in practice and there is an established culture of error tolerance. This analysis shows that the necessary basis for the implementation of BBS is a present topic.

The number of accidents were first compared with the industry average of the corresponding professional association. With regard to the total number of work accidents in 2013, the analyzed company is well below average. These work accidents were subsequently statistically evaluated concerning their technical/organizational and behavioral (personal) causes, on basis of accident reports and analysis, as well as on an accident data table. As Fig. 4 shows, 83.9 % of all work accidents are associated with behavioral causes. These results reflect a high level of technical and organizational maturity of the enterprise. According to this, the introduction of BBS for long-term reduction of work accidents promises high chances of success.

2.2.2 Planning and Implementation Phase

During the preparations of the test phase (phase 2), two pilot departments of one plant were selected (one production and one training area). The employees were systematically introduced to BBS through the following individual training sessions.

Beginning with a survey, the general willingness of employees regarding work safety should be carried out. Moreover, possible potential danger of the particular department should be identified (e.g. “What activities in your workspace would you

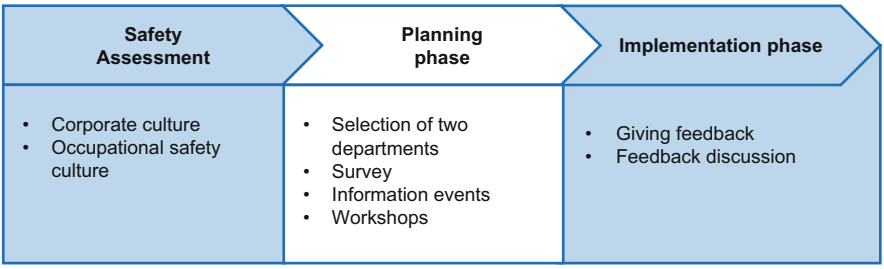

Fig. 3 Implementation plan of the BBS

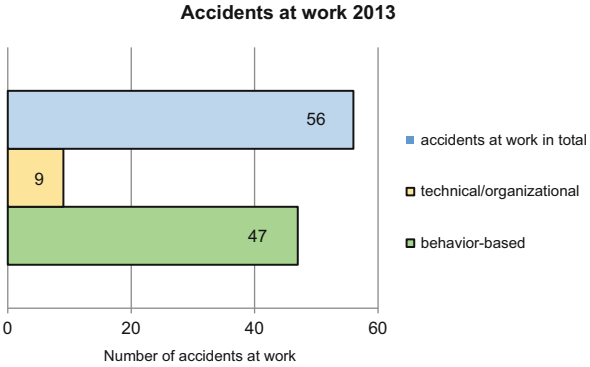

Fig. 4 Accidents at work in 2013

consider as particularly risky?"). The latter is especially interesting, because an employee is usually more familiar with his own workstation and therefore possible dangers are estimated very well.

The survey was followed by a one and a half hour information event preparing all employees for the upcoming test phase. Beginning with an introduction to general occupational safety (including the results of accident statistics), information to behavior-based occupational accidents and unsafe behavior were given. The employees got a detailed explanation of the method of BBS, including definition, its purpose and their own role in this system. Finally, further proceedings with regard to the test phase were discussed.

Specific trainings for a small group for each department (four employees) about observing and giving feedback, as well as the definition of behaviors could successfully be realized by these workshops. For practice, real accident analysis and first-aid books of other plants of the enterprise could be used exemplarily. Subsequently, four to five specific behaviors were identified for each area by using behavioral accident analysis, first-aid books, an evaluation of the prepared questionnaire and a typical course of a day and its workflow, which the employees prepared in advance. The behaviors defined in the workshop formed the basis of an observation card (cf. Fig. 5), which is used to document the observations during the

Department: _____
Date: _____ Sheet P-01

Nr.	Behavior	Safe	Unsafe
1.1	While hand deburring and handling raw materials/workpieces, the employee takes care of the work safety aspects. E.g. weight, using PPE (especially safety gloves and safety goggles), etc.		
	Causes for "unsafe": Possible countermeasures:		
1.2	The employee pays attention to safety, while dealing with oils and cooling lubricants, e.g. using personal protective equipment (PPE), order / cleanliness, etc.		
	Causes for "unsafe": Possible countermeasures:		
Further observed hazards: - e.g. near-accidents - technical and organizational, as well as behavioral causes			

Fig. 5 Part of an observation card

test phase. As Fig. 5 shows, safe and unsafe behaviors are recognized by tallying up the totals. This observation card was prepared accordingly to the theoretical BBS approach, but extended during the investigation by the following specific fields:

a. Employees can add causes for “unsafe” executed behaviors and also define countermeasures (elimination/improvement), if possible.
b. Additionally, employees can document undefined, unsafe behaviors and risks, e.g. near-accidents. Besides the behavioral causes, also the technical and organizational deficiencies should be listed.

Thus, this addition offers the opportunity to identify any technical and organizational defects at an early stage and also to avoid accidents at work.

During the subsequent 4-week test phase (phase 3) observations with daily documentation were conducted. The first week started with concealed observations

Nr.	Verhaltensweisen	Sicher	Nicht sicher
1.1	Der Mitarbeiter achtet beim Handentgraten und Hantieren mit Rohmaterial / Werkstücken auf die arbeitssicherheitstechnischen Aspekte, z.B. PSA (insbesondere Sicherheitshandschuhe und Schutzbrille), Gewicht, etc.	III	I
	Ursachen für "Nicht sicher": hat Welle innen entgratet und fuhr mit dem Finger über die Kante (ohne Handschuhe) – vergessen Mögl. Maßnahmen: Handschuhe an diesem AP bereitlegen, für wenn MA seine vergessen hat		
Weitere beobachtete Gefahren: **- auch Beinahe-Unfälle** **- Ursache kann sowohl technisch / organisatorisch / verhaltensbasiert sein**			
– Großer KSS-Schlauch stand ca. 30 cm in dem Gang. MA wäre fast drüber-gefallen – Messen, während Maschine noch eingeschaltet ist			

Fig. 6 A small excerpt of an originally filled-in observation card in German

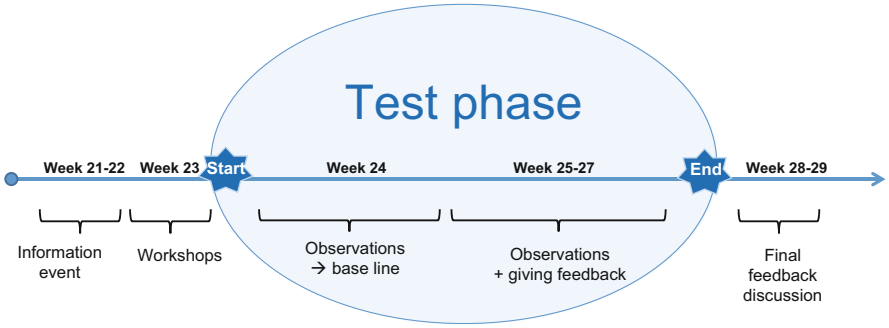

Fig. 7 Time line of the project

to determine the share of safe behavior before starting the BBS ("base line"). In this week, the observers didn't give feedback. The observed neither knew the fact that they were observed, nor which behaviors were observed.

Subsequently observations occurred with immediate oral feedback. Figure 6 shows an excerpt of an originally filled-in observation card in German. The employee noticed for example, that in the concerning workplace safety gloves should be provided, a tripping hazard existed and the machine was not turned off during the measurement process.

Weekly feedback meetings during the whole test phase supported both, the two active observer groups, as well as the regular employees in their daily execution of their work. Figure 7 shows the time line of the whole project.

3 Results

Already after this short test phase, the systematical use led to a better hazard perception and accident avoidance of the employees. Especially for young participants (trainees) a positive change in behavior could be determined. In addition to a higher sense of responsibility towards the safe behavior of their colleagues, they paid more attention with respect to occupational safety issues. Despite initial fluctuations, due to the training and implementation phase of the employees, the evaluation of the observation cards reveals a positive trend. For example, the share of the defined safe behavior "The employee pays attention to safety while dealing with oils and cooling lubricants, e.g. using personal protective equipment (PPE), order/cleanliness, etc." raised from 58.3 % (before) to 67.1 % during this short test phase (Fig. 8). It was observed in both departments (in total eight observers).

Due to low number of responses (eight observers for the above-described behavior) the Wilcoxon signed-rank test was used to verify the significance. Compared to the *t*-test, this non-parametric method doesn't require normal distribution. The test confirmed with a significance level of 5.0 %, that the application of BBS has led to a significant improvement of safe behavior. Nevertheless, the number of test subjects should be increased to get more reliable results.

It can be assumed that a continuing use of BBS will demonstrate a sustainable success in behavior-based injury prevention and the establishment of long-term health and safety measures.

During the implementation phase and the feedback discussions also some serious security problems could be identified and successfully resolved:

a. A used lift truck for high-level racks did not comply with the relevant safety standards anymore. The transported material could tip and fall down, so the machine was shut down immediately.
b. The fork-lift trucks are retrofitted with acoustic signals, in order to reduce the risk of collisions with employees.
c. While withdrawing machine tools, employees often get injuries by inadvertently touching neighboring tools, according to the narrow storage. Within a trainee project the old storage was optimized by a new design (cf. Fig. 9a). Now, the machine tools are placed on different levels and have a larger distance to each other. Figure 9b shows a similar form of storage from another company. A trainee has gone one step further and, as seen in Fig. 9b, developed magnetic protective caps for the milling heads. This idea has been awarded by the professional association of raw materials and chemical industry ("Berufsgenossenschaft Rohstoffe und chemische Industrie") with the special prize in 2015 in the mining sector ("Sonderpreis 2015 Bergbau" [1]).

Due to the success and the positive responses of the employees, BBS will be continued in the training area and should be extended to other plants in the medium term.

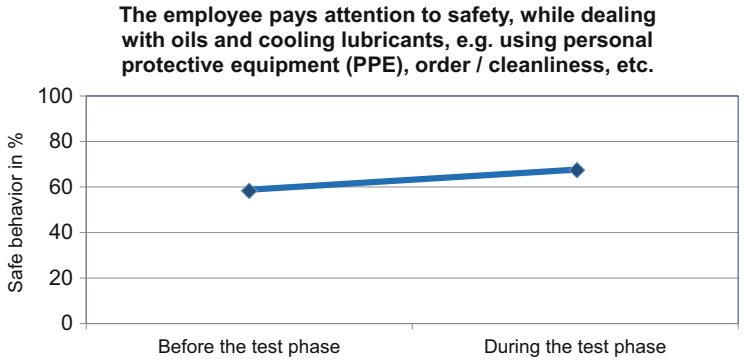

Fig. 8 Graphical analysis of observation before and during the test phase

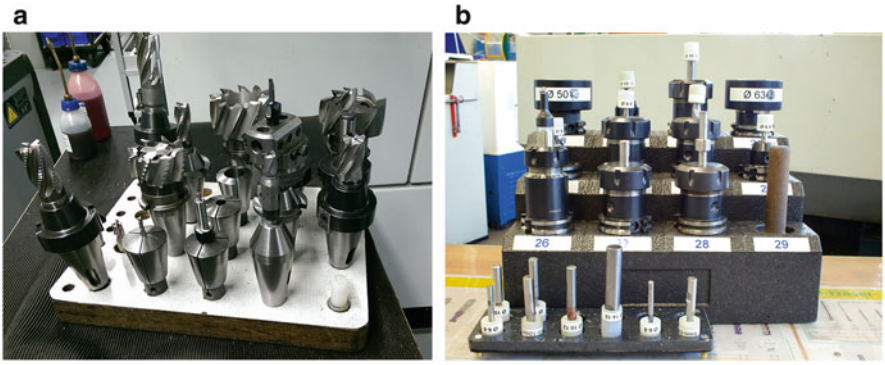

Fig. 9 Narrow storage for machine tools (**a**), magnetic protective caps for the milling heads (**b**) [1]

4 Discussion

The results suggest that a combination of targeted behavioral prevention and the classical German occupational safety and health (OSH) should be implemented in a uniform overall concept together with the idea of continuous improvement (cf. Fig. 10).

In addition to the German occupational health and safety system (i.e. mainly the technical and organizational accident prevention), by using the BBS approach, behavioral accident prevention can be operated. The extension of the observation card, by adding the documentation of further hazards (including technical and organizational causes), provides the ability to bring the company to an optimized position (in all three safety areas). Only a combination of both systems can lead to an effective and lasting reduction of accidents at work.

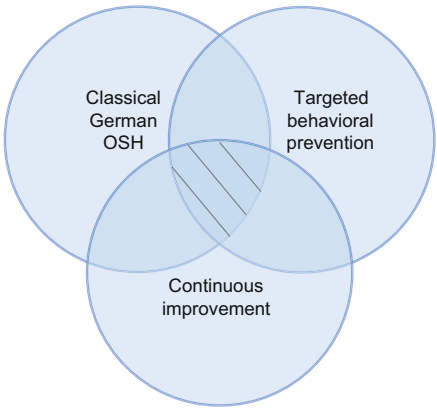

Fig. 10 The intersection of the work-scientific improvement methods

It is particularly important that the legal regulations of occupational safety are involved in the BBS process and not neglected. As the test phase points out, it is advisable to conduct prevention systems during the training period in an integrative framework. In this project especially the intersecting set of the existing approaches was interesting (cf. Fig. 10). In this context, the employees were motivated by the BBS to continually identify hazards and avoid technical/organizational, but also behavior-based accidents.

References

1. Berufsgenossenschaft Rohstoffe und chemische Industrie (BG RCI) (2015) Förderpreis 2015 Arbeit-Sicherheit-Gesundheit. http://www.bgrci-foerderpreis.de/foerderpreis/makepdf.php?nr=1807. Accessed 06 May 2015
2. Bördlein C (2009) Faktor Mensch in der Arbeitssicherheit – BBS. Erich Schmidt Verlag, Berlin
3. Daniels AC, Daniels JE (2004) Performance management: changing behavior that drives organizational effectiveness. Performance Management Publications
4. Edelmann W (1993) Lernpsychologie. Psychologie Verlags Union, Weinheim
5. Fleming M, Lardner R (2002) Strategies to promote safe behaviour as part of a health and safety management system. Health and Safety Executive, Edinburgh
6. Geller ES (2001) Actively caring for occupational safety: extending the performance management paradigm. In: Johnson CM, Redmon WK, Mawhinney TC (eds) Handbook of organizational performance: behavior analysis and management. Haworth Press, New York, NY, pp 303–326
7. Gray PO (2010) Psychology. Worth Publisher, New York, NY
8. Liersch A (2014) Arbeitsunfälle und arbeitsbedingte Gesundheitsprobleme. Wirtschaft und Statistik (Sept): 561–574
9. Loafman B (1996) Rescue from the safety plateau. Perform Manag Mag 14(3):3–10
10. McSween TE (2003) The values-based safety process. Wiley, Hoboken, NJ
11. Merdian J (2011) Arbeitssicherheitsaudits - Leitfaden für die betriebliche Praxis. Beuth Verlag, Berlin
12. Schraub EM et al (2009) Bestimmung des ökonomischen Nutzens eines ganzheitlichen Gesundheitsmanagements. In: Badura B, Schröder H, Vetter C (eds) Fehlzeiten-Report 2008

– Betriebliches Gesundheitsmanagement: Kosten und Nutzen. Springer Medizin, Heidelberg, pp 101–110
13. Skinner BF (1957) Verbal behavior. Copley Publishing Group, Acton
14. Thorndike EL (1898) The Psychological Review – Animal intelligence: an experimental study of the associative process in animals. Macmillan, New York, NY