Behavioral Safety: a way to decrease injuries at work (with science)

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Abstract: Work-related injuries are a well known problem all around European Union (EU): every year, at least 170000 workers die and even more suffer severe and permanent injuries.
Even if EU placed the goal of reducing this number by 25% by 2012, in many countries the situation remains unchanged despite the enforcement of increasingly stringent laws that, anyways, elude the most important question: *why?*
Moreover, in spite of a lot of American and European studies demonstrated that at least 76% of work-related accidents are due to workers unsafe behaviors, blaming workers is not a effective solution because it eludes again the question: w*hy a worker should act unsafe?*
An answer to this last question comes from studies about human behavior: a person acts a certain way because he is subject to a number of external stimuli, before and after his act. So, if a person receives a positive consequence as a reward for his behavior, he continues to output the same behavior.
Till 80's, Behavior-Based Safety (B-BS) uses this mechanic to provide positive consequences to safe behaviors, instead of negative ones, increasing safety and reducing injuries.
But does B-BS work? Even if a lot of literature case studies of successful B-BS implementation are present, all across the world, there is a lack of scientific experiments to unequivocally state that B-BS increases safe behaviors and reduces injuries. This work provides two different case studies, using not only a before-after analysis but also using an appropriate mathematical test (Young's C Test), to examine workers' behavior changes during time.
The work puts in competition two different B-BS protocols, which share all the fundamentals but differ for start-up time and cost, applied on two different Italian industrial sites: a glass bottle factory and a paint factory.
These protocols obtains the same results, demonstrating not only that B-BS works, but also that behavioral safety can be achieved at low cost even for small European industries.

Keywords: Behavior-Based Safety, Accident prevention, Injury reduction, Industrial safety.

1. INTRODUCTION

Death at work is one of the plagues of our times, a plague which affects both developed and underdeveloped countries everywhere in the world.
But, if such fatalities could be see as "casualties" for third-world countries, where money and safety-related technologies are often missed, European Union cannot let this massacre goes ahead into its bounds, leaving every year about one thousand families in mourning.
In Italy, each day, at least 3 persons loose their life while working. About one million workers suffer injuries of various degrees every year, in a country where the accident rate is below the European average (2.812 injuries every one thousand employed against 3.469 in EU, in 2006) [1].
It could be easily assumed that injuries are caused by lack of safety standards, laws or rules, but this is far from truth: in Italy there are specific laws since 1955 (DPR 547 (1955), DPR 303 (1956), 626 (2006), substituted in 2008 by the "Safety Consolidated") and every single EU country has a specific law regarding safety at work.
In addition to moral and social problems, lack of safety has its own costs. Only in Italy, every year, more than 40 billion euro are lost due to work related injuries and fatal accidents [1].
Because EU goal is to reduce this number of about 25% at the end of 2012, it is important to ask ourselves both how we can reach this objective and, even more important, why injuries happen despite there are specific laws and standards.

2. ABOUT BEHAVIOR

In order to reduce injuries, it is important to identify all their root causes.
Since 1959, a study from Heinrich [2] established a connection between injuries and unsafe workers' behavior, such as neither attaining to procedures nor using personal protective equipment and so on.
A more recent study [3] confirms such a connection, moving the question from “Why injuries happen?” to “Why a worker should act unsafe?”

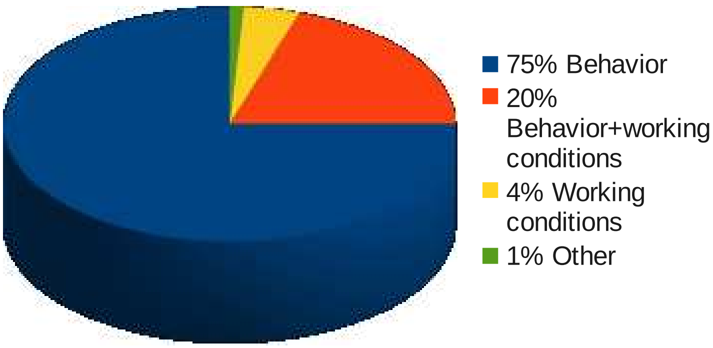

Figure 1: Causes of work-related injuries in western world [4].

It is a common misconception that a person should act in response to external antecedent stimuli: as an example, if there is a signboard which says “Wear the helmet”, every worker should wear the appropriate Individual Protection Device (IPD), but it is common knowledge that it is not true. Men are men, not machines acting in a simple input-output way.
An answer to our question is given by F.B. Skinner, a behavior psychologist who discovered the three-contingency model, which explains how and why a person acts in a certain way [5]. It is not a simple matter of antecedents but even consequences play their role in the process.
Using the same example, “wear the helmet” is a safe behavior but brings to suffer warm, little headache and it is common belief that using helmet brings to premature baldness.
These are all examples of negative consequences, which brings worker to act unsafe, wearing helmet only in presence of a chief or similar.
Skinner studies demonstrated that it is possible to influence people behavior by providing “right” consequences (reinforcements) and/or through the extinction of “wrong” consequences.
While rules and laws usually apply a punitive system (“If you don't wear these gloves, you will get a fine”), Skinner also demonstrated that humans are more sensitive to positive reinforcement (“If you wear these gloves, you will get a prize”) and it is from this feature that Behavior-Based Safety starts.

3. BEHAVIOR BASED-SAFETY

Behavior-Based Safety (B-BS or BBS) born at the end of the seventies in the United States, as a safety system deriving from a direct application of Skinner's principles.
To apply Skinner's research to work-related safety, B-BS relies on a group of volunteer workers, the Observers, who observe their comrades, using a particular anonymous checklist with a bunch of right correct behaviors listed on it, in a simple but effective way.
As an example, if the checklist states “Use of grounding clamps during paint's transfer operation” and there are three men performing transfer, two of them using clamps and one not, plus a man who is not performing transfer operation, observer will register 2 safe behaviors and 1 unsafe, ignoring the last worker.
Data collected by observers are analyzed and one or more goals are set for the next period (“Using grounding clamps must improve from 66% to 75% the next month”). If the department reaches the goals, all department workers will be prized. If not, there will be neither prizes nor punishment because B-BS is a positive-system only, not a punitive one.

Moreover, observers release feedbacks after every registration, reading the checklist, so that every worker can know performance trend and contribute to its improvement.
It is important to underline that these Observers are no more than common workers and that they perform this task only for few minutes per day. Since they register correct behaviors and the system is not punitive, they are usually well-seen among other workers.

3.1 Implementing B-BS

Despite its run could appear easy, implementing a working B-BS is not so simple because it requires a good knowledge of behaviorism and a lot of experience to face a large number of little but annoying problems that could undermine its correct functioning [6].
Therefore, implementing B-BS requires a semi-rigid protocol to be followed to ensure and maximize success probability: a well implemented B-BS could bring to an injuries decrease even to 40%, by mean, in one year. [7]
Anyway, since the start-up phase is usually time and money consuming, despite the evidence that usually B-BS repays itself in a short period (varying from company to company) [8], it happens that little, or even medium, companies do not posses funds or personnel enough to be diverted to B-BS start up.
This work provides the description of two protocols, a classical and a new one, created to reduce both costs and start-up time.

3.2 Behavioral Safety in Italy

It's important to state that almost all experimental studies about B-BS effectiveness has been conducted onto Anglo-Saxon realities [10], which are really different from the Italian one: as an example, in U.S., a common reward for a correct behavior is a plate for “employee of the month” or a standing ovation performed by all workers to honor a colleague [4]. In Italy, such rewards are seen as unnecessary, even offensive, and winners usually prefer to keep a low profile.
Similarly, delivering feedbacks is not so simple: Italian workers can be considered more susceptible to criticism because, in a standard context, feedbacks are used only to focus on incorrect actions and blame the worker itself. Even reminders letters or inspections are performed only to discover non-compliance to safety and health obligations [8] rather than focusing on improvement.
Therefore, applying B-BS in Italy means to completely turn worker's mentality and force people, from workers to executives, to reject a punitive system to increase safety and embrace a positive one.
In order to do this and, at the same time, avoid that B-BS can be transformed in a punitive system with a strictly enforced control, it's important to study and demonstrate a protocol (or more than one) that could be effective and easy to implement even in a complex reality, so far from that one for which B-BS is born.
Another aspect to be considered is that, in Italy, about 95% of the industries are small and medium enterprises (SME) with less than two hundred workers and, often, even less than fifty. It's obvious that the application effectiveness of a protocol suitably realized to be implemented in great or multinational enterprises must be demonstrated. Therefore, both theoretical and experimental methods analogous to those ones employed to validate B-BS protocols effectiveness in standard Anglo-Saxon contexts must be used to ensure the applicability of similar protocols to Italian realities.

4. B-BS PROTOCOLS

Each B-BS protocol relies on the same bases but application phases and time may differ. Scope of this work is to compare two protocols currently implemented in Italy. The first one, referred to as classical in the following, is a well known protocol normally applied to improve safety at work in medium and large enterprises [4]. The second one is an experimental protocol of new conception, derived from the former but particularly suitable for small enterprises. Such a protocol, referred to as BBS-A, has been created to strongly reduce all costs associated to B-BS operative implementation but keeping the same effectiveness of the classical one.

4.1 Classical Protocol

This protocol is well described by McSween [4] and it is applied in Italy with no, or minor, modifications.
As a primary aspect, classical protocol is based on the so-called “workers formation” and spends a lot of time in seminaries to provide workers a full-spectrum knowledge about behavior and its principles.

The protocol is implemented following seven different steps: 1) Presentation to executives, 2) Safety Assessment, 3) Constitution of work groups, 4) Seminary about B-BS principles, 5) Technical seminaries for workgroup, 6) Process start-up and, finally, 7) Process maintenance.

4.1.1 Presentation to executives

In this phase, the whole process is presented to the company's executives, reunited all together, to discuss about safety problems and B-BS in general. It is important that each executive knows something about the process because only like that a full commitment will be achieved.

4.1.2 Safety Assessment

This phase involves a detailed study of company's safety performance, including a detailed interview with workers, aimed to discover how safety aspects are perceived into production departments.

4.1.3 Constitution of workgroups

Classical protocol involves four different groups:
- Management Team, who provides financial resources and it is composed by the executives;
- Design Team, composed by executives, workers and foremen, who will design the whole process;
- Steering Committee, composed by foremen, who will lead and maintain the process;
- Observers, a group formed by workers, whose members will observe their colleagues during their normal work activity.

Members of the latter group are often changed, in rotation, to ensure that everyone in the company act as an observer.

4.1.4 Seminaries

A full three-day seminary about principles of B-BS is presented to members of each group, especially to that ones belonging to the Design Team. During this seminary, every aspect of behavior-analysis is taken into account to provide a full presentation.

After this seminary, a bunch of other technical seminaries is provided to each group, ensuring that everyone know their role.

4.1.5 Process start-up

This phase consists in the checklist (a brief list of safe behaviors regarding a particular department or activity) creation, focusing on positive behaviors such as the use of gloves or helmets, or the performance of determined actions on particular devices. This step is carried out by the Design Team.

4.1.6 Process maintenance

This last phase is carried out by the Steering committee, who uses data from observers to choose objectives, rewards for each department which achieved the predetermined goals and to maintain the process alive.

4.2 BBS-A Protocol

This protocol, designed by Artyll – Società Lombarda di Ingegneria, has been created to reduce application time and, thereafter, costs, in order to make accessible behavioral safety even to small enterprises, which possess little funds to spend for safety protocols implementation but are well aware of the importance of safety at work.

BBS-A protocol relies its effectiveness on people: formation of workers and executives is based on an on-site direct experience during process start up and maintenance. Particularly, a single man-in-charge, instead of the Management Team, leads the process. This person must be carefully chosen to ensure a correct start up and maintenance.

The protocol is implemented in six different steps: 1) Presentation to executives, 2) Safety Assessment, 3) Constitution of workgroups, 4) Training and design, 5) Observers training, and 6) process maintenance.

4.2.1 Presentation to executives and Safety Assessment

These steps do not differ from those ones presented with the classical protocol.

4.2.2 Constitution of workgroups
BBS-A have got only two different workgroups: the Project Board and the Observers. While the latter one is almost identical to that one presented above, the former unifies the tasks of Management team, Design team and Steering committee. This group is composed by executives (usually one, with spending power), foremen and workers, for a five to seven persons total.
One of the members of this group, usually a foreman, is chosen as B-BS Leader, with the task of maintaining the process alive.

4.2.3 Training and design
Members of the Project Board are trained on the principles of Behavior Analysis in a one-day seminary, which is followed by the process design (with checklist creation) and start-up.

4.2.4 Observers training
Observers are trained in two different steps: in the first one, a classroom-like training, giving all fundamental information needed to starting observations, is provided. In the second step, a one-by one formation about checklist content is performed, directly "on field".
Between these two steps there is usually a one week hiatus, during which observers take confidence with checklists.

4.2.5 Process maintenance
This phase is similar to the classical protocol one, with the Project Board who takes the role of the Steering Committee.

4.3 Differences and similarities between protocols

As stated above, there are little but important differences between the two protocols. First of all, BBS-A training impact is much lower than the classical protocol because it relies more on a brief, specific and on-field training than on a more conventional classroom-like training.
Moreover, in BBS-A the number of people involved in decisions and start-up times are reduced. Particularly, BBS-A shows a single decision team instead of three, and start-up times pass from a mean of thirty days (Classical) to ten-fifteen days (BBS-A).
Consequently, BBS-A is less time and money consuming with respect to the classical protocol. These features make BBS-A particularly suitable for small enterprises.
Anyway, both protocols are based on observations of worker's behaviors, data analysis and a goal-prize system.

5. EXPERIMENTAL STUDIES

In this section two different experimental studies, one for each protocol described above, are presented. While the first one is a 3-months study performed by Politecnico di Milano [11-12] and already presented (consequently, it will be only briefly summarized in the following), the second one is a new study, that started at the same time but lasted 14 months against 3. As a consequence, to make a comparison, partial results after 3 months have also been collected.
It is obvious that a simple before-after implementation analysis, even if tempting, cannot be considered correct: every single behavior depends on a lot of different antecedents and consequences and so it is subjected to an elevate degree of randomness during observations.
To reduce randomness, Young's C Test [9] has been used in both studies: this is a classical, even if non well-known, statistical test that allows for identifying if a registered variation of a single behavior is due to chance or a real, actual cause. A brief description is reported in appendix.
With a test result of $Z>1.64$, it is possible to state that a registered variation is real (not due to chance) with a probability of 95% (this result will be referred to as C95+ if variation is positive, C95- if negative).
This probability increases to 99% for $Z>2.326$ (C99+ or C99- as stated above).
With $Z<1.64$, variation is rejected, because there is a probability higher than 5% that such a variation has been overestimated or it did not occurred at all. In the results section it will be presented as NC, regardless its positivity or negativity.

5.1 Classical Protocol

Effectiveness of the classical protocol has been demonstrated in the US by the mean of a lot of experimental works [10]. In Italy, the first experimental activity has been carried out by Politecnico di Milano in 2009, proving the effectiveness of Behavior-Based Safety even on Italian companies [8-11-12] which exhibit, obviously, a different social background compared to US or UK ones.
In this study, the protocol has been applied on an Italian glasswork enterprise. After the start-up period, a bunch of 40 behaviors has been chosen from a pool listed in suitable checklists. These behaviors share the following characteristics:
- they are common (for each or all departments) and well-observable behaviors;
and / or
- they are considered as critical behaviors whose improvement is the first goal to enhance safety in either a specific department or more.

Experimental data have been collected at two different times: the first one at the early beginning of the process, as a sort of baseline in which observers had not started to provide feedback yet, and the second one after three months of full implementation.
Using data collected by the observers, a statistical study has been performed using Young's C Test.
The results of this study are reported in subsection 6.1.

5.2 BBS-A Protocol

To determine if BBS-A shares effectiveness with its ancestor B-BS, an experimental study has been carried out applying the protocol to an Italian chemical Industry, ALCEA.

5.2.1 About ALCEA
ALCEA, a coat and paints producer, could be considered a typical family company, founded by Giovanni Parodi in 1932 and now led by his grandson, Carlo Parodi.
Till 2007, after the infamous accident in ThyssenKrupp's Turin plant, ALCEA started an important initiative, called "Cerchio della Sicurezza" (Safety Circle) to improve its safety standard and to enhance workers involvement. In 2009, ALCEA implemented BBS-A protocol in its main production site, with about 200 workers over a 43000 m^2 plant.
For its "Cerchio", BBS-A implementation and related initiatives, ALCEA won several prestigious Italian prizes, such the "Premio Migliori Esperienze Aziendali" (Best Company Experiences Award).

5.2.2 BBS-A implementation and experimental study
As stated above, the implementation of BBS-A protocol in ALCEA started in 2009, following all the steps reported in subsection 4.2. Project Team nominated Mr. Paolo Nava, plant director, as B-BS Leader and Eng. Fabio Chiesa as Technical Executive.
The Project team also created twelve different checklists, each of them related to a different department, listing a total amount of more than 200 different safety behaviors.
In order to study BBS-A effects on workers and, thus, providing a comparison with respect to the classical protocol, the experimental study has followed the same pattern of the original study that demonstrated the effectiveness of B-BS [11-12].
Even if only 46 behaviors have then been chosen as samples for the Young's C Test analysis, observers did not know anything about such an aspect and, therefore, they continued to observe and release feedbacks on each single behavior listed in the checklists.
Observers collected data for over 60 weeks, four of them used later as a baseline. After that, a statistical analysis has been performed using the Young's C Test.

6. RESULTS

6.1 Classic Protocol results

Taking into account a bunch of 40 sample behaviors, 28 of them have been improved from a mean of 82.61% to 94.9%. The improvement has been validated for 19 of them, 2 with C95+ and 17 with C99+.
On the other end, six behavior worsened from a mean of 96.1% to 92.13%. Worsening has been confirmed for 3 of them, all with C99-.

Nine behaviors didn't change at all, and are listed in Table 1 as “S” (Stable).

6.2 BBS-A Protocol results

After a 3 months period, considering once again a bunch of 40 sample behaviors, 35 of them improved from a mean of 67.6% to 84.9%. The improvement has been confirmed for 33 of them (31 with C99+; 2 with C95+).
Moreover, three behaviors worsened from a mean of 79.2% to 75.2%. Worsening has been demonstrated for all of them (1 with C99-; 2 with C95-)
Two behaviors did not change at all.
After the full 14 months period, always taking into account the same bunch of 40 sample behaviors, 37 of them improved from a mean of 67,6% to 98.8%. The improvement has been demonstrated for 28 of them (20 with C99+; 8 with C95+).
Only one behavior worsened, from 100% to 98%, but it has not been confirmed by the Young’s C Test.
Two behaviors did not change at all.

Table 1. Comparison between Classical B-BS and BBS-A results after an implementation period of three months.

Classical B-BS Protocol						BBS-A Protocol					
S	C95+	C99+	C95-	C99-	NC	S	C95+	C99+	C95-	C99-	NC
9	2	17	0	3	9	2	2	31	2	1	2

9. CONCLUSIONS

It is important to note that C Test is not a magic wand and, therefore, it can only state whether a change can occur or not, but it cannot say anything about why this change happens. Anyway, since behaviors have been registered into different departments, with different workers, and that the only change occurred for each of them has been the application of a Behavior-Based Safety Protocol, it is not wrong to correlate B-BS and behavior changes in a cause-effect relationship.
Therefore, from the results, it appears clear that both protocols enforce and enhance correct safety behaviors.
On the contrary, it is much more difficult to compare the results: even if both studies started in the same year, differences in production sites (glasswork vs. paints factory) and enterprises dimension (big vs. small) make impossible to determine which protocol is the most effective in absolute terms.
Nevertheless, the following aspects can be analyzed.
For what concern start-up time, BBS-A takes one-third time than the classical protocol. Taking into account that start-up time is the most expensive step in a B-BS implementation, BBS-A is more economical than classical B-BS. Such an aspect, in a period of economical crisis, cannot be underestimated.
Referring to BBS-A, it has been demonstrated that behaviors improve continuously for at least 14 months (and probably more) during B-BS implementation. On the contrary, it is not possible to state anything about the effectiveness of the classical protocol beyond its 3 months period, due to lack of experimental data.
Then, with particular reference to the follow up, BBS-A start-up path uses a one-by-one observers training, to ensure better observations, while classical protocols relies only onto classroom-like training. Particularly, concerning such a last aspect, it must be underlined that BBS-A approach could be difficult and time-consuming in very great companies. In fact, its less-people-involved approach favors little and medium companies (for which an on-field implementation approach can be followed), but it is probably a problem for great enterprises.
Finally, these studies demonstrated that, with BBS-A, behavioral safety could be a truth even for little companies and that it cannot be confined to big and multinationals ones.
Concluding, basing on the demonstrated evidence that a correct B-BS implementation brings to an injuries decrease of 40%, by mean, this is obviously a path to follow to reduce work-related deaths, and it is probably one of our best chances to stop this terrible, silent massacre.

APPENDIX 1: YOUNG'S C TEST

Young's C Test [9] is a classical, even if non well-known, statistical test which allows to identify if a registered variation of a single behavior is due to a chance or a real, actual cause.
To do this, C Test evaluates time sequences of data, according with the following equations:

$$C = 1 - \frac{\sum (p_i - p_{i+1})^2}{2\sum (p_i - p_m)^2} \qquad (1)$$

$$p_m = \frac{\sum p_i}{N} \qquad (2)$$

$$Sc = \sqrt{\frac{(N-2)}{(N^2-1)}} \qquad (3)$$

$$Z = \frac{(C)}{Sc} \qquad (4)$$

where:

- *C: Young C factor*
- *N: Number of data*
- *pi*: frequency of behavioral emission, or number of safety behavior emitted in comparison to the total.

It is important to note that this factor cannot be calculated as a simple ratio between right and wrong behaviors, because, taking into account that observations are made in random moments of the day, there could be a different number of workers doing a specific work. Therefore, it is necessary to use an alternative calculation method.
Transformation of Freeman and Tuckey [13], applied with Tryon correction [14], allows us to consider the presence of more or less workers:

$$p_i = A - \frac{B}{2\mathrm{N}_b} \qquad (5)$$

$$A = \left(\frac{1}{2} * \left(\arcsin\left(\sqrt{\frac{S_i}{S_i + R_i + 1}}\right) + \arcsin\left(\sqrt{\frac{S_i + 1}{S_i + R_i + 1}}\right)\right)\right) \qquad (6)$$

$$B = \sum_{j=1}^{N_b} \left(\arcsin\left(\sqrt{\frac{S_{bj}}{S_{bj} + R_{bj} + 1}}\right) + \arcsin\left(\sqrt{\frac{S_{bj} + 1}{S_{bj} + R_{bj} + 1}}\right)\right) \qquad (7)$$

S_i: number of safe behaviors registered during the single observation
S_b: number of safe behaviors registered during a single baseline observation
R_i: number of unsafe behaviors registered during the single observation
R_b: number of unsafe behaviors registered during the single observation
Nb: number of total baseline data

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References

[1] INAIL (Italian National Institute of work-related injuries), Infortuni sul Lavoro 2009, 2010.

[2] Heinrich H. Industrial incident prevention, McGraw-Hill, New York, 1959.

[3] Masimore L. Providing the value of safety, Rockwell Automation, Milwaukee, 2007.

[4] McSween T. The value-based safety process, Wiley-Interscience, Hoboken, 2003.

[5] Skinner B. About Behavioism, Random House, New York, 1974.

[6] McLure J. Choosing a behavioral safety consultant. www.ishn.com, June 2000.

[7] Colombo A. and Marzo E. Il protocollo B-BS come sistema di gestione dei fattori umani, Politecnico di Milano, 2008.

[8] Tosolin F., Gatti M., Algarotti E. Behavior Based Safety: costruire comportamenti per ottenere risultati, Ambiente & Sicurezza, 3, 24-34, 2008.

[9] Young L. On randomness in ordered sequences. The Annals of Mathematical Statistics, 12, 293-300, 1941.

[10] Austin J. and Sulzer-Azaroff B. Does B-BS work? Behavior-Based Safety & Injury reduction: a survey of the evidence. Professional Safety, July 2000, 19-24, 2000.

[11] Torretta A. and Sala Cattaneo C. The first scientific experimentation on a B-BS protocol applied to an Italian factory [Studio sperimentale su un'applicazione del protocollo B-BS a una realtà industriale italiana], Giornale italiano di medicina del lavoro ed ergonomia, 32, 69-71, 2010.

[12] Gatti M., Rota R., Sala Cattaneo C., Silva P., Torretta A., Tosolin F. Application of Behavior-Based Safety in a Glasswork Enterprise. Acts of 8th IOHA International Scientific Conference, 28 September – 20 October 2010, 235.

[13] Freeman M. and Tuckey J. Transformation related to the angular and the square roots, The Annals of Mathematical Statistics, 21, 607-611, 1950.

[14] Tryon W. A simplified time-series analysis for evaluating treatment informations, Journal of applied behavior analysis, 15, 423-429, 1982.