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ILLUSION OF CONTROL IN PRODUCTIVE AND PREVENTIVE SCENARIOS AND IN THE CONTEXT OF SAFETY RISKS

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Joint doctoral thesis presented to the Programa de Pós-Graduação em Psicologia at the Universidade Federal do Rio Grande do Sul (UFRGS) and to the Programa de Doctorado en Psicología at Universidad de Granada (UGR) as a partial requirement for the Degree of Doctor in Psychology under the supervision of Lisiane Bizarro Araujo, PhD (UFRGS) and Jaime Vila Castellar, PhD (UGR).

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ABSTRACT

Illusion of control is the tendency to overestimate the probability of personal success in chance-based situations. This concept underlies productive and preventive scenarios in studies of motivation, superstitions, ungrounded beliefs and may help to understand the mechanisms of behaviors under risk. The objective of the four experiments was to explore the external and internal factors that affect judgments of control in productive and preventive scenarios and in the context of traffic safety in students and industrial workers. Participants were instructed to try control a light bulb or a traffic light on a computer by pressing or not the space bar, with a productive or preventive goal. Their pressings responses and self-assessment scales resulted that the high probability of the outcome generates illusions acompanied with positive affects. The probability of the action, the response bias and the reaction times indicate changings related to illusions. Workers with experience of severe accidents tend not to generate the illusion and changes in safety culture seem to make the workers eager to control through their actions.

Keywords: illusion of control, associative measures, Shewhart's charts, response bias

RESUMEN

La ilusión de control es la tendencia a sobreestimar la probabilidad de éxito personal en situaciones basadas en el azar. Este concepto subyace en escenarios productivos y preventivos en estudios de motivación, supersticiones, creencias sin fundamento y puede ayudar a comprender los mecanismos de los comportamientos bajo riesgo. El objetivo de los cuatro experimentos fue explorar los factores externos e internos que afectan los juicios de control en escenarios productivos y preventivos y en el contexto de la seguridad del tránsito en estudiantes y trabajadores industriales. Se instruyó a los participantes para que intentaran controlar una bombilla o un semáforo en una computadora presionando o no la barra espaciadora, con un objetivo productivo o preventivo. Sus respuestas de presión y las escalas de autoevaluación resultaron en que la alta probabilidad de que el resultado genere ilusiones acompañadas de efectos positivos. La probabilidad de la acción, el sesgo de respuesta y los tiempos de reacción indican cambios relacionados con las ilusiones. Los trabajadores con experiencia en accidentes severos tienden a no generar la ilusión y los cambios en la cultura de seguridad parecen hacer que los trabajadores estén ansiosos por controlar a través de sus acciones.

Palabras clave: ilusión de control, medidas asociativas, gráficos de Shewhart, sesgo de respuesta

RESUMO

Ilusão de controle é a tendência a superestimar a probabilidade de sucesso pessoal em situações baseadas no acaso. Este conceito fundamenta cenários produtivos e preventivos em estudos de motivação, superstições, crenças sem fundamento e podem ajudar a compreender os mecanismos de comportamentos sob risco. O objetivo dos quatro experimentos foi explorar os fatores externos e internos que afetam os julgamentos de controle em cenários produtivos e preventivos e no contexto da segurança no trânsito em estudantes e trabalhadores da indústria. Os participantes foram instruídos a tentar controlar uma lâmpada ou um semáforo em um computador pressionando ou não a barra de espaço, com uma meta produtiva ou preventiva. Suas respostas às pressões e escalas de autoavaliação resultaram que a alta probabilidade do desfecho gera ilusões acompanhadas de afetos positivos. A probabilidade da ação, o viés de resposta e os tempos de reação indicam mudanças relacionadas às ilusões. Trabalhadores com experiência de acidentes graves tendem a não gerar a ilusão. Mudanças na cultura de segurança parecem deixar os trabalhadores ansiosos para controlar suas ações.

Palavras-chave: ilusão de controle, associative measures, cartas de Shewhart, viés de resposta

INTRODUCTION

Individuals regard themselves as causal agents when trying to get an outcome. *Illusion of control* or *illusory control* (IOC) is one of the concepts that underlie several studies conducted over the last four decades demonstrating that people often perceive more control than they actually have and notice covariation where none exists (Presson & Benassi, 1996), so that randomly determined events are frequently interpreted as dependent on the subject's action (Biner, Johnston, Summers, & Chudzynski, 2009; Langer, 1975; Langer & Roth, 1975; Yarritu, Matute, & Vadillo, 2014). For instance, when someone blows on the dice in order to win, or if a pedestrian refuses to walk under a ladder – to prevent bad events – or repeatedly pushes the lift button in order to make it arrive faster. Individuals tend to attribute their successes to themselves, while they blame other people or external factors or chance for their failures. People are motivated to see themselves as causal agents, to be responsible for their successes, and are likely to seize cues in the environment to support this attribution (Langer & Roth, 1975; Yarritu, Matute, & Vadillo, 2014).

Illusion of control or *illusory control* (IOC) can be defined as "the tendency to overestimate the probability of personal success in chance-based situations" (Biner, Johnston, Summers, & Chudzynski, 2009, p. 32), or the original definition "an expectancy of a personal success probability inappropriately higher than the objective probability would warrant" (Langer, 1975). The phenomenon has been demonstrated by diverse lines of evidence: laboratory experiments, observed behavior in games of chance such as lotteries, and interviews that include self-reports of real-world behavior. The concept has been investigated in studies from a wide range of domains: social psychology, mental health, gambling behavior, motivation and emotion, and decision making (Stefan & David, 2013).

IOCs underlie everyday superstitions, pseudoscientific thinking, and irrational or ungrounded beliefs; they influence gambling behavior and decision making. Every psychologist knows that temporary loss of control is anxiety arousing. On the other hand, the introduction of control-related but outcome-independent factors induce an illusion of control through, and so people may be put more easily to increase their risk taking, that is, to accept the "unknown" (Langer, 1975).

The above original definition of IOC was first proposed by Ellen Langer and colleagues in their two seminal studies in 1975 (Langer, 1975; Langer & Roth, 1975), where they outlined several conditions which give rise to such beliefs. People believe that a certain degree of own skill is involved in the event: they become “skill-orientated” – in other words, they exhibit an inflated perception of their certainty of success (or chances of winning the outcomes). In behavioral terms, subjects judge contingency where there is none. It could be, in this sense, the inverse of learned helplessness (the perception of independence between actions and outcomes) – but results from studies with depressed and non-depressed college students were more consistent to illusion of control than to learned helplessness theory (Alloy & Abramson, 1982).

Langer (1975) proposed the “skill and chance confusion hypothesis”: people experience illusory control when they misinterpret chance situations as skilled-related situations. In her first experiments, she proposed that illusions occur when factors associated with skill-determined situations are introduced in skill-independent events. In other words, the situations include actions (like blowing on the dice, walking on the sidewalk, or pushing a button repeatedly) introduced in purely chance-based events (such as rolling the dice, the occurrence of casual bad or unlucky events, or the arrival of the lift at the floor). The more similar the situation is to a skill situation, the greater the likelihood of eliciting an illusion of control. The outcome was desired, with positive valence.

The seminal article included six studies conducted with people of different ages, socioeconomic status and sexes. All of them took place – except for one – in real-world (or ecological) settings. They demonstrated that whether or not a casual event was reacted to as if it was controllable depends on engagement on a competition situation, choice manipulation, stimulus familiarity (knowledge about the object to be controlled – e.g. its symbols), response familiarity (practice on the game), active and passive involvement in the event. The dependent variables proposed to measure illusory control were the amount of wagered or quoted money, the self-declared presence of physiological responses, the rate of a six-point competence scale, the will to change his own ticket, the rate of a ten-point confidence scale. As an example of the results, participants who could choose their own numbers in lottery were less likely to trade their ticket even for one with better odds. At last, the article proposed people will seek out or avoid the factors as control is desirable or undesirable (Langer, 1975).

Langer suggested that some variables prompt participants to notice the contingencies associated with the task and called this phenomenon “intrusion of reality”. Informing someone that the outcome might be contingent could make them more likely to include chance when making their judgments: awareness might lessen the illusion of control; on the other hand, informing the participant about the possibility of the outcomes to be determined by chance induces the illusion. Beyond the factors above, participants who were given more practice trials felt more confident in their outcome predictions and felt their concentration influenced the outcomes more than participants with fewer trials. That also happens when they could have information or foreknowledge regarding the outcome of a chance task (when participants were allowed to guess the outcomes prior to throwing a cube with different color faces) (as cited in Presson & Benassi, 1996).

Another factor that can affect the perception of a task as skill or chance determined – also related to the subject's experience of events (including risk events) – is the sequence of outcomes. An early, fairly and consistent pattern of successes on a task would induce a skill-orientation. Langer and Roth (1975) conducted a study using three sequence patterns (ascending, descending and random) and two levels of involvement (actor and observer) on ninety male Psychology undergraduate students. The experimental task was the flip of a coin 30 times by the experimenter. The participants should try to predict the outcome on each toss while the coin was still in the air. The dependent measures were "predictability of outcomes", "practice" and "distraction", measured in 11-point (0 – 10) scale. The results indicated that subjects in the descending condition rated themselves significantly better at predicting outcomes and expected more future successes than the other groups. Participants receiving more positive outcomes early during the task evaluated their degree of control higher than the ones who received more positive outcomes later in the course of the task – in other words, a single cue in the early steps is enough to induce the illusion and motivate people. Involvement at the task had the effect of increasing expectations of future success.

The first meta-analytic review study on illusion of control was published by Presson and Benassi (1996) including 29 papers and 53 studies. The main result the authors obtained was the overall weighted mean effect size estimate of Cohen's $d = 0.68$, 95% CI [0.61, 0.75]: a positive, consistent and moderately strong effect illusion of control effect. One of the purposes of the review was to examine whether different manipulated variables produced statistically significant and reliable effects. The researchers pointed out that experimenters had differed in conceptualization of illusion of control and that few of them had used a direct measure of personal control – as the sense that participants judge the extent to which they directly affect outcomes. Instead, most of them operationalized the concept in indirect, qualitative or quantitative assessments: they had actually measured prediction ability, judgments of contingency, willingness to trade, amount of wagered money, confidence of succeeding on a task, etc. The use of indirect qualitative measures tended to produce larger effect sizes compared to both direct and indirect quantitative estimates of control. Based on the variance among the studies, Presson and Benassi suggested that "illusion of control" was not the most appropriated label to describe the phenomena examined in the 53 experiments because not all such illusions had to do with the concept of control: they were rather a variety of other types of illusions. They proposed the term "illusory judgment" to better describe the variety of effects. The largest mean effect was informing the participants about the possibility of the task being a chance situation.

The authors also criticized that virtually all researchers applied statistical tests not to directly evaluate whether illusory control is present, instead, they assessed whether two or more groups differed one from another. The authors argued that most reported between-groups analyses would be appropriate if researchers were only interested in whether groups differ on dependent measures and are not interested in testing whether participants' judgments differ from some expected value, and recommended analyses to be matched to such issue. Another conclusion was that few studies examined the effects of illusory control orientation on subsequent behavior, that is to say, people who show illusory control effects in the laboratory are not necessarily more likely to engage in superstitious behavior in everyday life situations (Presson & Benassi, 1996).

Since then, a large number of papers have been published on the topic and a second meta-analytic review study in literature on illusion of control was published by Stefan and David (2013) with the purpose of offering updated effect-sizes estimates for the factors manipulated in studies and included 20 papers and 34 studies. The main result was $d = 0.62$, 95% CI [0.49, 0.75], $p < .05$, similar to the previous review. Still, the variety of studies and different dependent measures suggested that the underlying phenomena might be of different natures: there seemed to be a lack of agreement in terms of the concept's definition and measurement instruments. In terms of assessment methods, the authors took into consideration the independent variables used to trigger illusions (e.g., involvement, choice, outcome sequence), and the type and characteristics of the dependent measures (e.g., estimation of control, skill estimation, expectation of success). Variables were classified as direct-indirect and with behavioral-subjective character: a dependent measure was considered as direct if it explicitly involved an estimation of the perceived level of control in a given situation, or if it comprised an expectation of success; it was considered indirect if it did not explicitly enquire – or just assumed – the illusion of control (e.g., estimating the level of skill or betting a certain amount of money); behavioral if it involved performing a specific action (e.g., pressing a button) or making a decision (e.g., betting a certain amount of money, active involvement in the task); and it was considered as subjective if consisted of estimations of controllability, success, skill, or other features (e.g., finding a specific rule in the onset of stimuli). The tasks were coded either as skill-based or as chance-related (Stefan & David, 2013).

The review emphasized that a recent change in the literature about experimental paradigms for the study of illusory control should address the problem in situations where a certain degree of controllability is present (Thompson et al., 2007). Other developments were new theoretical concepts and explanatory theories such as the control heuristic (Thompson et al., 2004, 2007; Thompson, Armstrong, & Thomas, 1998). The list of factors considered to induce illusory control has been extended. Beyond the exercise of skill – in particular choice, competition, familiarity with the stimulus and involvement in decisions (Langer, 1975; Langer & Roth, 1975) – new modulating factors to influence perceptions of control in chance-based situations have been reported: instructions that state that the task might be chance-based (Presson & Benassi, 1996); the need to avoid aversive outcomes, as in public speaking (Biner et al., 2009); the confidence in avoiding a preventive outcome (forearm submersed in cold water; Biner et al., 2009), and the experience of power (Fast, Gruenfeld, Sivanathan, & Galinsky, 2009). Instructions describing outcomes or asking for naturalistic or analytic strategies are also relevant factors that increase the probability of responding and induce overestimates of control both in trial and free operant procedures (Benvenuti, Toledo, Simões, & Bizarro, 2017; Matute, 1996).

Some studies included new types of events such as near wins and near losses (Wohl & Enzle, 2003). The domains of interest on which the illusion of control paradigm has been applied became wider, for example, on decision support systems (Kahai & Solieri, 1998) and on obsessive-compulsive behavior (Reuven-Magril, Dar, & Liberman, 2008). About affective states, IOC was weaker for depressed individuals and was stronger when there is an emotional need to control the outcome, or in stressful and competitive situations like financial trading (Thompson, 1999).

Factors responsible for inducing illusion of control have been comprised in a unifying theory, the control heuristic (Thompson et al., 1998, 2004, 2007). This theory states that people use a control heuristic that allows them to estimate the connection between actions and outcomes and the intent to obtain those results. When people see a connection between their behavior and an outcome, they get motivated to attain that outcome and put effort into it. Such underlying mechanism in the self-assessment of personal control makes people report higher estimates of their personal control.

Another determinant of illusion of control is the individual's need for the chance-determined outcome, a factor proposed in the studies developed in laboratories (card tasks) and field (state lottery) settings by Paul M. Biner. The results converged in showing that the confidence of winning an outcome is a direct function of a person's need (e.g., food-deprivation) for that specific outcome (e.g., hamburger incentive in a purely chance-based card-drawing task) regardless of the odds of winning condition (as cited in Biner, Johnston, Summers, & Chudzynski, 2009; Biner & Hua, 1995). The dependent variables were winning confidence rate and degree of skill, and the results indicated that both are strongly related to individual's need.

For almost 20 years, illusions of control had been studied exclusively in the case of generative (productive, positive valence) scenarios – those in which a behavior is repeatedly followed (and reinforced) by a desired (positive) outcome that occurs frequently. However, this rationale does not seem to be suitable to the preventive scenarios – those in which an undesired (negative and to-be-avoided) outcome never or rarely takes place (Blanco & Matute, 2014). Aversive (preventive, negative valence) outcomes and scenarios have been introduced in illusion of control studies in 1992. In an experiment where participants had to bet in a roulette game, it was explained to some of them that losing would result in an electric shock to their hands, whereas to the others it was said that no consequence would be the outcome. All participants had the option either to let the wheel stop for itself or to operate a handbrake to stop it – with the restriction that in the handbrake option the bet should be placed on a smaller section of the wheel, with a lower chance of winning. Results showed that more participants in the shock condition chose to operate the handbrake than the no-shock ones (Friedland, Keinan, & Regev, 1992).

The literature review allows a summary of the issue and deduce that studies on the subject under both valences may help to understand the mechanisms of risk behaviors. Not only in the traditional productive scenario in IOC research, suitable to the search of opportunity, the so called "positive risk", where invested actions and successes can benefit and also contribute to the illusion, thus maintaining motivation to reach goals. Likewise in the preventive scenario or in the negative risk context, such as safety, security and health issues, when the lowest numbers of incidents and diseases may enables higher illusory control. In these studies, it is important to incorporate the knowledge about conceptualization and measurement of the illusion, therefore to include, at least:

- a defined and operationalized concept of illusion of control;

- the use of a task, stimuli and feedback (reinforcement) specially designed or suitable for the experiment, for the valence (productive or preventive), with known (un)familiarity by the participants, easy to be understood and to be trained, and enough number of blocks and trials to the establishment of the illusion (random, fixed, ascending, or descending);
- the control of the independent variables that could affect IOC such as the participant's skill (including tasks specially designed for the experiment and unfamiliar, control of foreknowledge and standardized training period), personal involvement, choice and probabilities, active and passive involvement;
- the care in the choice of the dependent variables that are valid to measure the illusion quantitatively and with a reference point to the null illusion, that are rather quantitative, preferably direct, and the use of both behavioral and subjective measures;
- the care for standardized instructions with enough information about the task, contingencies and chances,
- the use of samples large enough to the desired significance level and power, and whose responses represent in the laboratory the target behavior in everyday life situations;
- the use of statistical tests not only to compare groups, but also to measure differences expected or reference values.

These guidelines will be followed in the studies that constitute this thesis as much as possible. The next chapter will describe and discuss the first experiment, a replication of the light bulb task for the study of illusion of control in two scen

CHAPTER 1

STUDY 1 – REPLICATION IS WORTH

Actions performed by an animal are aimed at either producing desired outcomes (e.g., foraging or going to the store to gather food) or preventing an undesired ones (e.g., barking or shouting if a stranger enters his area to warn them to stay away, or spraying insect repellents to keep mosquitoes away). In their study about preventive illusions, Blanco and Matute (2015) recall that people and other animals match aspects of their behavior to the actual contingency between their actions and relevant outcomes, but also that systematic errors appear with some probability under certain circumstances. Some actions fail to yield the outcome they aimed at, either because no process is 100% effective (e.g., flipping a light switch to turn a light bulb on during an interruption of the electricity supply) or even because the action has not the potential to produce the outcome (e.g., using a lucky charm to attract a lover or money).

Such question is closely related to contingency learning. The degree of contingency between two events is represented by the Δp rule, which is the difference between two conditional probabilities: the probability of the outcome given that the action was performed, $p(O|A)$, minus the probability of the outcome given that the action was not performed, $p(O|{\sim}A)$ (Allan, 1980). If action and outcome are contingent on each other, To the extent to which these two conditional probabilities differ, Δp departs from zero. Note that there may exist a logical or physical cause-and-effect relation between action and outcome, or what happened was a casual coincidence, even so contingency is possible. A positive contingency ($\Delta p > 0$) means that the probability of the outcome occurrence (whether desired or undesired) is higher when the action is performed than when it is not, and it will be interpreted as if the action effectively causes (generates) the outcome. A negative contingency ($\Delta p < 0$) means that the action prevents the occurrence of the outcome the opposite situation, typical of a preventive scenario, either desired or undesired). Whenever $\Delta p = 0$, the action fails to affect the state of the outcome, that is the case of the null contingency in superstitious behaviors. There are situations in which there is no contingency between action and outcome, but some people still believe that their actions affect the outcome, i.e., these people present the phenomena of illusions of control (Langer, 1975).

The probability with which the outcome actually occurs, $p(O)$, and the probability of performing the action, $p(A)$, influence the illusion of control. In positive illusions, the higher the $p(O)$, the stronger the illusion, what some authors call the density bias (Alloy & Abramson, 1979; Buehner, Cheng, & Clifford, 2003). It is not surprising that pseudoscientific remedies are used to treat high rate of spontaneous relief diseases, such as back pain. An important question was whether changes in $p(O)$ that reduce positive illusions could be used to reduce negative ones (Matute & Blanco, 2014). In a paradigm to study the illusion in both desirable and undesirable outcomes with equivalent *p*(O), it was demonstrated that the occurrence of a desired outcome is equivalent to the non-occurrence of an undesired outcome (Blanco & Matute, 2015). This paradigm was an adaptation of the *light bulb task* described by Msetfi, Murphy, Simpson, and Kornbrot (2005), which consists of a computer-programmed sequence of events in a series of 50 trials with two different interpretations depending on the valence of the scenario presented in the instruction. Participants were assigned either to a produce valence (in which the light *on* was described as a desirable outcome the participant should try to produce) or a prevent valence (in which light *on* was undesirable, to be prevented). A second manipulation was the *p*(O), the probability of light coming on, in a high *p*(O) = .80 condition or in a low *p*(O) = .20 condition (the light came on in 40, or 10, out of 50 trials in a random order). Participants earned or lost 1 point when the light switched on, depending on the valence of the scenario, and the total score was continuously present on the screen in green or red color, depending on the positive or negative sum of scores. At the end of the series, participants were asked to answer the question "To what extent did you control the switching on of the light bulb?" by rating their judgment of control on a scale from -100 to +100. The results indicated that *p*(O) affects the illusion in opposite directions in both valences. However, the intensity of judgments of control depended on the probability of performing the action, *p*(A); i.e., the higher the probability of performing the action, *p*(A), the more intense judgments of control in any valence of the scenario. The light bulb task can be represented in a 2 x 2 contingency matrix: a binary judgment where the cue is either present (C) or absent (~C) and the outcome is either present (O) or absent (~O).

Different mathematical models can be applied to better understand what produces the illusion of control. Robert Rescorla and Allan Wagner proposed the causal, associative, and mathematical Rescorla-Wagner (RW) model to explain the quantity of learning that occurs on each trial along a sequence of a Pavlovian learning process (Gazzaniga, 2010; Hollis, 1997; Rescorla, 1966; Rescorla & Wagner, 1972). The model is represented by the equation $\Delta V = \alpha\beta(\lambda - \Sigma V)$, where V is the associative strength of the action and ΔV is the amount of learning or associative strength of the action in the trial, or the change in the predictive or expected reward value V of a current stimulus. The term λ represents the asymptote of learning possible with the outcome, and ΣV is the sum of the associative strength of the action, V, and the associative strength of a constant background stimulus. Learning depends on the amount of surprise, the reward or the difference between what actually happens, λ, and what one expects, ΣV. Conventionally, when the stimulus is present, λ is set to the value of 1, or to 0 when it is absent. The learning rate parameters, α and β, relate respectively to the salience or speed of the action and of the outcome. The kernel of the RW model is the mechanism of error via error correction. An individual's judgment of control is given by the strength of association between the representation of the action and the representation of the outcome, V, and such associative strength is updated every time the action is performed (Blanco & Matute, 2015).

The Probabilistic Contrast Model (PCM) is another contingency-based model, however it is not based on a learning algorithm. It assumes that the organism mentally compares the probability of an effect in the presence and in the absence of a potential cause. This model can be formalized in the equation $\Delta p = p(O|C) - p(O|{\sim}C)$, where Δp is the contingency metric, $p(O|C)$ is the conditional probability of the effect (outcome) in the presence of the cause, and $p(O|{\sim}C)$ is the conditional probability of the effect in the absence of the cause. This common index to measure the contingency between two events is also named as the normative Δp rule (Jenkins & Ward, 1965). If the contrast, or difference, is larger than zero, C will be perceived as producing or generating the effect; if it is less than zero, C will be perceived as preventing the effect. The organism's estimate of the strength of the causal relationship reflects Δp. Contrary to the assessment of covariation, Patricia Cheng has introduced the causal power theory of the Probabilistic Contrast Model, also named the Power PC theory, not only to assess causality but also to overcome some normative and prediction problems that apparently could not be solved by either the RW model or the PCM (Buehner, Cheng, & Clifford, 2003; Cheng, 1997). Despite Cheng's attempts to solve the PCM and RW model problems, many researchers conducted experiments that could not be accounted for in Power PC theory and presented evidence that participants use contingency information in a different pattern of judgment under many conditions (Collins & Shanks, 2006; Lober & Shanks, 2000; Perales & Shanks, 2003). Blanco and Matute (2015) examined the predictions made by Cheng's model in productive and preventive non contingent settings, computing the Power PC index for each participant and averaging the results per group, and obtained no significant deviation from zero (because it was a null contingency setting) and small variability due to slight departures from actual contingency (because participants were free to choose to act or not, and when to act).

Objectives of the Study

The objective of the current study was to analyze the effects of the valence of the scenario, of the probability of the outcome, $p(O)$, and of the probability of the action performed by the participant, $p(A)$, on the magnitude of illusion of control developed in the light bulb task. The effects were measured through a self-assessment scale for judgments of control, and through associative measures: the associative strength of the action (or expected reward), *V*; the Δp of the Probabilistic Contrast Model; and the Cheng's Power PC index, P_{PC}.

The work was a replication of the experiment and the study by Blanco and Matute, 2015. Based on it, the predictions were that the experimental task would generate the illusion in both scenarios (productive and preventive) with the same intensities but opposite signals, the productive valence would generate positive illusions and the preventive valence would generate negative illusions; *p*(O) would affect the magnitude of the illusion, the higher the probability of the successful outcome (high frequency of desired outcomes or low frequency of undesired outcomes), the stronger the illusion; *p*(A) would affect the magnitude of the illusion, the higher the probability, the stronger the illusion; and the associative measures would correlate to the judgment of control, the higher the illusion, the greater the measures, null illusion would be associated with null associative measures.

Method

Participants

The sample consisted of 81 undergraduate students (53 women), 18-31 years-old (M = 21.94 years, SD = 3.31) recruited in Health Campus of the Federal University of Rio Grande do Sul. The sample size can provide an α_{error} = .05 and power = .85 in a 2 X 2 ANOVA design to detect medium effect sizes, as calculated in software G*Power (version 3.1.9.2); it was approximately the same sample size as in Blanco and Matute (2015). The post hoc observed power for the significant effects was from .75 to .99. Ethics approval was obtained from Instituto de Psicologia da Universidade Federal do Rio Grande do Sul Research Ethics Committee.

Apparatus

One desktop computer with two 19-inch screens projecting the same image, keyboard and mouse were installed in a sound-attenuation chamber in an audiology laboratory at the university (*Laboratório de Audiometria do Instituto de Psicologia da UFRGS*). One screen, keyboard and mouse were set on an table inside the chamber; the desktop and the monitoring screen were installed outside the chamber. The task was developed in *E-Prime* for *Windows,* version 2.0.

The Light Bulb Task

The experimental task was a replication of the light bulb task programmed by Blanco and Matute (2015), which consisted of a sequence of instruction slides (translated to Portuguese) on the screen, followed by one sequence block of 50 trials where a light bulb that was off appeared on the screen. In the productive scenario, participants should try to produce the light on; in the preventive valence, they should try to prevent the light on. The instructions included texts (see Appendix A) that differed in the excerpts that specified the goal according to the valence: "to make the lamp bulb turn on", "if the lamp turns on, you earn 1 point", "you should try to earn as many points as you can by keeping the lamp bulb on", in the productive valence; and "to make the lamp bulb turn off", "if the lamp remains off, you earn 1 point", "you should try to earn as many points as you can by keeping the lamp bulb off", in the preventive valence.

Participants were randomly assigned to one of two experimental scenarios (productive or preventive valence) and two probabilities of the outcome (p(O) = .80 or .20 of light bulbs in on state) according to a systematic sequence programmed in the computer. The resulting four experimental between-subjects conditions (i.e., the groups) with approximately 20 subjects each were: productive-high (n = 19), productive-low (n = 22), preventive-high (n = 20), and preventive-low (n = 20).

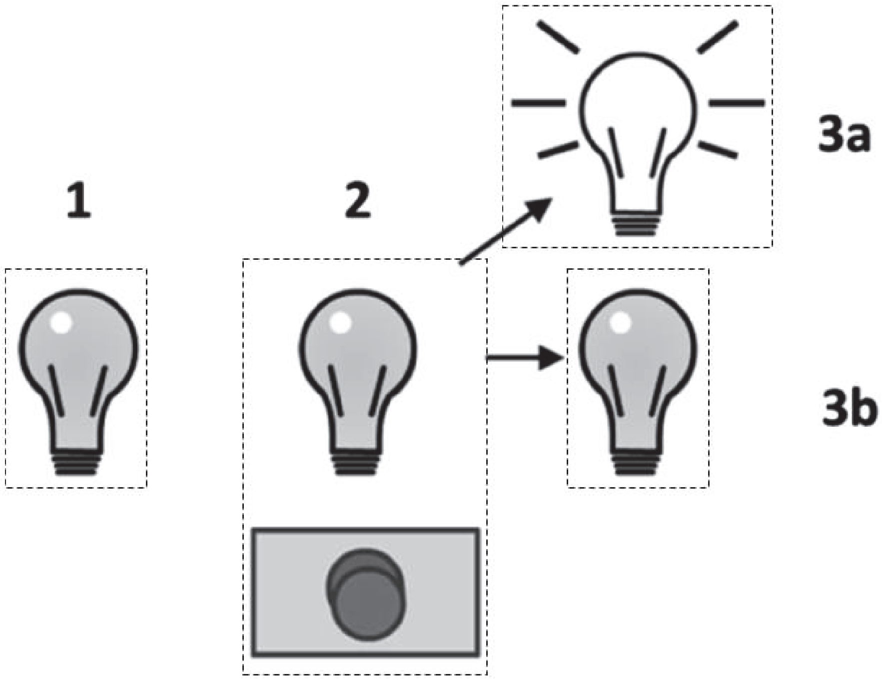

Figura 1.1. Diagram of the sequence of events in each of the 50 trials of Experiment 1. Each dotted rectangle represents the image that appeared on the screen during the event. On the left (1), Event 1 consists of displaying the image of a white lamp bulb that was off for 2.00 s, to constitute the interval-trial-interval (ITI) that marks the beginning of the trial. In the center of diagram (2), Event 2 consists of

the same previous image with a red button appearing below the lamp bulb for 2.00 s - the participant had the opportunity to press (or not) the spacebar on the keyboard, as a response. On the right, Event 3, in which one of two images appeared: either a bright yellow lamp was on (3a) or a white lamp off (in gray, 3b) for 2.00 s. Adapted from Blanco & Matute (2015) with permission.

Each of 50 trials was a sequence of the three events represented in Figure 1.1. The event 1 was the inter-trial interval (ITI) of 2.00 seconds, during which a picture of a light bulb that was off appeared on a white background in the computer screen. The participant had to wait until the next event. The event 2 was the first half of the trial itself, lasted 2.00 seconds, during which a picture of a light bulb that was off accompanied with a red button bellow and a textbox appeared on the white background in the computer screen. The textbox stated “You may press the button now”, indicating to the participant the opportunity to decide between two actions: to press the button by pressing the spacebar of the keyboard immediately; or do nothing and wait. The button remained available on the screen for 2.00 seconds before it disappeared (along all procedure, any response given or incidental pressing while the button was not present on the screen had no effect and was not recorded). The event 3 was the second half of the trial, lasted 2.00 seconds, during which either a picture of a light bulb that was on (outcome-present trial) or – alternatively and randomly – a picture of a light bulb that is off (outcome-absent trial) appeared on the white background in the computer screen. Then a new trial started and the ITI was presented again. After the series of 50 trials, a textbox appeared on the screen asking the participant to make his judgment of control, by answering to the question “To what extent did you control the switching on of the light bulb?” The rating is possible by clicking with the mouse on a continuous scale ranging from -100 to +100.

Procedure

Procedures were registered and approved in Plataforma Brasil (number 48155215.6.0000.5334). The researchers adapted the design from the study by Matute & Blanco (2015). Participants were recruited by invitation in the university facilities (corridors and rest areas), email, social media, and visits to classrooms) and took part as volunteers. Some paper documents were available (consent form, participants register, sessions register, operational protocol, lab book, see Appendix F)). Each participant read, signed and kept a copy of the consent form and entered the chamber that provided an environmental with limited visual and acoustic stimuli, see Figure 1.2. The researcher stated standard instructions and the participant started the task. The researcher monitored the screen outside the chamber, there was a little window but it was not possible to see the participants, their behavior or the responses. Each session took around 20 minutes.

Figure 1.2. Sound-attenuation chamber where data were collected in Experiments 1 and 2. The computer and monitoring screen were set outside the cabin (left). Inside, the participant tried to control the lamp bulb which appeared 50 times on the screen using the keyboard, and made self-assessments with the mouse (right).

The researcher, when conducting the participant out of the cabin, asked openly about the impressions during the task, through the question: "How was the task? Tell me a little what you saw, what you did, what you thought and what you felt. " The speech was recorded on paper. If the participant mentioned any changes occurring during the activity, the researcher asked: "At what time or moments did this change occur? Explain to Me how it happened." After the thanks and farewell, the researcher prepared the computer for the next participant and typed in spreadsheet the participant's data, oral response and private occurrences during the experiment. Data were collected by the PhD student and two undergraduate students, the team took turns in collecting.

Data Analysis

The study was an ANOVA 2 x 2 experimental design. The independent variables (IVs) were the productive or preventive valence, and the probability of the outcome (*p*(O) = .20 and .80). The dependent variables (DVs) were the participants': probability of the action (*p*(A), the number of trials in which the participant pressed the spacebar over 50 trials, a continuous variable, scale from 0.00 to 1.00); and the control self-judgement (the answer to the question "To what extent did you control the turning on of the light bulb?", a continuous variable, scale from -100 to +100).

The analyses were performed using IBM SPSS version 20.0.0, Minitab version 18.1, and Microsoft Excel 2013. Boxplots, interval plots, General Linear Models (GLM) were used to analyze the simultaneous effects of the multiple variables between- and within-participants and to search for differences and interactions. Data were normalized when possible by Box-Cox or Johnson's transformation formulas (Chou, Polansky, & Mason, 1998). The assumptions of homogeneity of variance and sphericity were checked, the results were adjusted when necessary, and confidence intervals were adjusted by Bonferroni's correction. Scatterplots, Pearson's correlation tests and simple linear regression analyses were used to represent and measure the relations between variables. It was important to verify through GLMs and confidence intervals of the means if the groups differed in the levels of *p*(A) and *p*(O), if there were reasons to suspect that participants pressed the spacebar if they were more or less frequently rewarded, and if there were different levels of actual contingency. An α level of .05 was used for all statistical tests.

Additional analyses of *potential confounds* need to be performed to ensure that there were no confounding factors acting during the experimental task: the comparison of all groups in their *p*(A) level should result equal, and the actual contingency should result null (Blanco & Matute, 2015). About the first analysis, it is known from previous reports, conducted in similar conditions than the present study, that regressions between raw judgments and *p*(A) yielded significant relations: the higher the *p*(A), the more intense the judgment of control both in productive and preventive scenarios (e.g., Blanco & Matute, 2015; Blanco et al., 2011; Matute, 1996). The comparison of the *p*(A)s, renders the effects of *p*(A) on the judgments of control, in a way that differences in *JC* can not be attributable to the groups differing in their levels of *p*(A), so it is better if there is no between-groups differences in *p*(A). Participants may press the button more often in those groups where are were more frequently rewarded, either because the desired outcome occurred often (e.g., in a Produce-High group), or because the undesired outcome was absent in most of the trials (e.g., in a Prevent-Low group).

The second analysis is on actual contingency. Studies reported that high contingency between action and effect (i.e., outcome) and high sense of control are both rewarding in any valence; not only, having an effect increases the frequency of response (Eitam, Kennedy & Higgins, 2013; Karsh & Eitam, 2015; Karsh, Eitam, Mark & Higgins, 2016). So it is important to ensure that there is also no between-groups differences in such metrics.

Actual contingency and the associative measures were analyzed through the Δp of the Probabilistic Contrast Model, the Power PC index, and the Rescorla-Wagner model. The associative measures from the Probabilistic Contrast Model and from Power PC theory are formulated at the computational level and try to specify what is computed over the course of a causal induction. The PCM was calculated by the equation $\Delta p = p(O|C) - p(O|{\sim}C)$, where the participant's estimate of the strength of the causal relationship reflects Δp. The 2 x 2 contingency matrix that contains the frequencies of the combinations can be used to calculate the conditional probabilities $p(O|C) = a/(a + b)$ and $p(O|{\sim}C) = c/(c + d)$. The term $p(O|C)$ denotes the conditional probability of the outcome (green light) in the presence of the "potential cause" (action of pressing the space bar), and $p(O|{\sim}C)$ is the conditional probability in the absence of the action; *a* is the number of present outcomes in the presence of the cause, *b* is the number of absent outcomes in the presence of the cause, *c* is the number of present outcomes in the absence of the cause, and *d* is the number of absent outcomes in the absence of the cause, for each block of trials. Note that in illusion of control experiments it is necessary to invert the logical position of the term *outcome*, which becomes the stimulus for the action response, but it will be treated in the analysis as a potential effect.

The Power PC index and Rescorla-Wagner's model were presented just in the discussion section of the original article, as a complement, but in the present study will be part of the main results. The Power PC index, P_{PC}, is usually calculated in order to isolate the causal strength of the action from other potential causes operating in the background that cannot be detected by Δp alone. For instance, if an effect is due to a cause with nonzero contrast, $\Delta p > 0$, or to any constantly present alternative cause, $p(O|{\sim}C) > 0$, it would not be possible to know whether one or the other or both causes at the same time lead to the effect. For this index, it is necessary to consider the causal valence (productive or preventive). Cheng has predicted that a reasoner would normalize Δp by means of the base-rate of the effect and the metric P_{PC} would review the causal power of cause C, $P_{PC} = \Delta p/(1 - p(O|{\sim}C))$; it isolates the causal strength of the action created by other potential causes operating in the background, which is the role of the denominator in the fraction in its formula (Blanco & Matute, 2015).

A similar argument concerning coincidences of C and alternative causes in preventive cases conducted to another equation, $P_{PC} = - \Delta p/p(O|{\sim}C)$ (Cheng & Holyoak, 1995). In the light bulb task, in the preventive valence participants were instructed to try to prevent the light from coming on.

The RW model, represented by the equation $\Delta V = \alpha\beta(\lambda - \Sigma V)$, was used in Microsoft Excel to simulate the associative strength of the action (also called expected reward), V, for each subject using the same individual trial sequence and then averaging the results per group of p(O) and valence. The learning rate parameters were: the salience of the action $\alpha = .6$ and the salience of the outcome $\beta = .5$ in the presence of the outcome, and $\alpha = .2$ and $\beta = .5$ in the absence of the outcome, $\lambda = 1$ for the presence of the stimulus or outcome green light, $\lambda = 0$ for the absence of the stimulus or presence of red light (Blanco & Matute, 2015).

Results

Judgments of Control

The distribution profiles of the ratings of judgments of control for each group are plotted in Figure 1.3. These results of *JC* were submitted to a GLM with valence and p(O) as factors, resulting in a significant and large effect of p(O) (F (1, 77) = 28.36, $p < .001$, $\eta^2 = .26$, $\eta_p^2 = .27$). The mean illusion was positive under high p(O) (*JC* = 32, 95% CI [19, 44], $n = 42$), and negative or close to null under low p(O) (*JC* = -15, 95% CI [-27, -2], $n = 39$). The confidence intervals of the means for each group of valence and p(O) are illustrated in Figure 1.4. There was no significant effect of interaction, nor of valence (Fs < 3.28, $p > .074$). It is important to highlight that individual values varied a lot and that 26% of participants declared to have null control on the light bulb.

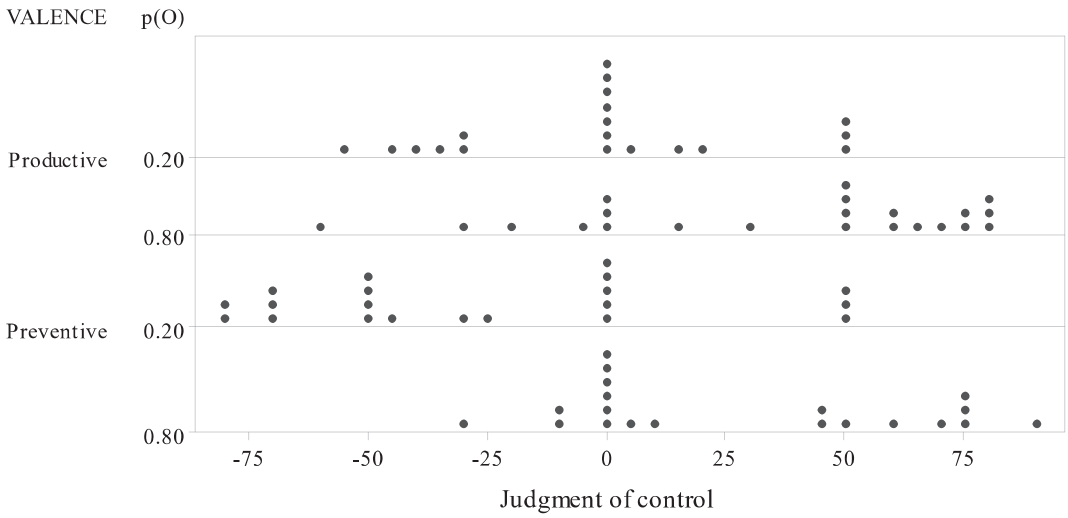

Figure 1.3. Dot plots of the judgment of control self-assessments results for each group of productive or preventive valence, and low or high probability of the outcome. It is observed the tendency for the positive illusions under high probability, but negative or zero when the probability of response is low.

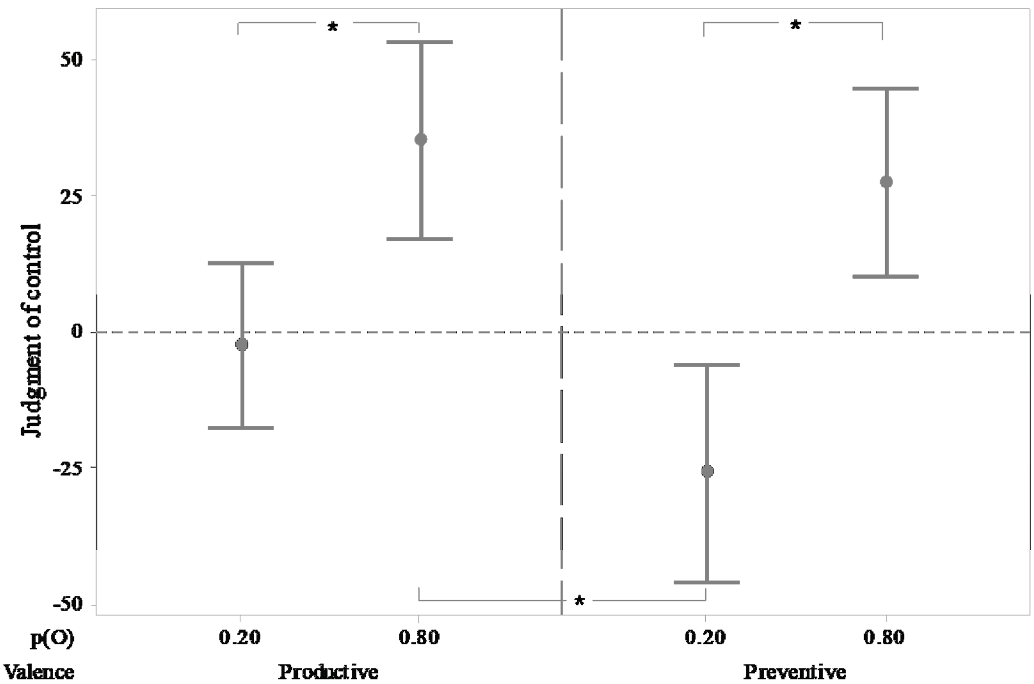

Figure 1.4. Interval plots for the judgment of control confidence intervals, according to the groups of participants under conditions of productive (appetitive) or preventive (aversive) and low or high probability of outcome for the light bulb to turn on. There was a clear difference between the preventive and productive groups; the high probabilities generated positive illusions while the preventive condition

with low probability of response generated negative illusions. The only group to have illusion of intensity close to zero was that of productive condition with low probability of response. * $p < .05$.

The results were also submitted to tests for mean comparisons between subgroups of the factors. All of the three tests for mean comparisons (Tukey, Bonferroni, and Sidak methods) indicated that the sample can be classified in three subgroups significantly different in *JC*. It was possible to separate data in three subgroups of participants, the “Low *p*(O)s” (negative or null illusion) , the “High *p*(O)s” (positive illusion), and an intermediary subgroup that can be partially confounded with the other two, see Table 1.1.

Table 1

Grouping Of Mean Values Of Judgment Of Control (JC) By Valence And Probability Of The Outcome (P(O)) Using The Bonferroni Method And 95% Confidence

Valence x *p*(O)	*n*	*Mean JC*	Grouping*		
Productive-High *p*(O)	22	35	A		
Preventive-High *p*(O)	20	28	A	B	
Productive-Low *p*(O)	19	-3		B	C
Preventive-Low *p*(O)	20	-26			C

*Note: The test resulted in three groups (A, B, C) partially superposed. Group A is characterized by positive illusions, Group B by null and positive illusions, Group C by null and negative illusions. The General Linear Model on which this analysis was made indicated only the significant main effect of p(O) (F (1, 77) = 28.36, p < .001, $\eta^2 = .26$, $\eta_p{}^2 = .27$)

The first subgroup (A) was constituted by all participants under low *p*(O), they presented negative or null illusion; another group (C) was constituted by all participants under high *p*(O), who presented positive illusion; these groups are entirely separated by the factor *p*(O) as it was indicated by the previous GLM. And there was a third subgroup (B), constituted by productive-low *p*(O) plus preventive-high *p*(O) participants, who presented null or positive illusion.

As the judgment scale was bidirectional (-100 to +100), it was also important to analyze the absolute values of the judgments of control, because positive and negative departures from zero could mask the illusions by compensation. Another GLM taking |*JC*| as the response, and the same factors of the previous GLM, revealed an intermediate effect of the interaction between valence and p(O) (F (1, 77) = 6.35, p = .014, $\eta^2 = .08$, $\eta_p{}^2 = .08$, r = .27). As it can be seen in Figures 1.5 and 1.6, *p*(O) affected the absolute judgments of control only under productive valence, where the greater *p*(O), the greater the illusion; the Tukey test also pointed such difference. In the preventive group there was no significant difference and there was no significant main effect (*F*s < 1.41, *p* > .023).

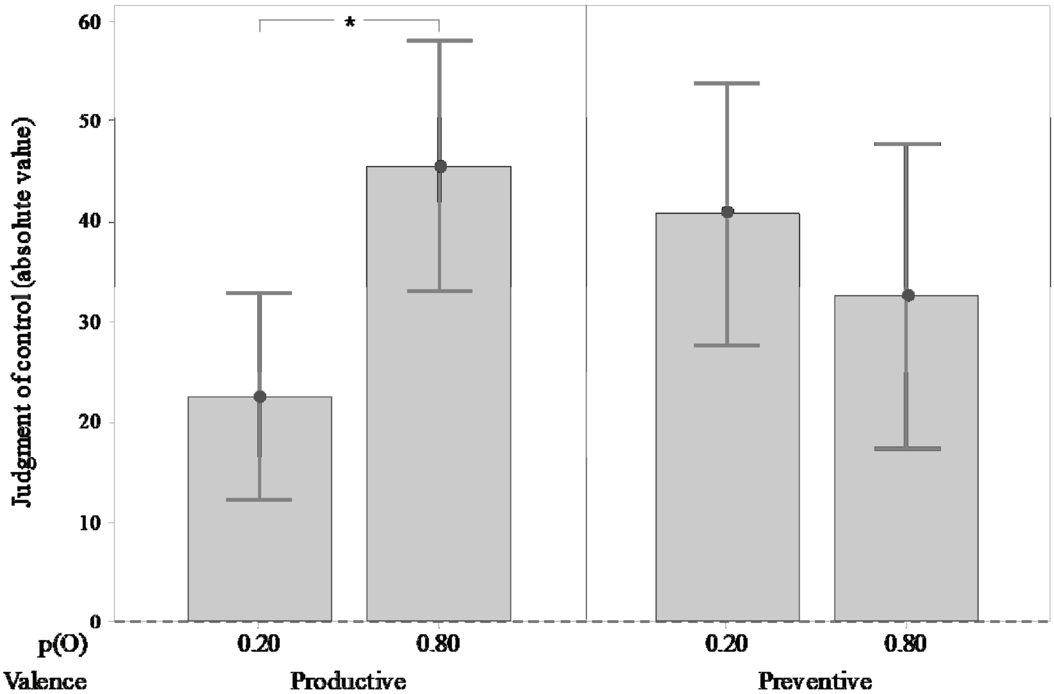

Figure 1.5. Interval bar charts of mean absolute values of the control self-assessments for the 4 groups, with 95% confidence intervals. Illusion of control is significantly affected by probabilities of the outcome only in the productive group (left), i.e., there was an interaction effect valence vs. p(O). Results suggest a tendency to a greater illusion in the Productive-High and Preventive-Low conditions, but there were no significant differences. * $p < .05$.

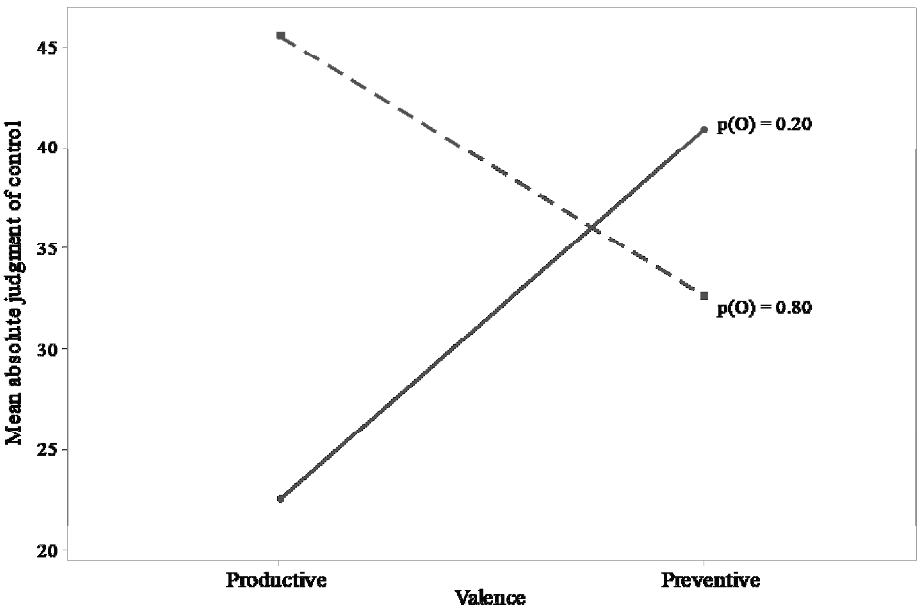

Figure 1.6. Plot of the interaction between the factors valence and probability of the outcome on the absolute values of the judgments of control. In the productive group (left), the higher p(O), the higher

the intensity of the illusion of control ($p < .05$). In the preventive valence (right), there is an apparent inversion, but there is no significant difference between probability groups.

Reaction times (*RT*s) were recorded by the computer program for the trials when the response was an action, although they were not included in the original project of this study and, therefore, will not be detailed. There was a small inverse Pearson correlation between mean *RT* and the participant's age ($r(79) = -.23$, $p = .37$) and a strong direct correlation between mean *RT* and *p*(A) ($r(79) = .60$, $p < .001$).

Probability of the Action

The probability of the action was calculated as the number of trials in which the participant decided to press the button over the total number of trials (i.e., 50). The original light bulb experiment and literature reported the effect of the *p*(A) on judgments of control, and how this effect could be modulated by valence and *p*(O) (e.g., Blanco et al., 2011; Matute, 1996). Simple linear regression analysis for each group (i.e., productive-low *p*(O), productive-high *p*(O), preventive-low *p*(O, and preventive-high *p*(O)) yielded no significant effect on *JC* ($F < 2.11$, $p > .161$), unlike the previous studies. The scatter plots in Figure 1.7 are presented just for comparison with Blanco and Matute (2015), but no regression was significant.

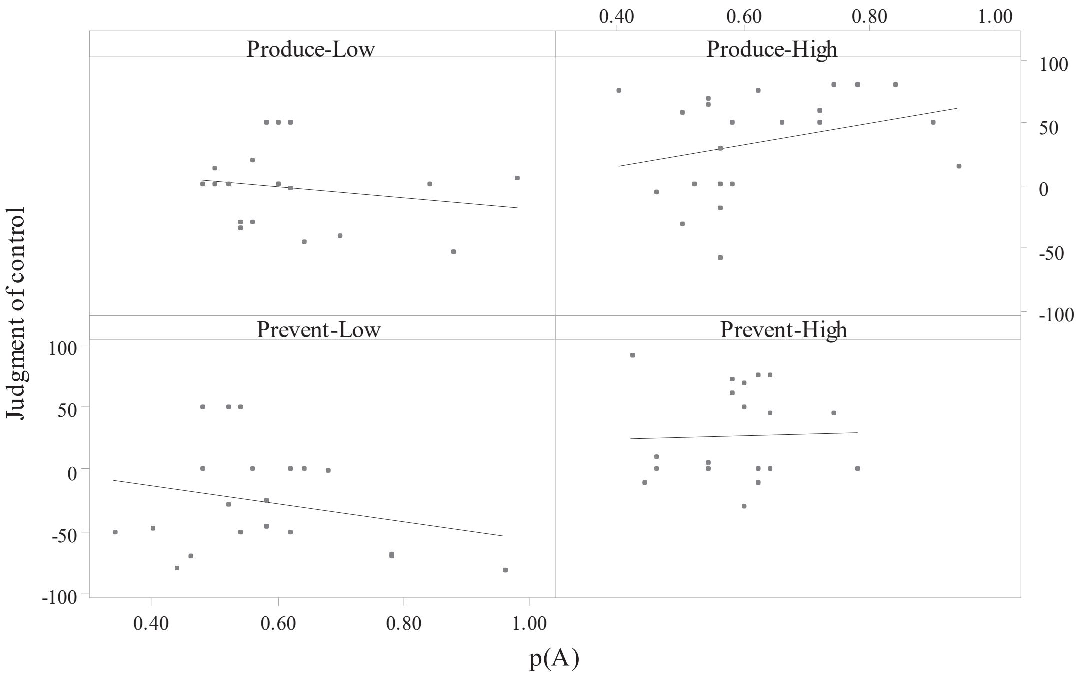

Figure 1.7. Scatter plots depicting the participants' judgments (vertical axes) as a function of their *p*(A) (horizontal axes), by group of valence and *p*(O). Regression lines are traced, however, the regressions presented no significant effect. As in the previous study (Blanco and Matute, 2015) the slopes tend to be positive in the high probability group and negative in the low probability group.

Analyses of the Potential Confounds

According to the previous study (Blanco & Matute, 2015), two additional analyzes need to be performed to ensure that there were no confounding factors acting during the experimental task: the comparison of all groups in their *p*(A) level, and the actual contingency. A first check made was if the response *p*(A) was equivalent among all groups through a GLM with valence and *p*(O) as factors. The model produced no significant main effect or interaction (see Figure 1.8; $F < 2.47$, $p > .121$). The mean probability of the action in the preventive group was *p*(A) =.62, 95% CI [.58, .67], while in the preventive group it was *p*(A) = .58, 95% CI [.54, .62], they are statistically equal and indicate that the participants responded with higher number of pressings than omissions.

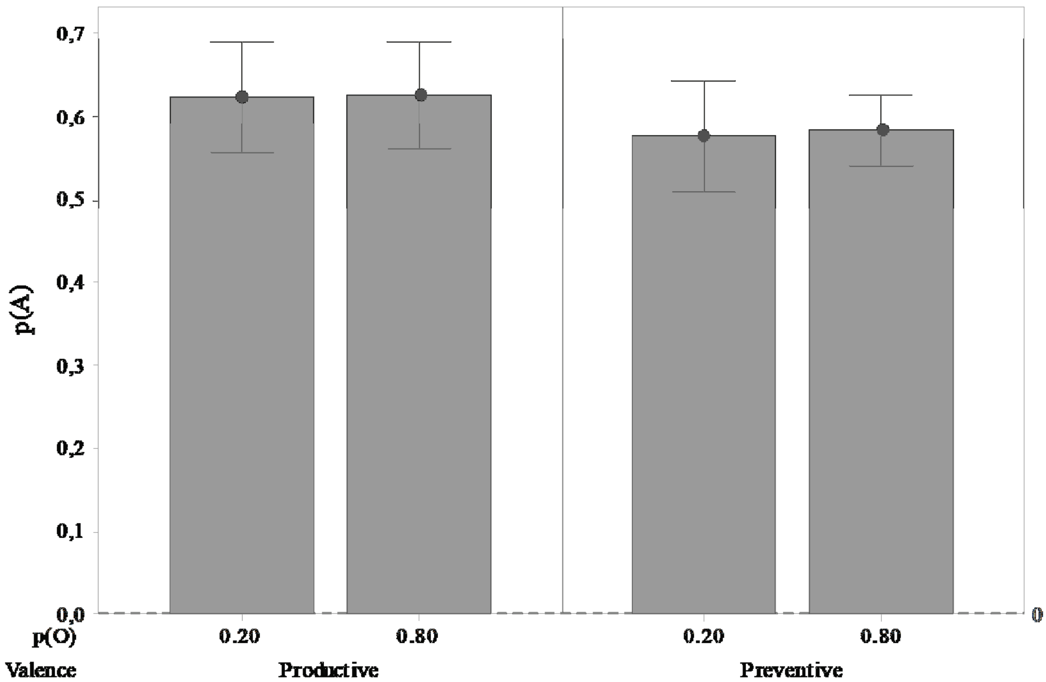

Figure 1.8. Mean probabilities of the action for the four groups and respective 95% confidence intervals, presenting no significant difference between groups. During the light bulb task, around 60% of the responses were actions.

The second potential confound was actual contingency, an important factor to analyze because participants may have ended up exposing themselves to slightly different levels of actual contingency by chance, even when the programmed contingency was set to zero (Blanco and Matute, 2015; Hannah, Allan, & Siegel, 2007). After removal of three outliers, actual contingency was measured by the Δp index of the Probabilistic Contrast Model, which was computed from the total of 50 trials for each participant and compared among all groups of valence and p(O). The result of Δp index did not exclude the possibility of null contingency (Δp = -.01, 95% CI [-.04, .02], n = 78). The GLM with valence and p(O) as factors was conducted for such Δp actual contingency values, and yielded no significant results for main effect or interaction (F(1,74) < .56, p > .458). Thus, it is unlikely that Δp can explain the between-groups differences in the judgments.

Causality models

Two theoretical models have been applied to represent illusion of control from its determinant factors, the actions and the effects: Power PC index and Rescorla-Wagner's model. The power PC theory is a recently developed model of causal induction which addresses causal judgment from contingency information about the dependence of one cause on an effect; that is, the extent to which one thing is present or absent when another is present or absent (White, 2005). The P_{PC} was slightly negative but very close to null (P_{PC} = -0.16, 95% CI [-0.32, 0.01], n = 77). The GLM with valence and p(O) as factors was conducted for P_{PC} yielded no significant results for main effect or interaction (F(1,73) < 2.27, p > .136).

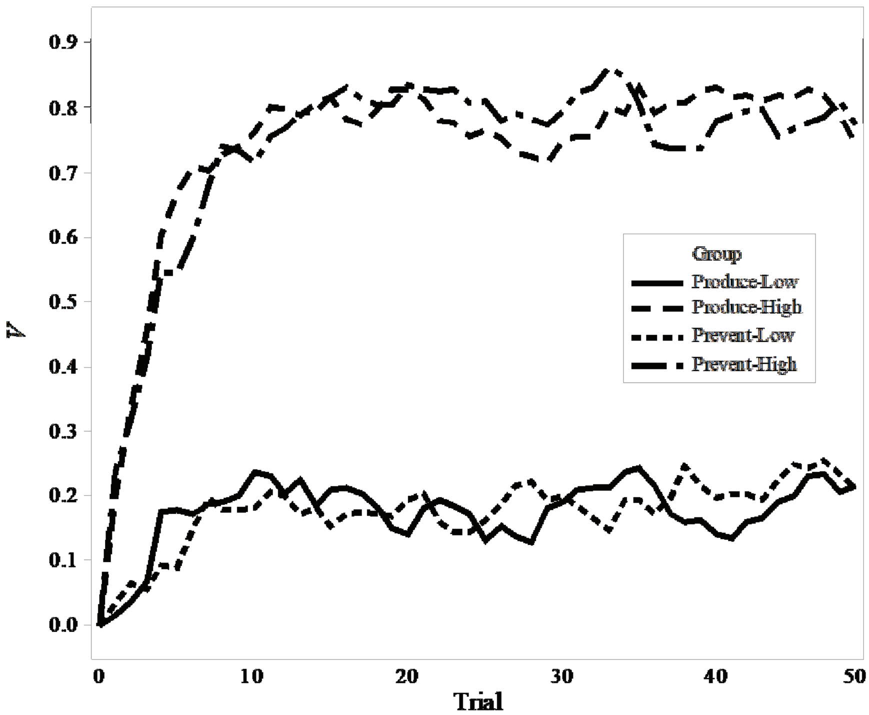

Figure 1.9. Line plot of the mean associative strength of the action (*V*) through the sequence of 50 trials, simulated and averaged per each of the four experimental groups, or combinations of valence (productive or preventive) and probability of the outcome (p(O); low or high), as simulated in the Rescorla-Wagner model (Rescorla & Wagner, 1972). The asymptotic patterns observed at the end of the sequences indicate that high probabilities of the outcome (p(O) = .80) resulted in stronger

associations between actions and outcomes, while low probabilities (p(O) = .20) resulted in weaker associations, independently of the valence.

The Rescorla-Wagner model was used to simulate the data with the original trial sequences produced by each participant. The parameter values were taken from previous publications in which the effects of *p*(O) and *p*(A) on control estimations were reproduced under the usual assumption that the salience of the action (or the target stimulus) is greater than that of the context (Blanco & Matute, 2015; Matute et al., 2007). Figure 1.9 depicts the results of the simulation. The results from groups under higher *p*(O) after stabilization through the sequence of trials produced higher mean associative strengths of the action, while the results from groups under low *p*(O) produced lower *V*s.

Discussion

The interest for this study was to conduct an experiment where the phenomenon of illusion of control in an uncontrollable task should appear, be measured, and analyzed in terms of three variables that modulate it: The probability of the outcome, *p*(O), the probability of the action, *p*(A), and the causal valence of the scenario (productive vs. preventive). The effect of *p*(O) has already been reported as the higher the frequency of desired outcomes, the stronger the illusion that the task is under the participant's control (Alloy & Abramson, 1979; Blanco & Matute, 2015; Buehner et al., 2003). Likewise, the effect of *p*(A) entails a similar illusion, the higher the frequency of action responses, the stronger the illusion (or the sense of agency; Blanco & Matute, 2015; Blanco et al., 2011, 2012; Eitam et al., 2013; Hannah & Beneteau, 2009; Karsh & Eitam, 2015; Matute, 1996). Both effects have been studied in productive scenarios where participants attempt to produce a desired outcome, but few studies have included preventive scenarios where an aversive outcome is to be prevented (Biner et al., 2009; Blanco & Matute, 2015).

In addition to the objectives of identifying and measuring the factors that affect the illusion of control in the task of the light bulb in a computer, one can compare the present study with the original one by Blanco and Matute (2015), since the procedure is the same and the size and profile of the sample are similar, that is, undergraduate students. The replication of experiments is a timely issue, given the recent discussion of a "replicability crisis", in which scholars have argued that replication are scarce and the results of many scientific studies are difficult or impossible to replicate or reproduce on subsequent investigation. Others argue that whereas direct replication attempts are uncommon, conceptual replication attempts are common and could provide an even better test of the validity of a phenomenon; in its turn this would open the door to literatures that appear to confirm the reality of phenomena that in fact do not exist, contributing to publication bias (Pashler & Harris, 2012). The response to the replicability crisis has generally resulted in the publication of articles providing guidelines and recommendations for best practices, such as updating of journal policies to require explicit justification of sample size selection, the use larger samples, the avoidance of underpowered studies, discouragement of traditional null hypothesis testing in favor of the "new statistics" (the adoption of known but underutilized techniques, including estimation based on effect sizes, confidence intervals, and meta-analysis), that all data and analysis scripts are made openly accessible, and preregistration of hypotheses and methods before data collection (Kappenman & Keil, 2017).

It was observed and confirmed that the phenomenon of the illusion of control exists and it is significant, if measured as the perception of control of the task by means of a self-assessment scale. In broad terms, the mean illusion, as measured by self-assessed judgments of control in the -100 – 100 scale, was positive under high p(O) and negative (with CI close to null) under low p(O) in any valence, as there was no significant difference between the productive and preventive valences and no interaction.

In the productive group (see Figure 1.4, left) the judgments were positive in the Productive-High group and null in the Productive-Low group, as expected in the hypothesis and also they were the same as those by Blanco and Matute (2015). However, in the preventive group (see Figure 1.4, right) the judgments were negative in the Preventive-Low, as expected and the same as in the previous study), but *JC* were *positive* in the Preventive-High group (it was expected that they were null). In the previous study and in the hypotheses, judgments were null or close to null in the Productive-Low and in the Preventive-High, because in these conditions participants are exposed respectively to low frequency of desired outcomes and high frequency of undesired outcomes. In brief, in the current study the results were similar, except for the Preventive-High group, presenting positive illusion (M = 27.60, 95% CI [10.24, 44.96], n = 20) instead of null.

It is possible to understand the reason of the difference in the Preventive-High group. Despite the GLM processed for *JC* which indicated only the main effect of p(O), the mean comparisons tests (Buonferroni and others) indicated that the Productive-Low and the Preventive-High groups can be grouped together. As their *JC* means are not statistically different (see Table 1.1, the two Groups B), it is suggested that both groups developed null or positive illusion and thus they are statistically equal and close to null in terms of *JC*. So there would be three latent types of group underlying the design: Product-High, Product-Low plus Prevent-High, and Prevent-Low.

Another comparison that can be made is between the medians of *JC*: the Productive-Low and the Prevent-High groups both have medians close to the null illusion (*Md* = 0, 95% CI [-30, 7] and *Md* = 8, 95% CI [0, 59], respectively). Such proximity to zero is due to the asymmetry of frequency distributions (see Figure 1.3). Both groups are different from the Groups Productive-High and Preventive-Low (*Md* = 50, 95% CI [0, 65] and *Md* = -37, 95% CI [-51, 0], respectively). Note that one of the CIs includes zero, and all the other three CIs have one of their limits as zero, but only the Productive-Low and the Preventive-High have means close do zero.

It seems there was not enough statistical power to detect the effect of the interaction between valence and *p*(O) in the GLM and, so, make the result of Bonferroni test (Table 1.1) reasonable. Although the assumptions to the GLM were met, *JC* distributions are not normal nor simetric and some bias is possible, even in analyses where subgroups have the same size. Thus, it is not possible to definitively state that the present results contradict the main conclusions of the previous light bulb experiment regarding Preventive-High group.

The non detection of the interaction effect of valence and *p*(O) in *JC* means may also have occurred due to differences between samples, apparatus, or procedures. Brazilian students rarely respond to bidirectional scales in psychological research or elsewhere, maybe it was difficult for them to understand the meaning of the interval -100 – 100, especially the negative scores; the previous study was performed in University of Leuven, Belgium, with European students from probably many nationalities and different cultural (and mathematical) backgrounds. The authors of the previous study seemingly chose the bidirectional scale to fit both scenarios; as the instruction allocated the participant to only one scenario, maybe it did not make much sense to have one logical direction (positive or negative) that met the participant's goal, and another direction apparently useless for the case. The instructions were translated from English to Brazilian Portuguese and some differences in interpretation may have happened (both texts are transcript in Appendix A). The data collection occurred inside a sound-proof chamber in as Audiology Laboratory (Figure 1.2), a new environment for most participants (some of them even refused do participate, due to the confined environment). Future studies in other conditions, and with greater sample sizes or longer sequence of trials (e.g., two blocks of 50 trials) maybe could help to clarify such differences and decrease uncertainties.

The probability of the outcome affected the *absolute value* of the judgment only in the productive group, an effect of the interaction between valence and *p*(O) (Figures 1.5 and 1. 6). The analysis of the absolute values prevents the annulation of negative values over positive ones and suggests a potential (yet non significant) small effect of valence that could appear in future studies under other conditions, other stimulus, or longer sequence of trials or greater sample sizes. Such interaction effect was not evident in the raw values of the judgments, in which only *p*(O) affected *JC* equally in both valences. The effect, group values and graph were similar to the study that was replicated. Note that in Figure 1.5 (right side) there is no significant difference between the *p*(O)s, but $|JC|$ means are visually higher in low *p*(O). By the same reasons already discussed, if the effect of the interaction was stronger, maybe the difference between the judgements in the preventive group could become higher (but it was not significant even in the previous study).

About the effect of the probability of the action on the illusion of control, the data presented in the four groups with a profile very similar to the previous study, with correlations in the same direction: The effect of increasing the illusion with the high probability of response in productive scenarios and decrease it in the preventive scenarios. However, the measured intensities were weaker and not significant at 95%.

The probability of the action has been reported in literature as affecting the illusion of control, but this effect has not been detected. The effect of this factor *p*(A) is controversial in the literature, according to Stefan and David (2013). The variable *p*(A) was considered in this paradigm as a dependent variable, as it is produced through the task and is one of the behavior measures that can be related with judgment of control (as reaction time will be in next studies). In the original experiment and in previous reports conducted in similar conditions (Blanco et al., 2011; Blanco & Matute, 2015; Matute, 1996) it was pointed that the higher p(A), the stronger both the positive and the negative illusions (the higher and the lower the judgment of control in a bidirectional scale, respectively). In their Productive-High and Preventive-Low *p*(O) groups, $R^2 = .35$ and $R^2 = .27$, respectively, corresponding to large effect sizes (Blanco & Matute, 2015). In other words, the effect of *p*(A) prevailed under highly rewarding situations, where desired outcomes occur frequently or undesired outcomes occur scarcely. In the other two groups there was no significant effect and illusion was null or close to null.

However, in the current replication with the same task, program, instructions, sample size, and group sizes, *p*(A) did not present any significant regression with the judgment of control in any group or combination of valence and *p*(O). The only significant regression related to the participants' actions of the participant was *RT* vs. age, inverse as expected. By the other side, either in this or in the previous study, *p*(A) was not affected by valence or *p*(O), which is a previous condition to prevent a potential confound of instrumental tasks in which the decision of whether or not to act is left to the participant. It is necessary that all groups are comparable in their *p*(A) levels, because it is known that *p*(A) affects *JC*. It may seem strange at first sight that conditions should not affect *p*(A), that is related to *JC*, but in turn the same conditions should affect *JC*. It was not presented a model that relates these concepts, but Rescorla-Wagner can help to understand the phenomena.

According to the RW's associative and mathematical model, the quantity of learning that occurs on each trial is a cumulative process represented by the equation $\Delta V = \alpha\beta(\lambda - \Sigma V)$ (Rescorla, 1966; Rescorla & Wagner, 1972). Learning would depend on the amount of surprise, the rewarding difference between what actually happens, λ, in our case the outcome *on* or *off*, and what one expects, ΣV, not measured, as it is a participant's internal process of representation or symbolization. When the stimulus (the light *on*) was present, λ was set to the value of 1, or to 0 when it was absent (light *off*). The participants adjusted their responses (the action of pressing, or the alternative of omission) through the mechanism of error correction. So the percentages of actions remained equal, but the trials had their association between response and outcome, "strengthened" (i.e., pondered) by the salience of the response ($\alpha = 0.6$ in the presence of an action, $\alpha = 0.2$ in case of omission) and the salience of the outcome ($\beta = .5$ either in the presence of the outcome or its absence). The accumulation of associations and their strengths (ΣV) is what represents learning in the model, or in our case the individual's judgment of control, given by the strength of association between the representation of the action and the representation of the outcome, *V*.

So it is not *p*(A) that affects *JC*, but the strength of the cumulative associations response-outcome. The probability of the action, *p*(A), is a measure based on the total of outcomes of the sequence or block, while the associative strength of the action, *V*, is taken trial by trial and summed up through all the sequence of trials. The association between *p*(A) and *JC* is actually a spurious correlation: both variables are affect by ΣV. A suggestion of conceptual model is represented in Figure 1.10. However, in the current study it was not possible to detect the correlation between *p*(A) and *JC*.

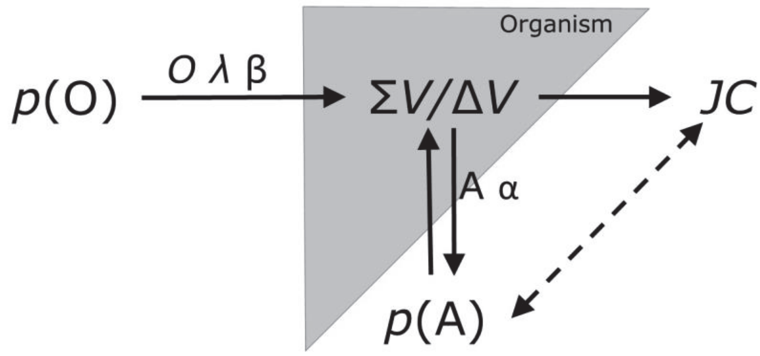

*Figure 1.10***.** Conceptual model of illusion of control incorporating the Rescorla-Wagner's model ($\Delta V = \alpha\beta(\lambda - \Sigma V)$). The model is valid for productive and preventive groups. Solid lines represent a cause-and-effect relation, dashed line represent a correlation. p(O) = probability of the outcome; O = outcome; λ = asymptote of learning possible with the outcome; β = salience of the outcome; A = action; V = associative strength of the action; ΣV = sum (accumulation) of the associative strength of the action; ΔV = amount of learning or associative strength of the action in the trial; A = action; α = salience of the action; p(A) = probability of the action; JC = judgment of control.

Thus it is reasonable to state that illusion of control is a product of action and outcome association. As expected, the order of the pattern of results of the simulations conducted with the Rescorla-Wagner model resembled the order of the judgments of control in both valences (cf. Figures 1.9 and 1.4). The order of the lines at the end of the experiment is almost identical to the order which was obtained with the *JC*s and respective confidence intervals. It must be noted that the choice of another set of parameters could lead to different predictions, but the resemblance between the results of RW's model and the results of self-assessed *JC*s also occurred in the previous studies which used the same values of the parameters α and β and of the variable λ in the formula $\Delta V = \alpha\beta(\lambda - \Sigma V)$ (Blanco & Matute, 2015; Matute et al., 2007).

Still, Cheng's (1997) Power PC theory is a model that did not predict the differences in the judgments of control between any groups. The P_{PC} index should predict no deviations from zero in null contingency settings, and the results did not depart significantly from zero, but were very close to it (P_{PC} = -0.16, 95% CI [-0.32, 0.01]). It is worth to comment that in Blanco and Matute's experiment, actual contingencies measured by P_{PC} departed slightly from zero, and the authors explain that it happens because in this paradigm the participants were free to choose when to act. Moreover, their predictions did not differ significantly from zero inside any group, and the order of the groups according to their mean Power PC predictions did not coincide with the order found in their participants' judgments. Whatever the result of one study or the other, deviations could not be attributable to the between-group manipulations, so the predictions of Cheng's Power PC theory did not explain the between-groups differences in *JC*s. An intriguing issue is about the small variances of P_{PC} under low p(O) that inexisted in Δp (which is the numerator of the formula of P_{PC}).

Blanco and Matute (2015) discussed that the mean predictions made by Power PC in their experiment were negative for the groups in which p(O) was high, and positive for the groups in which p(O) was low, although their P_{PC} 95% CIs did not differ significantly from zero. Both in the previous and in the current samples, there was a wide range in the P_{PC} values computed for each participant; data from three participants were excluded from the GLMs for P_{PC} because they were more than 3 *SD*s less than the sample mean. In active procedures like this, the actual conditional probabilities of the outcome, $p(O|A)$ and $p(O|{\sim}A)$, can vary due to chance and to the participants' decisions to act or not act on each trial (Blanco & Matute, 2015; Hannah et al., 2007). Blanco and Matute argued that in their experiment they used rather extreme values of p(O) (i.e., .80 and .20), which led some participants to be exposed to very high or very low values of the outcome base rate even when their p(A) level was medium. When computing Δp, these extreme values of $p(O|A)$ were probably compensated by the similar values of $p(O|{\sim}A)$, leading to actual values of Δp that were close to the programmed null value. Such "extreme" values of of the outcome base rate supposedly affected the result of the computation of Power PC. As an example, if the outcome base rate was very high in the non contingent and productive scenario, then Δp would be close to zero, whereas the absolute value of P_{PC} would increase without limit. Thus, participants seemingly did not use the type of causal induction that Power PC describes when they judged their control over actually uncontrollable outcomes.

The analysis of the results of Experiment 1 indicated that higher probability of the random outcome, p(O), affected the illusion of control of the participants in the positive direction, as measured by a bidirectional continuous self-evaluation scale, both in generative (productive) and aversive (preventive) scenarios. The lower probability corresponded to null illusions in the productive scenario and negative illusions in the preventive scenario. So the strong illusions occur, in different directions, when there is high probability of success, that is, high frequency of desired outcomes or low frequency of undesired outcomes, but in opposite directions in the scale. Null and weak illusions should happen when there is low probability of success, that is, a low frequency of desired outcomes, or a high frequency of undesired outcomes. Nevertheless, in the current study positive illusions were also present in the last case, although deeper analysis indicated a tendency to null illusion. The results did not indicate either any significant effect of the probability of action by the participant, p(A), on the intensity of the illusion of control, on the contrary of previous studies. Associative measurements complemented the analysis and the Rescorla-Wagner's model could reasonably model the judgments of control; the other tested model, Power PC, was unsuccessful. At last, a conceptual model of illusion of control incorporating the Rescorla-Wagner's model was propos

Suggestions of improvements can be made to the paradigm in future experiments. To the self-assessment by the participants, the use of an unidirectional scale (from 0 to 100) or a bidirectional scale easier to understand could improve the precision and discrimination of the scores. It is also suggested to substitute the image of the light bulb and the button, which is common in productive scenarios but rarely associated with aversive scenarios, for another stimulus that could be more appropriate to either one scenario or the other. The task took short time (6 minutes for the 50 trials), a longer sequence of blocks and trials can be programmed to test the permanence of the phenomenon and its changes in time and intensity. It would be interesting to try different probabilities of the outcome and measure how the illusion varies under different frequencies of successful events.

CHAPTER 2

STUDY 2 – ILLUSION PERSISTS AS A PRODUCT OF ACTION AND OUTCOME

The first study was a replication of the light bulb experiment on illusion of control (IOC) by Blanco and Matute (2015). Participants were exposed to different valences of scenario and different probabilities of the outcome, and one block of 50 trials, then judgments of control were assessed immediately after the task through a numerical scale. The main results of the replication confirmed partially the conclusion of the original study that low probabilities of the outcome induce low or null illusion in both scenarios, and high *p*(O) was associated to positive judgments of control. Nevertheless, the Prevent-High group also presented positive judgments and there was no effect of the probability of the action response by the participants, contrary to hypothesis and contrary to the results of the original study. It is important to search for explanations to such differences through more complex paradigms and to investigate other less subjective measures to evaluate illusions. Another limitation of Study 1 was the use of an inappropriate stimulus for both productive and preventive scenarios. Moreover, beyond the behavioral and cognitive aspects of IOC, it has not yet been sufficiently discussed in literature how illusory tasks and resulting judgments of control relate to emotional states.

Stimulus and Duration of Illusory Tasks

Blanco and Matute (2015) discussed that in their experimental setting involving buttons and light bulbs, people would be, presumably, more familiar with the productive (appetitive, generative, or positive) scenario and that in everyday life most causal relations between buttons and light bulbs are productive. They also argued that the experimental instructions and contingencies guided participants in the preventive scenario, not solely their previous interactions with similar situations.

Maybe it is possible to find a better stimulus to represent both positive and negative goals, and to explore larger ranges of probabilities of the outcome, and even the effect of different probabilities exposed to the same participant. In the second experiment it is important to choose and try a better stimulus that could be usually associated in ordinary life with both productive and preventive scenarios, nonetheless which effect could be emphasized through instructions: a pedestrian semaphore or traffic light in a risky situation would be a simple stimulus that could be adapted for the next experimental task.

Issues about duration of the illusion have rarely been discussed in literature. The first participants were exposed to one block of 50 trials that lasted 5 minutes, and judgments of control were assessed immediately after the task. Blanco, Matute, and Vadillo (2011) found in two experiments that illusions were persistent after 100 trials and these IOCs were significantly stronger in the experiment with a longer training phase. Most paradigms in literature presented less than 100 trials and studies did not discuss the duration or remaining time of the phenomenon of the illusory control (Presson & Benassi, 1996; Stefan & David, 2013).

Action Responses in Illusory Tasks

Investigation on illusion of control can be enriched if it is linked to other fields of research, for instance, the *sense of agency*, "the feeling or judgment of being in control over the internal or external environment" (e.g. the sensation that "I did it"). Karsh, Eitam, Mark, and Higgins (2016) summarized that one's sense of agency can be determined unconsciously through the motor control system and by more top-down conceptual forms of attribution to self, independent of any motor command. According to the authors, although most studies on the influence of the brain's reward system on action selection focus on positively valenced (hedonic) outcomes (e.g., food or money), some works suggest that high action-effect contingency and high perceived control also activate the brain's reward-related circuits, regardless of the outcome's valence. In other works, Eitam, Kennedy and Higgins (2013), and Karsh and Eitam (2015) showed that if one's actions are followed by a seemingly neutral perceptual effect, both the speed and frequency of performing the action associated with that control increases, and so merely "having an effect" facilitated both the speed and frequency of action selection independent of the valence of the outcome. However, their tasks required participants to "freely and randomly" select and press one of four response keys on the appearance of a cue. Their random responses should "avoid any fixed or planned response sequences". Their participants seemingly attempted to respond "randomly", trying to match the probability of emitting the four responses: the action (and the decision) was restricted to press or not press randomly different keys, so participants did not use strategies related to sequences of different combinations of pressings/omissions, nor different reaction times (*RT*s) in the attempts for control.

Affective Assessments in Illusory Tasks

Affect or emotion is a psycho-physiological construct that mediates an organism's interaction with stimuli. Regardless their countless definitions, in emotional situations, the body acts, so that both the word "emotion" and the word "motivation" stem from the Latin *movere*, meaning to move. These two descriptors have been pointed as in close relationship since Charles Darwin's and William James' writings, and nowadays the motivational systems, defined by limbic circuits, are a major focus of neuroscience research. Emotions are action dispositions and mobilize the body for behavior; the action itself can be emitted, delayed or totally inhibited (Cacioppo, Tassinary, & Berntson, 2007, p. 581-582).

Affective states can be detected by the (self-)observation, and assessed by psychophysiological measures or by psychological scales. There are different models of emotion and of motivation. In Margaret Bradley's and Peter Lang's approach (Cacioppo et al., 2007), emotions vary along two principal dimensions: valence and arousal. Valence is the subjective evaluation of emotions in positive (good, appetitive, agreeable) or negative (bad, aversive, disagreeable), an it is related to two motivational systems linked to the parameter of direction in animal behavior. Arousal is the intensity of the activation of the sympathetic nervous system, measured objectively with psychophysiological equipment or subjectively via self-reported scores in scales. Arousal is a construct that is closely related to motivational intensity. However, motivation necessarily implies an action (or an omission related to a possible action), it is the impulse to act; in other words, arousal is the strength of the urge to move toward a stimulus or away. Arousal does not necessarily implies an action, it refers to an intensity measured also in a permanent static or passive state.

The two motivational systems are activated by a wide range of unconditioned stimuli, and additionally have reciprocal inhibitory connections which modulate learned behaviors and responses (Dickinson & Dearing, 1979). Cacioppo and Berntson (1994) suggested that valences have a biphasic activation, which varies from being mutually reciprocal, to being simultaneously active, and to being separable active. A bidimensional space can be defined by two axes with the intensities of the biphasic motivational activation (the arousal), highly co-active where the possible scenarios can be plotted and represented in any 2-axe coordinates.

Another way to conceptualize emotion is in terms of a set of discrete emotions, such as fear, anger, sadness, happiness, depending on the theorist, from Descartes, Watson, Izard, Plutchik, to Ekman. In the PANAS scale there are 20 diverse affects, 10 with positive and 10 with negative valences. William James conjectured that our feelings, the consciously apprehended emotional states, were in fact percepts of the bodily changes induced by a compelling stimulus. The basis for psychophysiological research is the idea that specific emotions would have a specific physiological pattern, which has become a controversial issue in a field that searches for criteria for determining emotional specificity with replicable autonomic differences (Cacioppo et al., 2007, p. 582-583).

Behavioral and cognitive issues prevail in IOC research. About emotional, affective, or mood[1] states, the illusion of control was initially described as an optimistic, self-enhancing bias (Langer, 1975; Langer & Roth, 1975). The latest metanalysis in the subject included 20 articles, but only one described "depression" as an independent variable; no affective effect was mentioned (Stefan & David, 2013). Most studies that include such assessments in IOC tasks investigated depressive realism.

An investigation that included four studies found that judgments about the likelihood of future events were biased by affective reactions to future events, after parings with positive and negative affective reactions, as a desirability bias (Lench, 2009). Another study sought to examine the impact of the near-misses on subsequent learning and choice, and discussed how changes in the expectancy of winning after near-misses was also associated with gambling persistence effects; it also implied that electrodermal activity (EDA) might reflect frustration or negative affects following near-misses. However, the design contained no direct measures (either behavioral or physiological) of frustration, thus it did not address directly any relationship or competition between the proposed learning and affective mechanisms of near-miss effects (Clark et al., 2013).

Most studies about IOC and emotion relate valence of the outcome to winning confidence: appetitive outcomes has a positive effect, while the need to avoid an aversive outcome affects winning confidence in the same fashion (Biner, Johnston, Summers, & Chudzynski, 2009). A recent review examined the studies on the relationship between mood and causal illusion, and stated that it is not entirely clear if positive mood facilitates illusion or if it is the illusion which influences mood; many of these studies reported that people tended to overestimate a null contingency between the action and the outcome when the probability of the outcome was high, as an outcome-density bias (Blanco, 2016). Additionally, they found that the bias was dependent on the participants' mood, so that dysphoric participants were apparently less vulnerable to the causal illusion bias than non-dysphoric participants. This result was soon called the ''sadder-but-wiser", or the ''depressive realism" effect (Alloy & Abramson, 1979; Alloy & Tabachnik, 1984). In studying emotion as the consequence, some authors argued that perceptions of high control seem to buffer against the emotional consequences of failure (Bandura, 2006; Langens, 2007). Participants who received (or not) explicit failure feedback

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[1] It is not an aim of the present work to distinguish or to discuss theoretically these three terms. We chose the term "affect" once it is the one used in the PANAS scale.

after a judgment of control task in an unsolvable problem had their fluctuations in mood assessed by self-ratings in a mood adjective checklist; the study demonstrated that emotional reactions to failure were jointly determined by IOC and the explicitness of failure feedback (Langens, 2007).

The Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) has been used in the assessment of depressive symptoms in illusion studies, usually it was completed before the task (Blanco, Matute, & Vadillo, 2009; Martin, Abramson, & Alloy, 1984). The current study included the Positive and Negative Affect Schedule (PANAS) scale in order to assess both positive and negative moods in a non-clinical context. The PANAS scale was developed to fill the need for reliable and valid positive and negative affect scales that are also brief, easy to administer, internally consistent, uncorrelated and stable, developed as two 10-item mood scales. The PANAS is credited with being able to distinguish depression and anxiety and its internal consistency reliability for the trait form was reported as a Cronbach's alpha of 0.87 and 0.88 for the negative and positive scales, respectively (de Carvalho et al., 2013; Watson, Clark, & Tellegen, 1988).

Objectives of the Study

Besides the contextual valence as an inter-participants factor, the probability of the outcome, p(O), and the probability of the action, p(A), are factors that hypothetically modulate illusion of control. Past studies used to submit participants to only one value p(O) as a fixed factor. The purpose of the current study was to configure the p(O) as a within-variable and to expose participants to four different values (p(O) = .1, .30, .70, and .90), and consequently to analyze how such variation in a long sequence of trials might affect the illusion. Thus, the objective of the current study was to analyze the effects of the valence of the scenario, of the probability of the outcome, of the probability of the action performed by the participant, and of the experimental blocks on the magnitude of illusion of control in the traffic light task. The effects were measured through a modified self-assessment scale for judgments of control, and through associative measures: the associative strength of the action (or expected reward), V, the Δp of the Probabilistic Contrast Model, and the Cheng's Power PC index, P_{PC}. The scores of the PANAS scale were also analyzed and compared to the judgments of control in each valence scenario.

Based on the knowledge from literature and on the previous studies (Blanco & Matute, 2015, and Study 1), the predictions were that:

- the experimental task would generate the illusion in both valences (productive and preventive) with the same intensity;
- *p*(O) would affect the magnitude of the illusion, the higher the probability of the successful outcome (high frequency of desired outcome or low frequency of undesired outcome), the stronger the illusion;
- *p*(A) would affect the magnitude of the illusion, the higher the probability, the stronger the illusion; the magnitude of the illusion would decay along the sequence of blocks;
- sequences of blocks with increasing probabilities of success (*p*(O)) would generate stronger illusions;
- associative measures would correlate to self-assessment (judgment) of control, with bias for action in strong illusion and null bias in null illusion;
- and positive affects would be associated with higher positive illusions, while negative affects would be correlated with null or lower illusions.

Method

Participants

Eighty-one undergraduate students (56 women), 18-31 years old ($M = 22.00$, $SD = 3.10$) from a public urban university in the south of Brazil took part as volunteers. This sample size can provide an $\alpha_{error} = .05$ and power = .90 in an Analysis of Variance (ANOVA) with repeated-measures and within-between interaction design to detect medium effect sizes, as calculated in G*Power software (version 3.1.9.2); it was the same sample size as in Blanco and Matute (2015). The post hoc observed power varied from .52 to .99. Ethics approval was obtained from Instituto de Psicologia da Universidade Federal do Rio Grande do Sul Research Ethics Committee (Appendix H).

Apparatus, Instruments and Materials

One desktop computer with two 19-inch screens projecting the same image, a keyboard, and a mouse were installed in a sound-attenuation chamber. One screen, keyboard, and mouse were set on an individual table inside the chamber in an audiology laboratory at the university (*Laboratório de Audiometria do Instituto de Psicologia da UFRGS*); the desktop and the monitoring screen were installed outside the chamber. The task was developed in *E-Prime* for *Windows,* version 2.0.

The PANAS scale is a 2-factor structure and 20-item instrument designed to measure positive and negative affect (Watson et al., 1988). The scale comprises two mood scales (factors), one measuring the positive affect and the other measuring the negative affect, and it includes the words (items) “active”, “alert”, “attentive”, “determined”, “enthusiastic”, “excited”, “inspired, “interested”, “strong”, “afraid”, “ashamed”, “distressed”, “guilty”, “hostile”, “irritable”, “jittery”, “nervous”, “proud”, “scared”, and “upset”. It was developed with a sample of undergraduate students and validated with adult populations. The Brazilian-validated version excludes the word “proud” (de Carvalho et al., 2013). Participants were asked to report how much each word corresponded to their feelings at the time of the experimental task using a 5-point Likert scale (*not at all, a little, moderately, a lot, extremely*) on the computer screen. The item scores of each category were summed, indicating either more positive or more negative affect. In order to identify specific moods in each group, moods with responses 4 and 5 were selected and compared.

The Traffic Light Task

The experimental task was named *the traffic light task*, an adaptation of the light bulb task programmed by Blanco and Matute (2015), and consisted of a sequence of instruction slides displayed on the computer screen, followed by four blocks of 50 trials. Figure 2.1 represents one trial and the sequence of blocks and measurements. Given that causal relations between buttons and light bulbs in everyday life are often productive, it is likely that participants are more familiar with the productive valence in the light bulb task (Blanco & Matute, 2015). In this way, the current stimulus was the figure of a traffic light for pedestrians to convey either a productive or a preventive valence.

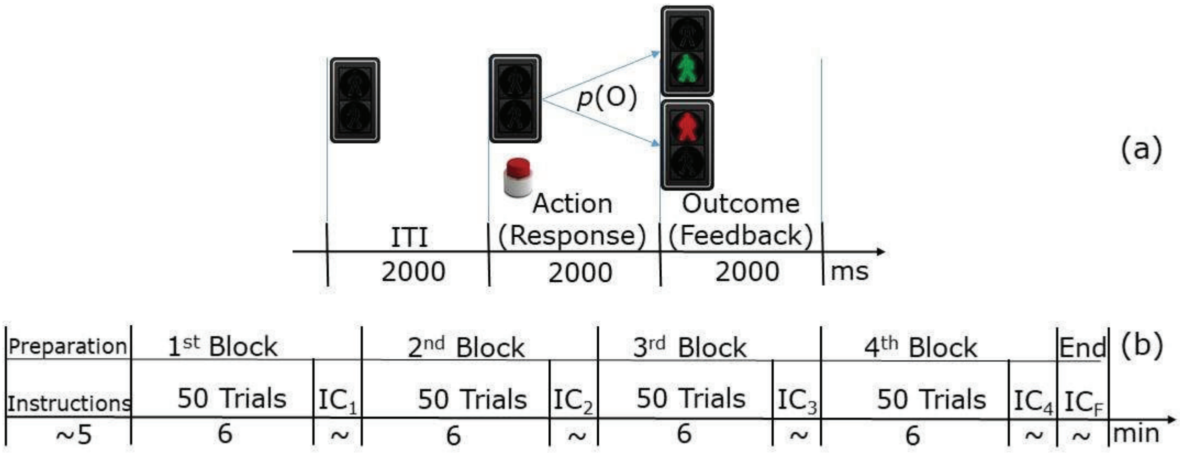

Figure 2.1. Diagram of the sequence of events in each trial of the experiment (a) and the sequence of blocks (b). Above (a, left), the image of the traffic light *off* during the inter-trial interval (ITI); a button appeared and the participant had the opportunity to press (or not) the spacebar on the keyboard in response (center); then one of two images could appear, *walk* (in green color) or *stop* (in red) image (right). Below (b), the sequence of four blocks with 50 trials followed by the self-reported partial judgments of control (IC_1, IC_2, IC_3, and IC_4), and the final judgment (IC_F).

Two different sets of written instructions specifying the goal to the participant appeared on the computer screen, according to either productive or preventive valence. The text included a description of a shopping center with four exits (each one corresponding to one of the experimental blocks) with traffic lights that the participants should try to control in the context of a very crowded shopping day. In the productive group (n = 40), the *green* light was described as the desired outcome that participants should try to produce to allow pedestrians to cross the street. In the preventive group (n = 41), the *red* light was the undesired outcome that participants should try to prevent, because pedestrians could be hit when crossing during a red light when there is intense car traffic[2]. So the productive or preventive valence was the factor between groups.

Each group had a sequence of four 50-trial blocks. Each block had one out of four probabilities of the outcome (counted as probability of green lights), p(O) = .10 (5 out of 50 trials) or .30 (15 out of 50 trials) or .70 (35 out of 50 trials) or .90 (45 out of 50 trials) in random order[3]. The probability in each block was random, and each participant was exposed to the four

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2 This situation does not make sense in many countries today. Despite legislation, in Brazil it is still common for pedestrians not to have a preference between red and green lights. Pedestrians and vehicles often continue during the red light

3 In a pre-analysis made immediately after the 18th participant's session, a systematic sampling error was detected: Block 1 had unbalanced probabilities, with few cases of p(O) = .10 and .70 in the productive sample and few cases

different probabilities so that *p*(O) and the blocks in sequence were two within-participant factors.

Each trial was a sequence of three events as depicted in Figure 2.1. Event 1 was the inter-trial interval (ITI), lasting 2.00 seconds, during which a picture of a traffic light that was *off* appeared on a white background on the computer screen. Event 2 was the first half of the trial, lasting 2.00 seconds, during which a picture of a traffic light that was *off* accompanied with a red button below and a textbox appeared on the white background on the computer screen, stating "You may press the button now" and indicating to the participant the opportunity to make either of two actions: To press the button by pressing the spacebar on the keyboard immediately; or not to press the button and just wait. The button remained available on the screen for 2.00 seconds before it disappeared. If the participant responded with the action of pressing the button, the pressing of the spacebar was recorded once during Event 2. Event 3 then lasted 2.00 seconds, during which either a picture of a traffic light that was green or red appeared on the white background on the computer screen as the outcome.

After each block, participants reported self-judgment of control, by answering the question "What is the influence of your actions on the traffic light in Exit No.# of the shopping center?" Answers were given by clicking with the mouse on a continuous scale, represented as a horizontal yellow bar with inscriptions close to the left corner ("The results were totally the opposite of my actions"), to the center ("The results were not influenced by my actions") and to the right ("The results were totally according to my actions"). Note that the negative scores in this scale have a different meaning than in the scale of the light bulb experiment in Study 1 (Chapter 1), they now refer to an absence of control by the individual. There was no numeric reference on the screen, but the software registered the response on a scale from -100 (extreme left) to 100 (extreme right). Thus, *partial judgment of control* (*pJC*) was a repeated measure taken immediately after each block. After the fourth rating, there was a *final judgment of control* (*FJC*) on the same scale, by answering the question "What was the influence of your actions on the whole traffic lights set of the shopping center?"

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of *p*(O) = .30 and .90 in the preventive sample. The computer script was corrected, including compensation of the proportions. Unfortunately, after some days the script containing the error was put back into use by mistake. However, the chosen statistical models for the analysis were robust to unbalanced groups and were also calculated with the numeric probabilities recoded to the categorical values *Low p(O)*, corresponding to *p*(O) = .10 and .30, and *High p(O)*, corresponding to *p*(O) = .70 and .90; the conclusions were the same.

Procedure

Procedures were registered and approved in *Plataforma Brasil* (number 52037115.0.0000.5334) and in faculty research ethics committee (Appendix H). Participants were recruited by invitation in university facilities, email, social media, and visits to classrooms; they were invited to participate in a research about controlling a situation on a computer. After reading and signing the consent form (Appendix G) and sitting on the chair inside the sound attenuation chamber, the participant listened to oral standardized instructions and started the traffic light task individually. The sessions lasted about 30 minutes.

Data Analysis

The current study was a 2 x 4 x 4 mixed experimental design. The independent variables (IVs) were the productive or preventive valence, as the between-participants factor; the blocks (the sequence of "exits" 1 to 4) and the probability of the outcome (p(O) = .10, .30, .70, and .90) were within-participants factors. To simplify the many possibilities of combinations of the four probabilities in analyses and graphs, some results are reported with the categorical values *Low p(O)*, corresponding to p(O) = .10 and p(O) = .30, and *High p(O)*, corresponding to p(O) = .70 and p(O) = .90, although all calculations were also done and checked with the four numeric values.

The dependent variables (DVs) were the partial judgments of control (a continuous variable, scale from -100 to +100), the probability of action (p(A), the number of trials in which the participant pressed the spacebar over 50 trials), the associative strength of the action (V), the estimate of strength of the causal relationship (Δp), the Power PC index (P_{PC}) – all repeated measures; and the final judgment of control. The PCM was calculated by the equation $\Delta p = p(O|A) - p(O|\sim A)$, where the participant's estimate of the strength of the causal relationship reflects Δp. The term p(O|A) denotes the conditional probability of the outcome (green light) in the presence of the "potential cause" (action of pressing the space bar), and p(O|~A) is the conditional probability in the absence of the action. The Power PC index was calculated as $P_{PC} = \Delta p/(1 - p(O|\sim A))$. In the current traffic light task, the preventive participants should try to prevent the red light, which is equivalent to the green light coming on, in such a way that a high p(O) was the "desired" outcome for both productive and preventive valences.

The Rescorla-Wagner (RW) model, represented by the equation $\Delta V = \alpha\beta(\lambda - \Sigma V)$, was used in Microsoft Excel to simulate the associative strength of the action, V, for each subject using the same individual trial sequence and then averaging the results per group of valence and p(O). The learning rate parameters were: salience of the action $\alpha = 0.60$ and salience of the outcome β = 0.50 in the presence of the action, α = 0.20 and β = 0.50 in the absence of the action (Blanco & Matute, 2015), $\lambda = 1$ for the presence of the stimulus or outcome green light, $\lambda = 0$ for the absence of the stimulus or presence of red light.

The DV named *oscillation* was built to study the effect of the order of *p*(O)s in the sequence of blocks. As there was a sequence of four blocks with four different probabilities of the outcome, it was important to study how such variation affected the judgments of illusion. To evaluate the effect of such profile of the sequence of probabilities, oscillation was used to measure the participant's sequence of *p*(O)s according to the differences between *p*(O) in one block and in the following. Participants were classified as *under large oscillation of* p*(O)* if their sum of the absolute differences between probabilities in adjacent blocks was at least 1.60, using the filter $(|(p(O)_{Block1} - p(O)_{Block2}| + |(p(O)_{Block2} - p(O)_{Block3}| + |p(O)_{Block3} - p(O)_{Block4}|) >= 1.60))$. For example, the sequence .90, .10, .70, .30 was classified as under large oscillation of *p*(O) (*oscillation* = .80 + .60 + .40 = 1.80).

The analyses were performed using IBM SPSS version 20.0.0, Minitab version 18.1, and Microsoft Excel 2013. Boxplots, interval plots and General Linear Models (GLM) were used to analyze the simultaneous effects of the multiple variables between- and within-participants and to search for differences and interactions. Data were normalized when possible by Box-Cox or Johnson's transformation formulas (Chou, Polansky, & Mason, 1998). The assumptions of homogeneity of variance and sphericity were checked, and the results were adjusted when necessary. Scatterplots, Pearson's correlation tests and simple linear regression analyses were used to represent and measure the relations between variables. It was important to verify if the groups differed in the levels of *p*(A) and *p*(O), if there were reasons to suspect that participants pressed the spacebar if they were more or less frequently rewarded, and if there were different levels of actual contingency (Blanco & Matute, 2015). An alpha level of .05 was used for all statistical tests. Beyond ANOVA methods included in the GLM models, confidence intervals (CIs) of the mean or of the median were calculated according to the mensuration level of the variable.

Trait-positive affectivity and trait-negative affectivity were measured in the present study with the PANAS scale, and subjects were asked to respond how they felt at the time of the task in a 5-points Likert scale. The total sum of each affectivity trait (positive and negative) were processed as parametric data. Some experts assert that if there is an adequate sample size (at least 5–10 observations per group) and if the data are normally or nearly normal distributed, parametric tests can be used with Likert scale ordinal data (Sullivan & Artino, 2013); even so, as data from some of the 20 individual moods were not nearly normally distributed, their analyses were performed by calculating the 95% confidence intervals of the medians. The percentiles of lower and upper limits of the CI of the median were obtained through the equations 1 and 2, by rounding *r* and *s*, respectively, where *n* is the subsample size and $N_{1-\alpha/2}$ is the appropriate value from the standard Normal distribution for the 100(1 - α/2) percentile, i.e., 1.96 (Campbell & Garnder, 1988).

$$r = \frac{n}{2} - \left(N_{1-\frac{\alpha}{2}} \cdot \frac{\sqrt{n}}{2} \right) \quad (1)$$

$$s = 1 + \frac{n}{2} + \left(N_{1-\frac{\alpha}{2}} \cdot \frac{\sqrt{n}}{2} \right) \quad (2)$$

Results

In order to analyze the effects of the valence, of the probability of the outcome (green lights) and of the sequence of blocks on the magnitude of illusion of control, General Linear Models were run for each of the following DVs: the self-reported judgments of control, the probability of the action of pressing the keyboard, and the associative measures – Rescorla-Wagner's *V*, Δ*p*, and Cheng's P_{PC} index. The measure of final (the last and general) judgment of control is analyzed in the first GLM. Then, the partial measures corresponding to the assessments after each of the four blocks are analyzed. Sequentially, the probability of the action and its effect on the partial judgment of each block is analyzed. At last, the analyses of the associative measures are presented. The values of means, SDs, SEMs, and 95% CI for each condition are reported in the Appendix B (Tables B1 and B2, Figures B1 and B2).

Illusion of Control Final Self-Reported Assessment

Figure 2.2 represents de distributions of judgments of control (the partial repeated self-assessments and the final assessment) in both groups, and reveal the variability of data. Several participants responded with judgments of zero[4], especially in the final assessment, but most of them (66%) declared positive or negative control. Final judgment of control was submitted to a GLM including the factors group (productive and preventive), blocks in sequence (1 to 4),

[4] As participants used a mouse to click on a graphical scale without numerical labels as reference, values from -5 to 5 were counted as zero.

and p(O) (.10, .30, 0,70 and .90). This revealed a significant intermediate main effect of group, $F(1, 234) = 6.49$, $p = .013$, $\eta^2 = .08$, $\eta_p^2 = .08$, $R^2 = 8\%$, $r = .28$, such as mean illusion was greater and positive in the productive group ($M = 20$, 95% CI [11, 29]) and null in the preventive group ($M = 3$, 95% CI [-6, 13]). There was no difference based on gender or age if these factors were included in the model ($F(1, 309) = 1.92$, $p = .167$ and $F(1, 309) = 0.37$, $p = .543$, respectively).

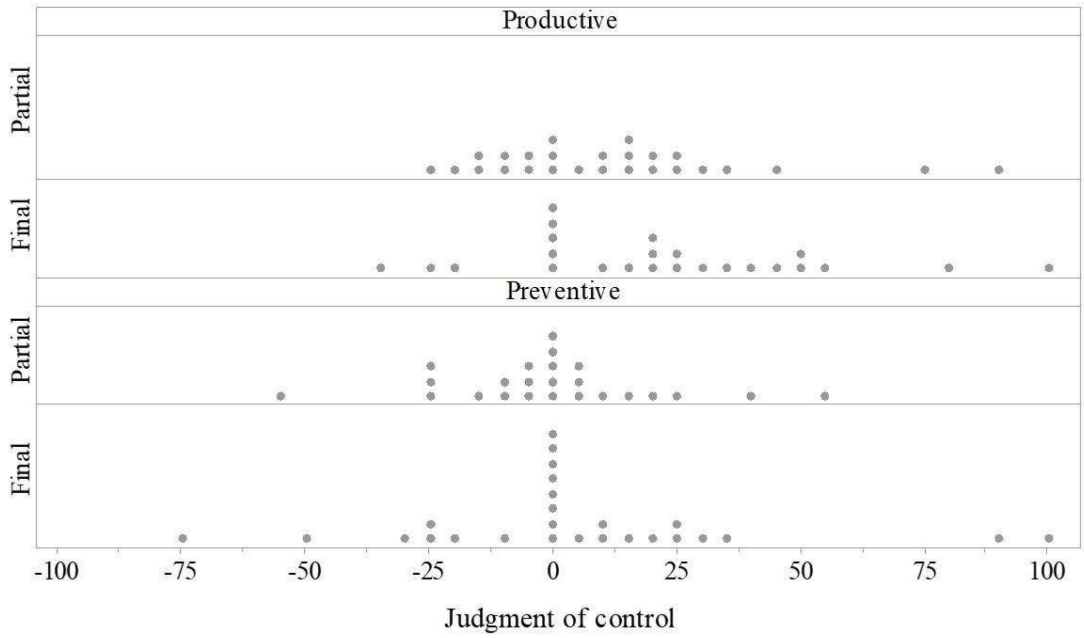
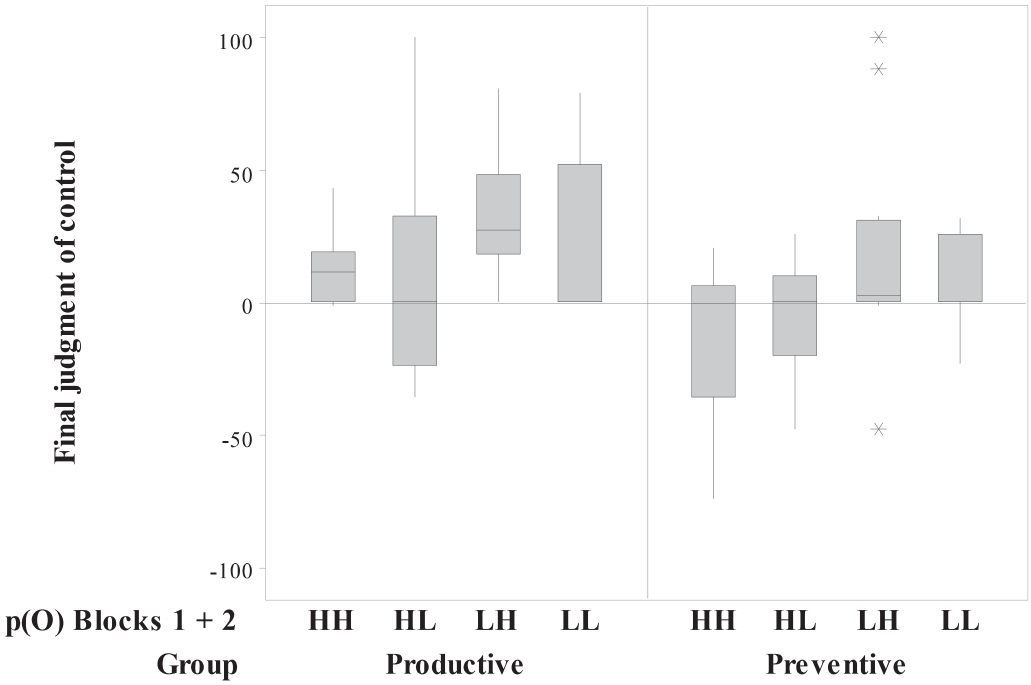


Figure 2.2. Dot-plots of partial and final judgments of control for both productive and preventive groups. Each symbol represents up to 2 observations.

As apparently participants with the strongest illusions had been under oscillating p(O) along the sequence of blocks, the final judgment response was also submitted to a GLM with fixed factors of group and oscillation (measured for each participant by the sum of the differences between p(O)s along the sequence of blocks, cf. section Data Analysis in Method). Results are represented in Figure 2.3 and show significant intermediate main effects of group and oscillation ($F(1, 77) = 5.42$, $p = .022$, $\eta^2 = .06$, $\eta_p^2 = .07$, $R^2 = 6\%$, $r = .24$; $F(1, 77) = 9.54$, $p = .003$, $\eta^2 = .10$, $\eta_p^2 = .11$, $R^2 = 10\%$, $r = .32$) and null interaction ($F(1, 77) = 0.16$, $p = .690$). Contrary to the hypothesis that increasing probabilities would generate stronger illusions, participants subjected to large oscillations of probabilities of the outcome (*oscillation* ≥ 1.6, e.g., .90, .10, .70, .30) presented positive illusion ($M = 25$, 95% CI [11, 39]; $n = 28$) while participants under small oscillation presented null illusion ($M = 4$, 95% CI [-2, 11]; $n = 53$). Tukey and Bonferroni comparison tests indicated that the illusion of control was higher when the sequence of trials started with Low *p*(O) (.10 or .30) in Block 1 and increased ("jumped") to High *p*(O) (.70 or .90) in Block 2; the illusion tended to be null when there was high *p*(O) in Block 1 (and consequently some decrease in *p*(O) along the sequence). The majority (12 out of 14 participants) whose final judgments were negative had been submitted to high *p*(O)s (.70 or .90) in Block 1, $\chi^2(1, 14) = 7.77$, $p = .005$, $\eta^2 = .56$, $r = .74$. The different possibilities of combination between the high and the low *p*(O)s in the sequence or trials and the resulting *FJC*s are represented in Figure 2.3.



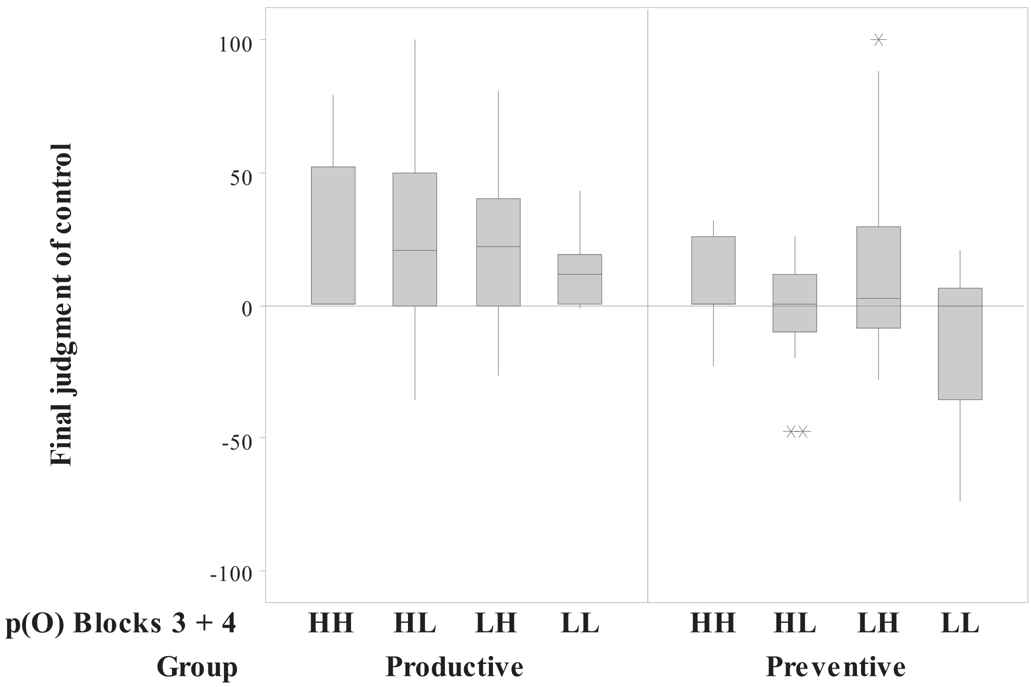


Figure 2.3. Box-plots of final judgments of control in both productive and preventive groups and the four combinations of levels of probabilities of the outcome *p*(O) in the first two blocks (above) and last two blocks (below). The valence of the group and the oscillation of *p*(O) had significant intermediate main effects. The illusion of control was higher when the sequence of trials started with low *p*(O) in Block 1 and high *p*(O) in Block 2, especially in the productive group. HH = High p(O) in the first/third block and High p(O) in the second/fourth block; HL = High *p*(O) and Low *p*(O); LH = Low *p*(O) and High *p*(O); LL = Low *p*(O) and Low *p*(O).

Illusion of Control Partial (Repeated) Self-Reported Assessments

The partial judgments of control after each block were included as response in a GLM with factors of group, blocks in sequence, and *p*(O). The model revealed that only *p*(O) had a significant and large main effect, $F(3, 234) = 36.46$, $p < .001$, $\eta^2 = .26$, $\eta_p^2 = .32$. Figure 2.4 shows partial judgments (measured immediately after each block) averaged by *p*(O) in the productive and preventive groups. Low probabilities produced null or negative judgments, corresponding to an absence of control by the participant, and high probabilities produced positive judgments in both groups. Bonferroni and Tukey post hoc tests indicated significant grouping in partial judgment means between probability levels *p*(O) = .10 and .30, and between .70 and .90; so the first pair (.10 and .30) is equivalent to the level of low probabilities (*Low p*(O)), and the last pair to the level of high probabilities (*High p*(O)).

Such GLM showed no effect of valence ($F(1, 234) = 2.93$, $p = .091$) and no order effect, i.e., no difference among the blocks ($F(3, 234) = 0.47$, $p = .707$) on the partial judgment after each block. In other words, illusion persisted with same magnitudes from the beginning to the end of the traffic light task, depending only on *p*(O). There was no significant difference among the percentages of null judgments of control per block ($Q(3, 81) = 4.83$, $p = .185$), so it was not possible to conclude that nulls increased at the end of the sequence. There were no differences based on gender ($F(1, 309) = 0.01$, $p = .917$) or age ($F(1, 309) = 0.85$, $p = .359$) when these factors were included in the model. The descriptive measures for each combination are provided in Appendix B (Table S1).

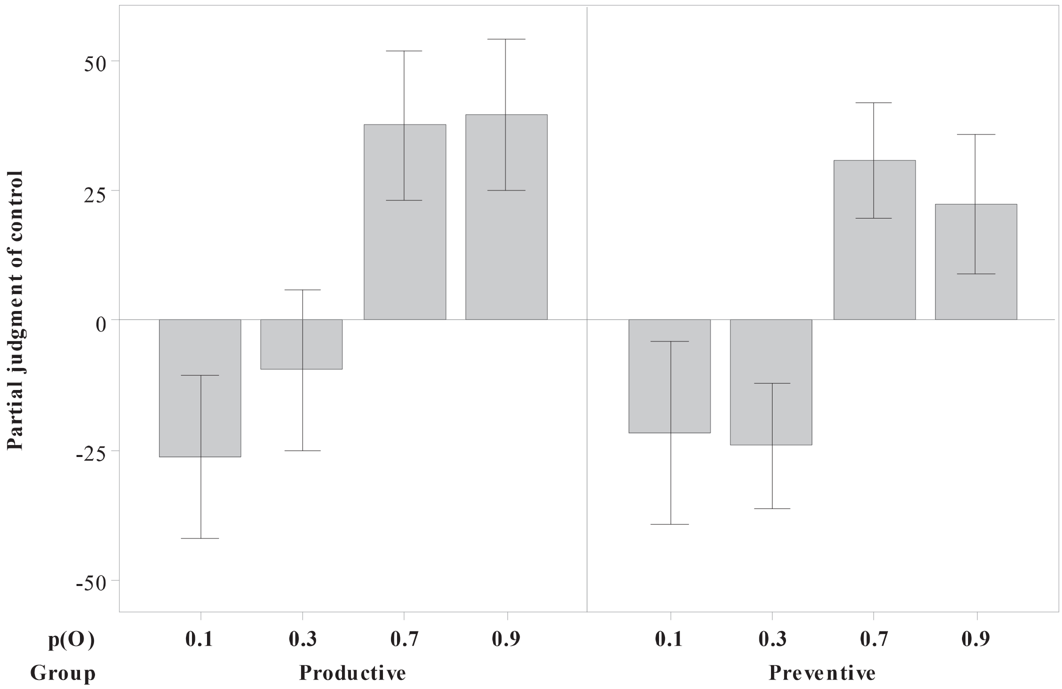


Figure 2.4. Bar charts of mean partial judgments of control and confidence intervals (95% CI) by group and probability of the outcome, *p*(O), across all exits. Low probabilities tended to produce null or negative judgments, and high probabilities produced positive illusions.

Analysis of the Probability of the Action

The probability of the action, *p*(A), has been studied in the illusion of control literature as one of the factors that affect judgments of control, regardless of whether the outcome is desired or undesired (Blanco & Matute, 2015). The proportion of actions of pressing the button, calculated as the number of trials in which the participant decided to press the button over the total number of trials, was calculated for each block (i.e., 50 per block) and for the total of 200 trials (*p*(A) = .58, 95% CI [.56, .60]). One participant had *p*(A) = .00 in all blocks (no pressing was registered) and was not included in the analyses; there were some participants who pressed the button in all trials of a block, these results were excluded, but some of their data remained in the study because they had *p*(A) ≠ 1.00 in other blocks. The descriptive measures for each combination are provided in Appendix B (Table S1, and Figures S1 and S2).

The probability of action per block was submitted to a GLM with factors of group (productive and preventive), blocks in sequence (1 to 4) and probability of outcome, producing neither significant main effect nor interaction (Fs $\leq$ 2.23, ps $\geq$ .094). As in Blanco and Matute (2015), simple linear regression analyses were processed to study the relation between raw judgments and *p*(A), and yielded a significant negative relation in *p*(O) = .30 (β = -0.001 , t(79)

= -2.50, p = .015, R^2 = 6%) and a positive relation in p(O) = .90 (β = 0.001 , $t(79)$ = 2.11, p = .038, R^2 = 4%) and slopes (β) close to null; the other slopes were not significantly different from zero ($t(79)$s $\leq$ 0.89, ps $\geq$ .378).

It is important to provide additional information concerning the two potential confounds of instrumental tasks in which the decision of whether or not to act is left to the participant: checking that all groups were comparable in their p(A) level and analyzing the actual contingency to which the participants were exposed during the session (Blanco & Matute, 2015; Hannah, Allan, & Siegel, 2007). For the first, as the previous GLM on p(A) indicated, neither the interactions, nor the main effects were found significant, there were no differences between groups.

The second potential confound was the actual contingency. Even when the sequence of outcomes is programmed to be random and, therefore, contingency is set to zero, participants may be exposed to slightly different levels of actual contingency. The data of 2 blocks from different participants that deviated from mean more than 2 SD were removed from analysis. The actual contingency values, measured by Δp index, were included as response in a GLM with factors of group, blocks in sequence, and p(O), and yielded neither significant main effect, nor interactions ($F(df, 211) \leq 1.03$, $p \geq .414$). The descriptive measures for each combination are provided in Appendix B (Table S2, and Figures S1 and S2).

Analysis of the Associative Measures

Beyond the self-assessment scales used to measure judgments of control, it is important to analyze other behavioral measures that could express how participants react when trying to control a situation. In the previous studies, researchers used the influential Rescorla-Wagner's model, represented by the equation $\Delta V = \alpha\beta(\lambda - \Sigma V)$, and simulated the associative strength of the action, V, for each participant using the same individual trial sequence and then averaged the results per group and p(O), producing asymptotic patterns that resembled the results of their experiment (Blanco & Matute, 2015, and Study 1 in Chapter 1). This procedure was repeated in the current study using the same learning rate parameters (αs and βs) in the learning algorithm. The sequences of trials were plotted in lines representing the means of V by trial, group and p(O) as illustrated in Figure 2.5. The asymptotic patterns observed in V and the sequences of partial judgments of control, both represented in Figure 2.5, are very similar in a visual analysis. There is a very large positive correlation between the sequence of mean Vs and the corresponding sequence of mean judgments of control, $r(30) = .83$, $p < .001$. The descriptive data for each combination of all associative measures are provided in Appendix B (Table S2, and Figures S1 and S2).

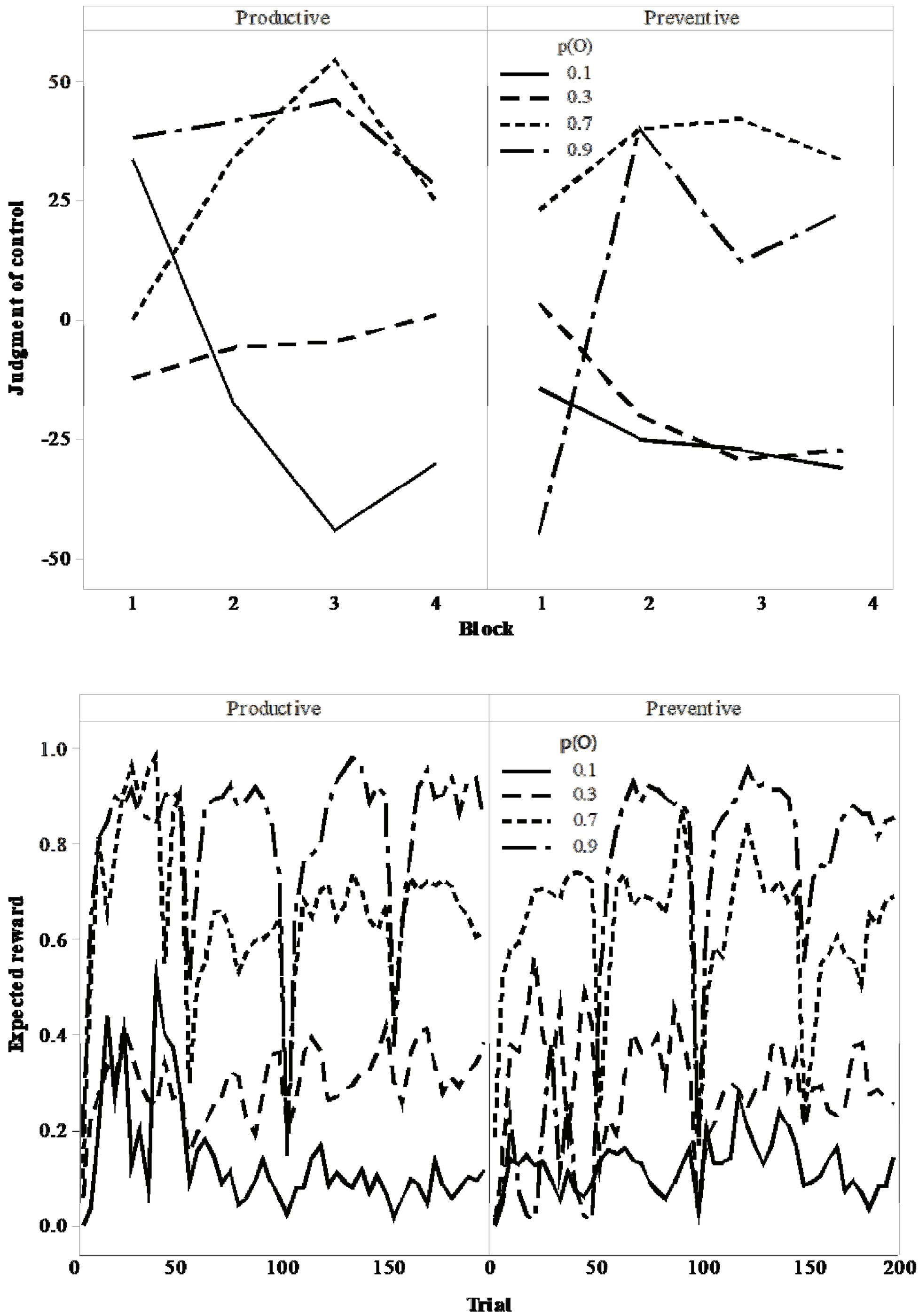


Figure 2.5. Line plots representing sequences of the mean values of judgments of control in blocks (above) and expected reward mean values (V) after simulations for all trials using the

Rescorla-Wagner model (below), for both groups by probabilities of the outcome. Note that the asymptotic patterns observed in the judgments resemble the sequences of *V*.

In the Probabilistic Contrast Model (PCM; Cheng, 1997), the participants' estimate of the strength of the causal relationship is represented by Δp, an index that assesses covariation. These results were already analyzed in the previous second confound analysis, there is no significant difference among factors that could affect actual contingency.

The power PC index was computed for each participant and the averaged results per group, block in sequence, and probability of the outcome, with the formula $P_{PC} = \Delta p/(1 - p(O|{\sim}A)$ for both groups. Data from 16 out of 320 blocks, from 12 participants, were discarded from the analysis because they yielded invalid values (i.e., the denominator was 0). The P_{PC} data were normalized and submitted to a GLM with factors of group, blocks in sequence and p(O), yielding neither significant main effect nor interaction (*F*s ≤ 0,93, *p*s ≥ .428). So the values calculated for P_{PC} and for the previous Δp provide the same interpretation. There was no significant correlation between partial or final judgments of control and Δp ($r(302) = .03$, $p = .59$) or P_{PC} normalized values ($r(288) = .03$, $p = .61$)). There were positive and very large correlations between Δp and P_{PC} ($r(288) = .87$, $p < .001$).

Measurement of Positive and Negative Affects

The sum of scores of positive and negative affects in PANAS scale resulted in moderate intensity of positive affects (*M* = 28, 95% CI [26, 30]) and little intensity of negative affects (*M* = 21, 95% CI [19, 23]). The productive and preventive groups declared the same intensity in the positive and in the negative affects.

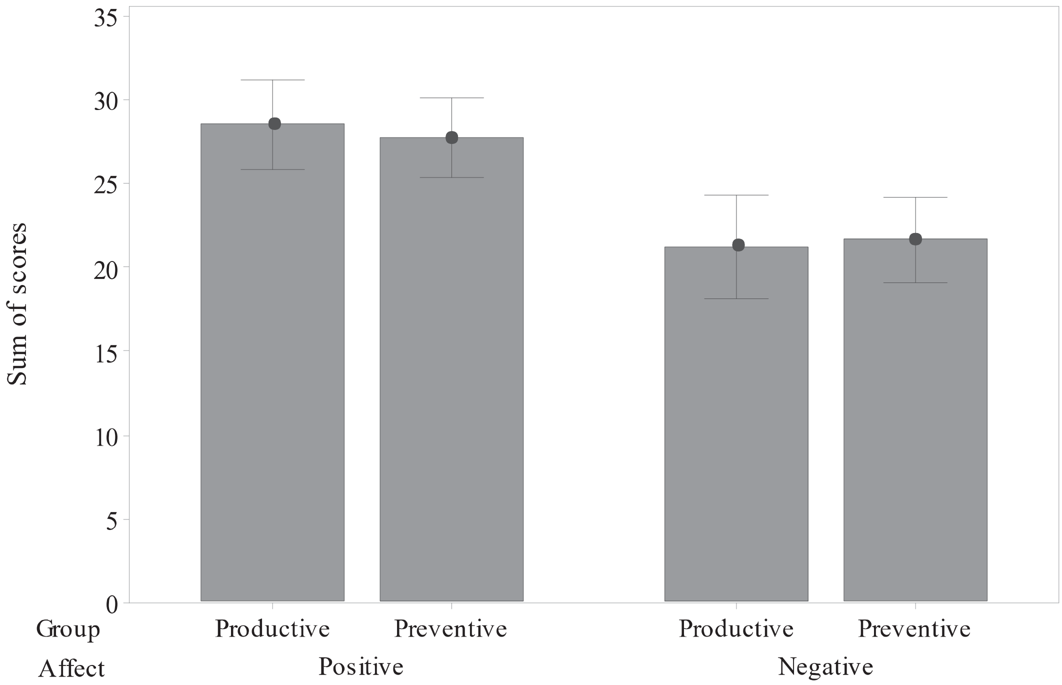


Figure 2.6. Bar graphs of the sum of scores of positive and negative affects in PANAS scale by valence. Positive affects were in moderate intensity and negative affects were in little intensity; there was no valence (group) effect.

The intense affects were *active, alert, attentive, determined, interested* and *jittery*. These were the categories which presented medians statistically greater than 3 in the 5-point scale, i.e., their confidence interval lower limit was 3. All affects were positive, except for *jittery* in the productive group. Table 2.1 lists medians for all affects and groups. The results were similar for both valences (groups).

The intensities of the 20 affects were also compared to the judgments of control and there were significant differences and correlations. Table 2.2 presents the medians and respective CIs for each affect, by level of judgments (negative, null, low positive and high negative). The positive affects *active, alert, attentive, determined, and interested* were intense in most subgroups; the negative illusions *irritable* and *jittery* were declared by participants who had negative judgment of control at the end of the task. Most positive affects were moderately correlated to the raw scores of the general judgment of control: *attentive* ($r_s(79) = .24, p = .029$), *determined* ($r_s(79) = .32, p = .004$), *enthusiastic* ($r_s(79) = .36, p = .001$), *excited* ($r_s(79) = .23, p = .041$), *inspired* ($r_s(79) = .22, p = .045$), *interested* ($r_s(79) = .31, p = .004$). The affect *active* was marginally significant ($r_s(79) = .21, p = .059$). The affect *proud* ($r_s(79) = .25, p = .022$) has not been validated in Brazilian version of PANAS scale.

Table 2.1

Medians And Respective 95% Confidence Intervals Of The 20 Affects From PANAS Scale, By Group

	Productive			Preventive		
Affect	n	Md	95% CI	n	Md	95% CI
Active	40	**3**	**[3,4]**	41	**3**	**[3,3]**
Alert	40	**4**	**[3,4]**	41	**3**	**[3,4]**
Attentive	40	**4**	**[3,4]**	41	**3**	**[3,4]**
Determined	40	**3**	**[3,4]**	41	**3**	**[3,4]**
Enthusiastic	40	3	[2,3]	41	2	[2,3]
Excited	40	3	[2,3]	41	3	[2,3]
Inspired	40	2	[2,3]	41	2	[2,3]
Interested	40	**3**	**[3,4]**	41	**3**	**[3,4]**
Strong	40	2	[1,2]	41	2	[1,3]
Afraid	40	1	[1,1]	41	1	[1,1]
Ashamed	40	1	[1,1]	41	1	[1,2]
Distressed	40	2	[1,3]	41	2	[2,3]
Guilty	40	1	[1,2]	41	2	[1,2]
Hostile	40	1	[1,2]	41	1	[1,2]
Irritable	40	2	[2,3]	41	2	[2,3]
Jittery	40	**3**	**[3,4]**	41	3	[2,4]
Nervous	40	2	[1,3]	41	2	[2,3]
Scared	40	1	[1,1]	41	1	[1,1]
Upset	40	2	[1,3]	41	2	[2,3]
Proud	40	2	[1,3]	41	2	[1,3]

	Negative illusion			Null illusion		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	14	3	[2,3]	27	3	[2,4]
Alert	14	**3**	**[3,4]**	27	**4**	**[3,4]**
Attentive	14	3	[2,4]	27	**4**	**[3,4]**
Determined	14	**3**	**[3,3]**	27	3	[2,4]
Enthusiastic	14	2	[1,3]	27	2	[2,3]
Excited	14	2	[2,3]	27	2	[2,3]
Inspired	14	2	[1,3]	27	2	[1,3]
Interested	14	3	[2,4]	27	**3**	**[3,4]**
Strong	14	2	[1,3]	27	2	[1,3]
Afraid	14	1	[1,1]	27	1	[1,1]
Ashamed	14	1	[1,4]	27	1	[1,2]
Distressed	14	3	[1,5]	27	3	[1,3]
Guilty	14	2	[1,4]	27	1	[1,2]
Hostile	14	2	[1,3]	27	1	[1,3]
Irritable	14	**4**	**[2,5]**	27	2	[1,3]
Jittery	14	**4**	**[2,5]**	27	3	[2,4]

Nervous	14	2	[1,5]	27	1	[1,2]
Scared	14	1	[1,3]	27	1	[1,1]
Upset	14	3	[1,4]	27	2	[1,2]
Proud	14	1	[1,2]	27	2	[1,3]

	Low positive illusion			High positive illusion		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	20	**3**	**[3,4]**	20	**3**	**[3,4]**
Alert	20	**3**	**[3,4]**	20	**4**	**[3,4]**
Attentive	20	**4**	**[3,4]**	20	**4**	**[3,4]**
Determined	20	**3**	**[3,4]**	20	**4**	**[4,4]**
Enthusiastic	20	3	[2,3]	20	**3**	**[3,4]**
Excited	20	2	[2,3]	20	**3**	**[3,4]**
Inspired	20	2	[1,3]	20	3	[2,3]
Interested	20	**3**	**[3,4]**	20	**4**	**[3,5]**
Strong	20	1	[1,2]	20	2	[1,3]
Afraid	20	1	[1,1]	20	1	[1,1]
Ashamed	20	1	[1,1]	20	1	[1,4]
Distressed	20	2	[1,3]	20	2	[1,4]
Guilty	20	1	[1,1]	20	2	[1,3]
Hostile	20	1	[1,2]	20	1	[1,2]
Irritable	20	2	[2,3]	20	3	[2,3]
Jittery	20	3	[2,4]	20	3	[2,4]
Nervous	20	2	[1,3]	20	2	[1,4]
Scared	20	1	[1,1]	20	1	[1,2]
Upset	20	2	[2,3]	20	2	[1,3]
Proud	20	1	[1,2]	20	3	[2,3]

Values statistically greater than 3 are highlighted in bold.

Discussion

To have perception of control over life events is important in the strive for proficiency and mental health. It is adaptive as motivates people to persist at tasks when they might otherwise give up, even when success is not guaranteed (Taylor & Brown, 1988). Similarly, illusion of control is necessary to confront aversive and dangerous situations in life. By contrast, ungrounded beliefs, such as superstitions and pseudosciences, imply that financial, medical and political decisions are often based on illusions, individually and socially (Matute & Blanco, 2014). This study aims to contribute to the analysis of the factors that modulate illusion of control. In case, the effects of valence (productive and preventive) presented in instructions, probability of the outcome (p(O)), and resulting probability of the actions performed by the participant (p(A)), on self-reported assessment of illusion of control and associative measures. Another factor is the sequence of four blocks of 50 trials, so that this is the first study to submit each participant to four different values of p(O)s that vary intra- and inter-subjects, in the longest series of trials in illusion studies of our knowledge.

Generically, the final judgments of control by the productive group were positive but not large (M = 20 in a bidimensional scale -100 — +100), while the mean estimate was not different from zero in the preventive group. The partial judgments of control after each block were sensitive to p(O) in both groups of valence, as expected. So, the prediction that the experimental task would generate illusion in the same intensity in both valences depended on the measure: the illusion measured by the *FJC* was stronger in the productive valence, while there was no significant difference between groups in the more specific *pJC*. It can be visualized in Figure 2.2 that apparently the distributions are less symmetrical and have a bias to the right (positive values) in the productive group and that there was not negligible variability in data. Figure 2.4 also suggests a tendency of stronger illusions in the productive group in *pJC*, however there was significant difference. The majority (66%) of the judgments were positive or negative, i.e., these participants have not become aware of the programmed null contingency between their actions and the outcome. All this may suggest that the current paradigm of the traffic light task induces the illusion as expected in the hypotheses, in productive and preventive scenarios, and so it may be useful to the comprehension of how to manage people's perception of control in this and in future studies.

The hypothesis that the illusion would decay along the duration of the task and that most of the sample would cease to judge control in the end of the sequence of blocks was not supported. The illusion persisted after 200 trials and almost half an hour of experimental session, in both groups. The number of responses declaring less degree of control after the last block was not found significant. So it was not possible to establish the duration limit of illusion in the current paradigm. Such finding helps us to understand how people keep on motivated in life, even in a complex reality where events are out of our control or people do not have continuous success in their decisions. E.g., at this moment, Brazil presents an unemployment rate of almost 13% and in the middle 2010's the country was under economic, political an moral crisis with a very slow recovery, but citizens still conducted their lives normally, without the occurrence of major riots. Similarly, many people persist engaging with superstitions and false beliefs, e.g., carrying charms, wearing certain clothes, praying for success in games or saying "bless you" when someone sneezes; despite all contemporary scientific advances.

The illusion of control was persistent and affected only by the valence (group), in the final judgment assessment, and p(O), in the partial assessments after each block, as shown in

Figures 2.3, 2.4 and 2.5. The most important factor that encourages the illusion of control was the probability of the outcome, the unique large effect found in the experiment. The patterns of results were similar in both groups: high probabilities (p(O) = .70 and .90) generated positive illusions, while low probabilities (p(O) = .10 and .30) produced null or negative illusions, with equivalent magnitudes. In the current experiment, the preventive group presented negative illusions more intensively (Figures 2.1 and 2.4), under all low probabilities; while the productive group gave negative judgments under .10 and null judgments under .30. So the partial and the final judgments of control assessments suggest that the illusion is sensitive to p(O), but it depends on the valence of the participant's goal. These results are similar to the light bulb study by Blanco and Matute (2015) that compared both valences and two probabilities (.20 and .80). Generically, the occurrence of desired outcomes can be treated as equivalent to the absence of undesired outcomes, but the way the objectives are productively or preventively presented in instructions may influence results, consequently changing the distribution of positive and negative judgments.

Oscillation of the probability of the outcome produced the strongest illusions, which is one of the most interesting results of this study and can be named "the kangaroo effect". One of the hypotheses was that the strongest effects would be in ascending or descending probabilities in the sequence of blocks (e.g., the sequence .10, .30, .70 and .90) as previous studies have indicated largest effects under ascendant or descendent patterns (Coventry & Norman, 1998; Langer & Roth, 1975; Stefan & David, 2013). The effect of oscillation is represented in Figure 2.3 and happened in productive and preventive scenarios, but it can be noted again that there were differences between valences (groups) in the intensity of the illusion. Independently of the valence, the illusion was higher when the sequence started with a block of trials under low number of successes (lower p(O)s) and, firstly, the probabilities oscillated in the following blocks, or, secondly, such block was followed by an ascending sequence of successful events (higher p(O)s), especially in the productive group. One of the predictions was that increasing p(O)s would generate strong illusions, and in fact they do, but the strongest effect is under oscillating p(O). Illusions could be prevented when there was a first successful block of trials (higher p(O)s) in the beginning of the sequence, and the number of successes oscillated during the process. Negative illusions, the judgment that the object behaves in the opposite way of the participant's actions, typically occurred when there was a high number of successes in the first half of the sequence (first two blocks) and, suddenly, the primality of the outcome fell, and unsuccessful events kept happening frequently until the end of the task. Oscillation resembles ordinary situations, where events do not usually occur in ascending or descending patterns, but the number of successes and failures swing in a natural day-by-day routine. This result makes sense and can be used to explain why illusions are so persistent in life. On the other way, people lose positive illusions when a successful period of life is followed by a phase when events that are seen as aversive happen often.

Nevertheless, it was not possible to find significant effects of the factors that modulate probabilities of action p(A). And regressions between raw judgments and p(A) yielded significant relations only under two p(O)s, with very small effects and slopes close to null. This is not consistent with previous reports conducted in similar conditions (e.g., Blanco & Matute, 2015; Blanco et al., 2011; Matute, 1996), in which the higher the p(A) was, the more intense the judgment of control both in productive and preventive scenarios. The fact that there were no significant differences in p(A) among groups, blocks or p(O) and the undermost regressions with the judgments of control prevent us to attribute differences in illusions to the proportion of actions.

The text of the instructions can be consulted in the Appendix A. It stated two possibilities of action, to press or not press the button (space bar), but also encouraged the participants to change the way of responding: “While the button appears on the screen, you have the option to press the button or not to press the button”, “you will have 2 seconds to decide whether or not to press the button”, “you can take advantage of pressing the button on some of the attempts and stop pressing it on others”, “remember that you should try to do everything you can [...] through your actions and omissions”. So the participants were stimulated to alternate the actions of pressing and not pressing, “action” was not limited simply to the single pressing or not pressing of the space bar.

Having an effect facilitates both the speed and frequency of action selection, independently of the valence of the outcome (Eitam, Kennedy and Higgins, 2013; Karsh and Eitam, 2015). However, tasks that require participants to freely and randomly select and press a response key on the appearance of a cue, and whose participants attempt to respond randomly, restrict the response to press or not press different keys. In such experiments, apparently participants do not use strategies related to different combinations of pressings/omissions, nor different reaction times in the attempts for control. It seems that it was not the case in the current experiment.

After the experiment sessions, participants used to give feedbacks such as “I started with a first strategy that consisted of always pressing the button”, “then the logic changed”, “I stayed many runs without touching to see what happened", "so I changed the strategy again, pressing twice and not pressing twice", "sometimes I tried to press very fast; afterwards, I responded on the limit of the two seconds". It seems that participants, as they could not control the outcome, did try many different strategies during each block, e.g., different sequences and varying proportions of pressings and omissions in a much more complex way than random yes/no trials. It seems that participants consciously tried different types of actions through planned sequences of trials, and the "causes" were in fact the sets of combinations of pressings and non-pressings, sometimes trying different reaction times. Once many different strategies changed in time within- and between-participants, "pure pressing" was not the action associated with the control. Group results appear as completely random and so p(A), a unique value for the whole experimental block, can not proxy the pattern of strive for control. Such variability of responses seems to be the reason why the current experiment was insensitive to the effects of p(A).

The application of the Rescorla-Wagner's model (Rescorla & Wagner, 1972), however, provided a very interesting result: The resemblance between the asymptotic patterns observed in the sequences of partial judgments of control and the expected reward mean values, V (Figure 2.5). From the original sequence of stimuli presented to each participant and his/her respective actions, the calculus of the surprising[5] differences between what actually happened, λ, and the expected product, ΣV, resulted in a strong correlation indicating that the sequences of events (stimuli and actions) may be a predictor of the illusion (self-reported on the judgment of control scale) for each combination of valence and probability. Recent studies have shown that an artificial learning system using the algorithm of the RW model developed illusions when the outcome occurred frequently and the system acted frequently (Matute et al., 2015; Matute, Vadillo, Blanco, & Musca, 2007) and demonstrated that the probability of responding is a better predictor of judgments of control than actual contingency (Blanco et al., 2011). Blanco and

[5] Schultz (1998) argued that dopamine neurons show activation-depression responses after liquid and food (unconditioned stimuli) reward information and conditioned reward-predicting stimuli, as well as new and salient ones, and consequently are involved in learning behavior. These neurons would fail to discriminate between rewards, and emit alerting messages in situations where presence or absence of a reward is surprising: event predictability is necessary for rewarding responses. Events that are better than predicted activate dopamine neurons, events as good as predicted do not influence them, and events worse than predicted depress the neurons. So, dopamine systems are dependent on unpredictable events, and are related to reinforcement learning theories as they signalize prediction errors (both for better and for worse) through which learning occurs. Fully acquired behaviors are predictable and related events do not activate dopamine neurons.

Matute (2015) demonstrated in their light bulb experiment that the asymptotic pattern observed in the RW model sequence *at the end of the training* resembles the results on the judgment of control scale. This result was partially confirmed in the previous Study 1 (Chapter 1). The current study adds the comparison between the asymptotic patterns of the repeated sequential expected reward mean values (*V*) with the repeated sequential mean values of partial judgments of control (mean *pJC*), by valences, blocks and probabilities of outcome. In the present case, the model that best reproduced the dynamic of the estimates was the associative-based Rescorla-Wagner's model. Probably because it takes into account the cumulative associative strengths of association of the actions as long as they predict errors, even if the cognitive strategies and the sets of presumed "causes" (e.g., combinations of pressings, reaction times) change, as if keeping the "history" of associations made. So it is worthwhile to study the illusion of control through action responses by models that include the whole sequence of trials, besides the traditional approach of only comparing means and variances of the experimental blocks.

On the other hand, the other action contingency models applied, the Probabilistic Contrast Model and the Power PC, did not produce significant outcomes or contributions. In PCM, the index used to estimate the strength of the covariation is Δp. The results were non significant and, consequently, it is unlikely that action contingency can explain the differences in the final and partial judgments of control that were reported previously. The power PC index was conceived to assess causality rather than covariation, so, in principle, it should predict no deviations from zero in null contingency settings (the case of random outcomes). Blanco and Matute (2015) found actual contingencies that departed slightly from zero and a small variability in P_{PC}, but it could not be attributable to their experimental manipulations. In the current experiment, even using rather extreme values of p(O) that exposed participants to very high and very low values of the outcome base rate (p(O|~A) than the previous studies, the contingency was nil and p(A) was medium. So the results were as expected, but the model did not contribute to the explanation of different levels in judgments of control. The descriptive measures for each combination of the associative indexes are provided in the Appendix B (Table S2, and Figures S1 and S2). The validity of Cheng's (1997) causal power theory has been questioned for being unable to find consistent support for the mechanisms of human judgments of causality (Collins & Shanks, 2006; Lober & Shanks, 2000; Lober & Shanks, 1999; Perales & Shanks, 2003).

Therefore, the Rescorla-Wagner model and other models that include the dynamics of the sequence of trials seem to be more suitable for illusion studies. Techniques that analyze the sequence of trials are the most promising once they include the dynamics of the behavior of the process of behavioral and cognitive data involving perceptions of control or agency, learning, and decision making and action selection. There are methods commonly applied in other areas that can potentially contribute in future studies to the analysis and understanding of contingency data and process data from trial-by-trial predictions, such as signal detection theory (Vadillo et al., 2016), statistical process control charts and cumulative sum (CUSUM) methods (Hoover, Singh, Fishel-Brown, & Muth, 2012), and Markov chain analysis (Visser, Raijmakers, & Molenaar, 2002). These techniques should be applied to reaction time data, not only in terms of block means, but on the temporal sequence of *RT*s and its effect on judgments of control under random outcomes.

The positive affects, as measured by the sum of the items in PANAS scale, prevailed over the negative affects equally in the two groups. There was a spoken feedback by the participants just after the session, many of them declared to be interested in the task and expressed positive terms for the affects, especially under the scenarios of positive illusion. But negative affects were not despicable and many participants complained of frustration, irritation and boredom with the task (as usual in psychological experiments).

In this paradigm it is not possible to state if positive affects facilitates illusion or if it is the illusion which influences affects, because PANAS scale was responded only once, in the end of session. The instructions asked participants to assess the affects *during* the task, thus it is preferable to imagine that affects emerged while illusions were generated. In the present study the only difference in affects was found among different levels of control. As expected, the more intense the illusion, the more positive emotions received high scores, note Table 2.1. Many positive affects were directly correlated with judgments of control. The items alert, attentive, and interested had higher scores in almost all groups and levels of illusion. Only positive affects received higher scores under positive illusions: active, alert, attentive, determined, inspired, interested; and when illusion was highly positive, the scores of excited and enthusiastic also received high scores. The negative illusion had the fewer high scored positive affects (alert and determined) and it was the only level to have high scores in negative affects (irritable and jittery). Null illusion had the lowest affective intensities, only three items were highly scored (alert, attentive, and interested), the ones that were present in almost all levels of control and groups of valence. The prediction of positive affects associated with higher positive illusions was confirmed, but the negative illusions had both positive and negative affects; null illusion was associated with very few affective intensities. So it is reasonable to state that stronger illusions of control are motivating; even the negative illusion, but maybe in a disruptive way, since people get irritable and jittery. And null illusions take people to a mild emotional state, not necessarily peaceful.

One limitation of the current study was the unbalanced probabilities in the first block, due to a randomization error, though this apparently did not affect the conclusions. The probabilities .10 and .90 appeared to be respectively too low and too high to generate little discrepancy between successes and failures, but it seem that the results were not affected. It is recommended to keep *p*(O)s between .20 and .80, and to include fewer options of probabilities intra-subjects to provide less variation, in comparison to the randomization of four values and their presentation order.

The traffic light image was the only stimulus to provide outcomes. Maybe productive and preventive valence could be enhanced through a less neutral image, plus the use o performance scores (they were removed in the present paradigm) and the use of more impressive instructions. It would be interesting to emphasize instructions, rewards, and punishments to develop tasks that could resemble preventive situations (e.g., in a more explicit safety context). It is necessary to better understand the phenomenon of negative illusions (judgments below zero, corresponding to results on the contrary of the participant's), especially in preventive valences, where they happen more often.

CHAPTER 3

STUDY 3 – CLOSER TO THE LIMIT OF THE ILLUSION?

When researchers tried to measure the phenomenon of illusion of control in paradigms where it was asked how much actual control there was over the outcome, participants were more likely to realize that in fact no contingency existed. Therefore, direct assessments of control were associated with smaller effect sizes than indirect assessment, like asking about the prediction of the outcome, the willingness to trade, the amount of money to wager, or the confidence of succeeding on a task. The first meta-analysis on illusion of control by Presson and Benassi (1996) concluded that few experiments had actually measured IOC in the sense that participants judged the extent to which they directly affected outcomes. Instead, most researchers operationalized the concept in indirect, qualitative or quantitative assessments. The reviewers argued that most between-groups analyses were appropriate if researchers were only interested in whether groups differed on dependent measures, and were not interested in testing whether participants' judgments differed from some expected value. They recommended analyses to be matched to such issue.

Since then, a large number of papers have been published on the topic and a second meta-analysis review was conducted by Stefan and David (2013) with the purpose of offering updated effect-sizes estimates for the factors manipulated in studies. In terms of assessment methods, the authors took into consideration the independent variables used to trigger illusions (e.g., involvement, choice, outcome sequence), and the type and characteristics of the dependent measures (e.g., estimation of control, skill estimation, expectation of success). Variables were classified as direct-indirect approach and as behavioral-subjective character: a dependent measure was considered as behavioral if it involved performing a specific action (e.g., pressing a button) or making a decision (e.g., betting a certain amount of money), and it was considered as subjective if consisted of estimations of controllability, success, skill, or other features (e.g., finding a specific rule in the onset of stimuli).

Signal Detection Theory (SDT) Measures

Besides traditional associative models, alternate measures derived from Signal Detection Theory (SDT; Green & Swets, 1966; Macmillan & Creelman, 2004) have been used in recent studies on illusory correlations to measure participants' ability to discriminate when the outcome was more likely to appear and when it was less likely to appear (Perales et al., 2005; Vadillo, Blanco, Yarritu, & Matute, 2016). SDT provides theory and methods in order to discriminate two possible stimulus types: stimulus containing a signal (always accompanied by noise), and stimulus containing only noise. Originally SDT was related to the assessment of the likelihood of a subject identifying correctly the occurrence of a signal between signals (stimuli) and noise (no stimuli) in studies of perception. Nowadays they are used in many other areas, including decision making and performance studies with a variety of tasks, such as yes/no tasks, rating tasks, and forced-choice tasks (Stanislaw & Todorov, 1999).

On trials where signal is present, *yes* responses are correct and are named *hits*. On trials where there is only noise, *yes* responses are incorrect and are named *false alarms* (see Table 3.1). The *hit rate* (*h*, the probability of responding *yes* on signal trials) and the *false-alarm rate* (*f*, the probability of responding *yes* on noise trials) fully describe detection performance on a yes/no task, because the other possible responses, *no* responses on signal trials (*misses*) and *no* responses on noise trials (*correct rejections*), are complementary. When the parameters hits and false alarms are plotted against each other, the resulting set of points falls on a *receiver operating characteristic* (ROC) curve (Green & Swets, 1966).

Table 3.1
Contingency Matrix With Possible Responses In Prediction Tasks

	Outcome	
Predictive response	Present	Absent
Yes	Hit (a)	False alarm (b)
No	Miss (c)	Correct rejection (d)

Note: hit rate is *h* = hits/(hits + misses); and the false alarm rate is *f* = false alarms/(false alarms + correct rejections).

Performance on discrimination tasks involves two separate factors, the *sensitivity* to the signal and the *response bias* or bias for the response, which theoretically determine where an individual's point falls on the coordinates of the ROC curve. The hit and false-alarm rates reflect both factors: sensitivity (when signal is presented, the decision variable will have a greater value in participants with more sensitive discrimination, depending on the degree of overlap between the signal and the noise frequency distributions), and response bias (the general tendency to respond yes or no, as determined by the location of a criterion). As sensitivity and response bias are confounded by most performance measures including the hit rate, the false-alarm rate, and the proportion of correct responses in a yes/no task, so the major contribution of SDT to psychology was the separation of sensitivity and response bias.

Sensitivity can be quantified by using the hit and false-alarm rates to determine the distance between the means, relative to their standard deviations, e.g., the measure *d'*. However, *d*' is a pure measure of sensitivity (i.e., it is unaffected by response bias) if two assumptions regarding the decision variable are met: the signal and noise distributions are normal and both have the same variances. Beyond normality and homogeneity, the classical premise of a Gaussian distribution of sensory events is a series of assumptions that include independence, skew and kurtosis. But these assumptions can not be tested in yes/no tasks (rating tasks are required for this purpose) and in some cases *d*' cannot be calculated, so some researchers prefer to use nonparametric measures in theses cases (Green & Swets, 1966; Stanislaw & Todorov, 1999).

The most popular nonparametric measures of sensitivity and response bias are *A*' and *β*. The statistic *A*' is a sensitivity measure that ranges from 0.50 (signal and noise cannot be distinguished) to 1.00 (perfect performance). *A*' also is used to estimate the ROC curve area from only one point, and it does so without assuming that the decision variable has a particular distribution; however, *A′* is problematic in respect to very high or low performance levels, it is symmetric and its use implies an equal-variance representation (Macmillan & Creelman, 2004). The statistic *β* is a response bias measure that assumes responses as based on a likelihood ratio, the likelihood of obtaining the value on a signal trial divided by the likelihood of obtaining the value on a noise trial: values of *β* less than 1.00 signify a bias toward *yes* response, whereas values of *β* greater than 1.00 signify a bias toward the *no*. It is common to analyze the natural logarithm of *β*: negative values of ln(*β*) signify a bias toward *yes*, whereas positive ln(*β*) signify a bias toward the *no* response. $\beta = 1.00$ or $\ln(\beta) = 0.00$ indicate that there is no response bias.

Another option of nonparametric measure is the sensitivity index (*SI*), based on the percentage of hits and false alarm scores, and developed for use in animal discrimination procedures with forced-choice and in yes-no choices, two response alternatives that are formally distinct (Frey & Colliver, 1973). Tendencies to respond a forced option, to press or not to press the button, may make responding to an alternative more likely and thus contribute to bias (Sahgal, 1987). The range of *SI* is 0.00 – 1.00.

There are other possible response bias measures: *c*, *B*", *RI*, and *Y*. The measure *c* is based directly on the decision variable, with no assumption of likelihood ratio, and it is not affected by *d*' (whereas *β* is affected). It is defined as the distance between the criterion and the *neutral point*, where there is no response bias ($\beta = 1.00$ or $c = 0.00$). Negative values of *c* also signify a bias toward *yes* response, whereas positive *c* signify a bias toward the *no*. There is another nonparametric measure of response bias, *B*", which values range from -1.00 (extreme bias to *yes* response) to 1.00 (extreme bias to *no* response); and the responsivity index, *RI* (Talwar & Gerstein, 1999). The index *Y* was developed specifically for use in two-choice recognition paradigms to assess the degree to which subjects may adopt a "win-stay" strategy as an alternative index of bias for memory tasks involving variable delay intervals; in this index, false alarm rates are not taken into account (Melia, Koob, & Ehlers, 1990; Sahgal, 1987). The range of *Y* is 0.00 – 1.00; the greater the *Y*, the higher the bias and the weaker the stimulus control. Although illusion studies have been published with the measure *d*' (Perales et al., 2005; Vadillo et al., 2016), they did not discuss the two assumptions of normality of the distributions and equality of standard deviation, the impossibility of testing these assumptions in yes/no tasks, or the impossibility of separating sensitivity and response bias in case of violation, when *d*' would vary with response bias (Stanislaw & Todorov, 1999).

Results from SDT on causal learning tasks showed that the discriminability index, *d*', turned out to be sensitive to a contingency manipulation, but not to a cue-density manipulation (i.e., the biasing effect of the higher or lower probability of the cue, or of the cause). Such index would be a direct measure of an unbiased learning process, in contrast with the patterns of results found in numeric self-reported judgments, which were sensitive to both contingency and cue-density biases (Perales et al., 2005, Experiment 1). Alternative interpretations were also presented, since in null-contingency conditions the participants could not predict the outcome as successfully as demonstrated in computer simulations (Vadillo et al., 2016).

Reaction Time Measurement and Statistical Process Techniques in Illusion of Control Studies

The two meta-analyses on illusion of control did not mention the variable reaction time (*RT*) in illusion of control studies, a potential indirect-behavioral measure. Bechara and Damasio (2005) argued that somatic markers such as autonomic responses to anticipation of choices during the Iowa Gambling Task (IGT) can influence decision-making under uncertainty in healthy individuals. Moreover, task demand placed upon a sedentary person is called *workload*, which has an effect upon cognitive changes, e.g., decreased attention and concentration, and upon physiological changes, e.g., increased muscle tension, coordination difficulties, decreased heart rate variability (*HRV*); consequently, workload affects individual's performance. Actions derived from muscular responses are also affected and can be indicators of workload and cognitive changes, that is the case of reaction time (*RT*), a measure that can be easily included in computerized illusion of control studies. *HRV* has been proposed to detect mental workload changes in real-time (Hoover, Singh, Fishel-Brown, & Muth, 2012). In order to detect the point in time at which a change occurs in *HRV* in real-time, statistic models have already been used to recognize the properties of one state of a signal and the change to another state, for instance the change from a reasonable workload state to a detrimental workload state. Recently statistical control techniques started to be used in the monitoring and change point detection of psychophysiological variables related to cognitive tasks (Cacioppo, Tassinary, & Berntson, 2007).

The Study of Changes in Variation by Statistical Process Control

Most statistical methods for change point detection model the signal in terms of its statistics, and look for changes in those statistics. One of the traditional solutions to the problem has taken the approach of the detection of a substantial change in the distribution statistics as new samples are obtained. Perhaps the most popular example is the cumulative sum (CUSUM) method (Hoover, Singh, Fishel-Brown, & Muth, 2012; Page, 1954) for monitoring a change in the mean. In the current case, it is not necessary to monitor a signal on-line and more generic tools for detecting changes in an already existing sample may be one of the types of statistical process control charts.

From 1924 onwards, Walter Andrew Shewhart of Bell Telephone Laboratories developed a theory of statistical quality control (Breyfogle III, 2003; Shewhart, 1931), a successful method applied since then in industrial process control and engineering, and nowadays in physics, economics, weather monitoring, signal processing, computer network security, biology and genetics (Hoover et al., 2012). The method differs whether the changes are being detected in real-time (as long as the process is running, prevalent in monitoring of industrial production and biomedical problems such as intensive care patients, anesthesia and pregnancy contractions) or off-line (in later analysis approach to determine whether there is instability in the process, after the entire data set is available, as in the case of current work). The model tracks the signal in terms of its statistics (usually the estimated μ and σ) represented in time charts, and looks for changes in them.

Statistical process control charts are tools that can be used to distinguish chronic problems, also called common causes, from sporadic problems, also called special causes (Breyfogle III, 2003). Sporadic problems can be defined as un expected change in the normal operating level of a process, while chronic problems are those issues that exist when a process is at a long-term unacceptable level. If the process is stable at a long-term acceptable level and it is considered as normal, the goal will be to identify only sporadic problems to be solved, unexpected and significant changes in the normal operating level of a process. Such special causes can be of many different types, each one fitting a different statistical criterion. Control charts are used to identify special causes and their types, visually. That is, the charts can highlight significant changes in process that are beyond a normal, chronic, common, and steady random variation. Thus, statistical process control charts provide the study of variation and its source, separating special from common assignable cause issues of a process or sequence of data. They are normally associated with manufacturing processes, however the techniques can be used to assess parameters in other business or academic areas.

Shewhart control charts can track sequences by plotting data over time in the form shown in Figure 3.8. There are specific charts for all types of variables. The horizontal center line represents the process mean (μ), calculated from all data included in the chart or in the chart section, it is recommended using at least 20 data points. The upper and lower lines represent the *control limits*, typically plus and minus three standard deviations from the center line, nevertheless there are many options of formulas to calculate them. Points are plotted sequentially in time and, when the process is in control, the pattern should exhibit a random characteristic.

Objectives of the Study

The purpose of the current study was to introduce and analyze additional techniques to the measurement of the illusion of control. The objective was to analyze the effects of the valence of the scenario, of the probability of the outcome, of the probability of the action performed by the participant, and of the experimental blocks on the action and on the reaction time through techniques of Signal Detection Theory and Statistical Process Control, and to analyze the respective relationships with the self-assessment of illusion of control.

Based on the literature and on the previous Studies 1 and 2, the predictions were that:

- As *p*(O) is the same in both blocks, the illusion would decay in the second block;
- the SDT measures would have different error variances and so it is possible to choose a better measure to model the behavior;
- the valence of the group and the *p*(O) would not affect the sensitivity but would affect the response bias in the SDT measures, the productive group and the high *p*(O) would be associated with higher bias for action, higher responsive bias would be associated with stronger illusions;
- *RT* would be higher in low *p*(O), in the last block and in null illusion;
- it would be possible to find group patterns in the SPC charts for *RT*, the charts would present more special causes in high *p*(O) and strong illusion;
- and *p*(A) would not be affected by, nor affect, any of the variables.

Method

Participants

Sixty three undergraduate students (*n* = 54 or 86% were women), 19-24 years old (*M* = 20.90, *SD* = 1.15) from a university in the south of Spain participated in exchange for course credits. Most part of the sample was Spanish, three German and one Ukrainian students also took part. Participants underwent procedures individually and were randomly assigned to one of the four conditions: Productive-Low *p*(O), Productive-High *p*(O), Preventive-Low *p*(O), Preventive-High *p*(O).

Apparatus, Instruments and Materials

One desktop computer with keyboard and mouse was installed in a control room with two 19-inch screens projecting the same image, one of them installed in the next participants' room. Participants sat one at a time in an armchair in front of a moving table where one of the screens, a response pad and a mouse were installed. Consent forms (Appendix G) were also available on the table. The rooms were lit at a minimum level during the task and there was an observation glass window on the wall between rooms, which remained covered with a paper mask most of the time; the participant sat facing the opposite wall, with his/her back to the window.

The traffic light task was developed in *E-Prime* for *Windows,* version 2.0, installed in the desktop computer. The program included an electronic form of a Spanish version of the PANAS scale, participants were asked to respond how they felt at the time of the task in a 5-points Likert scale for the measurement of their trait-positive and trait-negative affectivity states.

As psychophysiological measures – Event-Related Potentials/Electroencephalography (ERP/EEG) central measures; Electromyography (EMG), Galvanic Skin Response (GSR), and Heart Rate (HR) peripheral measures – were also collected for another study at the same time, in the participants' room there was another bench with a 34-channel bioamplifier, EEG caps, sintered Ag-AgCl electrodes, electrolytic gels, stickers, injection syringes, alcohol, cotton, scissors. In the control room other psychophysiological equipment were installed: two 15-inch notebooks running the central and peripheral measures data analysis software, the data acquisition devices and cables connecting the equipment between the two rooms. Other electronic equipment was installed on another bench in the control room, but they remained off during the experimental sessions, only the researcher was present.

Traffic Light Task

The experimental task was the same traffic light task used in Study 2 (see Chapter 2). It consisted of a sequence of instruction slides in Spanish displayed on the computer screen, followed by two blocks of 50 trials. The stimulus was the figure of a traffic light for pedestrians. Figure 3.1 represents one trial and the sequence of blocks and measurements.

Two sets of written instructions specifying the goal appeared on the computer screen, according to the productive or to the preventive valence, randomly assigned to the participant. The instructions included basically the same text, but differed in short excerpts where the task goal was specified or emphasized (e.g., “to make the traffic light turn green” or “to make the traffic light not turn red”; “to seek the light to turn green” or “to avoid the light turn red”; see Appendix A). The text stated that the participant’s task was to *learn* a way to make the light turn green (or not turn red) and that there were moments to take an action (to press the blue button on the response pad), so it was suggested that they actually could have control and had to try to discover a way to do it.

The instruction included a description of a shopping center with two exits (each one corresponding to one of the experimental blocks) with traffic lights that the participant should try to control in the context of a crowded shopping day. In the productive group (n = 32), the green light was described as the desired outcome that participants should try to produce to allow pedestrians to cross the street. In the preventive group (n = 31), the red light was the undesired outcome that participants should try to prevent. As data were collected from students from European Community, the information about pedestrians who could be hit when crossing during the red light did not make sense and was removed from the text. After the instruction screens, there was a black screen, with a little cross in its center, lasting 3 minutes before the 100-trials sequence (used to establish and measure the baseline for psychophysiological measurements).

Each participant had a sequence of two blocks of 50 trials (see Figure 3.2) and one out of two probabilities of the outcome (counted as probability of green lights), a low $p(O) = .30$ (15 of 50 trials) or a high $p(O) = .70$ (35 of 50 trials), randomly assigned to the participant, and the outcome (green or red light) also appeared in random order. The two blocks were under a same $p(O)$. So the both valence (productive or preventive) and probability of the outcome (.30 or .70) were the factors between groups.

Each trial was similar Study 2 (Chapter 2), there were some differences because of the psychophysiological measurements that were taken in the same experiment, which were not included in the current study. It consisted of a sequence of four events, as illustrated in Figure 3.1. Event 1 was the 1-second inter-trial interval (ITI), during which an image of a traffic light that was turned *off* appeared on a white background on the computer screen. Event 2 was the response time interval, during which a picture of a traffic light that was turned *off* accompanied by a blue button below and a text box appeared on the black background on the computer screen, stating "You may press the button now" and indicating to the participant the opportunity to perform one of two actions: To press the button by pressing the blue button on the response pad immediately; or not to press the button and just wait. The button remained available on the screen until the button was pressed and the reaction time was registered, and it disappeared finally after 2 seconds. So Event 2 lasted the reaction time if the response was an action, or it lasted 2 seconds if the response was no action (an omission), whichever occurred first (in the other studies, Event 2 always lasted 2 seconds). Event 3 lasted 4 seconds, while the participant waited for the outcome, it has no function in the current study, but it was the necessary period of time to the ERP registration in the psychophysiological study. Event 4 lasted 2 seconds, it was the outcome or feedback interval during which either a picture of a traffic light that was green or red appeared on the black background on the computer screen as the outcome. Note that the color of the response button (blue) and of the background (black) were different than the other studies, for quality reasons related to the EEG, but it is not expected that such changes affect the behavioral measurements.

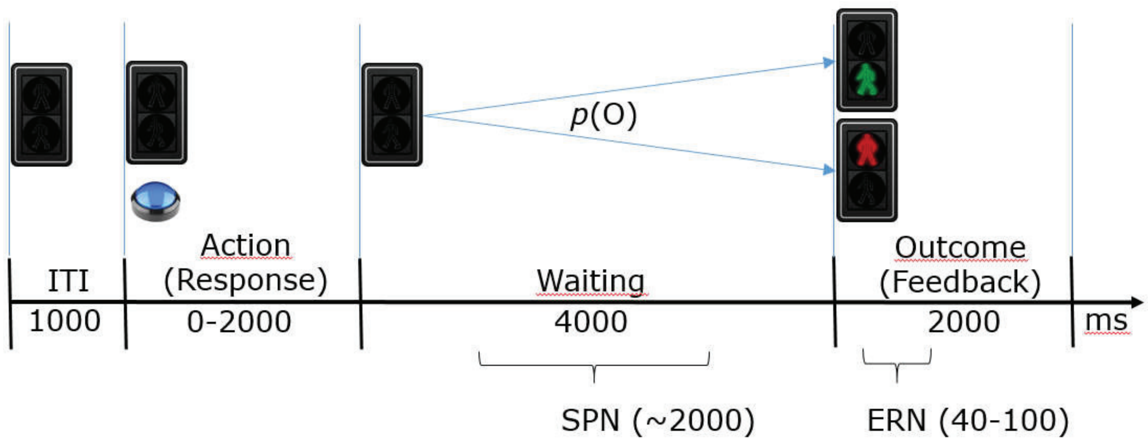


Figure 3.1. Diagram of the sequence of events in each trial of the experiment. Left: the image of the traffic light *off* during the inter-trial interval (ITI). Center-left: a button appeared and the participant had the opportunity to press (or not) the spacebar on the keyboard in response. Center: waiting period, necessary for psychophysiological measurements (not included in this study). Right: then one of two images could appear, *walk* (in green color) or *stop* (in red color). *p*(O) = probability of the outcome; SPN = stimulus-preceding negativity; ERN = error-related negativity.

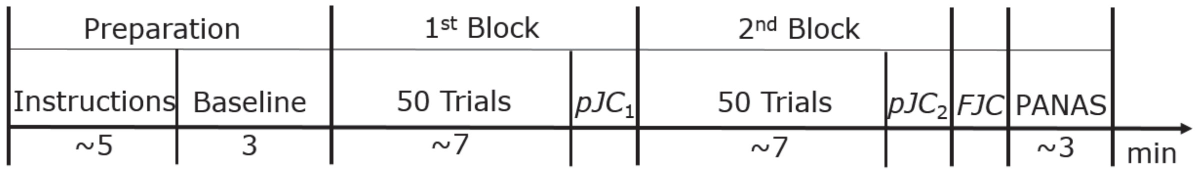


Figure 3.2. Diagram of the sequence of blocks in the experiment. From left to right, the sequence consisted of a preparation period with instructions on the screen, followed by a period of baseline with black screen (necessary for psychophysiological measurements, not included in this study), two blocks with 50 trials followed by the respective self-reported partial judgments of control in a [-100 – 100] scale (pJC_1 and pJC_2), the final judgment about the whole task (*FJC*), and the 20 items of the PANAS scale.

After each block (see Figure 3.2), participants reported the self-judgment of control, responding to the question "What is the influence of your actions on the traffic light in Exit No.# of the shopping center?" Responses were given by clicking with the mouse on a continuous scale, represented as a yellow horizontal bar with inscriptions near the left corner ("The results were totally the opposite of my actions"), to the center ("The results were not influenced by my actions") and to the right ("The results were totally according to my actions"). There was no numerical reference on the screen, but the software registered the response on a scale from -100 (extreme left) to 100 (extreme right). Thus, the partial judgment of control (*pJC*) was a repeated measure taken immediately after each block. After the second rating, there was a final judgment of control (*FJC*) on the same scale, by responding to the question "What was the influence of your actions on the whole set of traffic lights in the shopping center?". After the FJC rating, there was a sequence of screens in white background with the instructions and the 20 affects of the PANAS scale to be responded.

Procedure

Participants were recruited by invitation during classes in the Facultad de Psicología in Universidad de Granada, city of Granada, Spain. Volunteers interested in participating wrote their data in a form, received email and exchanged messages in WhatsApp to schedule the sessions. After reading and signing the consent form and sitting on the armchair inside the room, the psychophysiological apparatus (EEG cap, electrolytic gels, stickers, electrodes) were fit and the signals tested and adjusted in the programs. The preparation process lasted approximately one hour. Then the participant listened to standardized oral instructions in Spanish; the stranger participants listened to the instructions a second time, in English. They started the traffic light task individually. The researcher remained inside the control room and spent the entire time observing the computer screens and signals. The task lasted around 25 minutes. Then the apparatus was taken off the participants, who cleaned themselves in a lavatory next to the lab rooms. The whole sessions lasted about 1 hour 45 minutes. Data were collected during five weeks in May and June, 2017.

Data Analysis

In the current 2 x 2 x 2 mixed experimental design, the IVs were the valence (productive and preventive groups) and the probability of the outcome (p(O) = .30 and .70), as the between-participants factors; the block (the sequence of exits 1 and 2 of the shopping center) was the within-participant factor. The DVs were the partial judgments of control (a continuous variable, scale from -100 to +100), the probability of action (p(A), the number of trials in which the participant pressed the spacebar over 50 trials, calculated per block), the trial *RT*s in milliseconds, and the 20 PANAS scale 5-point scores.

The analyses were performed using IBM SPSS version 20.0.0, Minitab version 18.1, and Microsoft Excel 2013. Boxplots, interval plots and General Linear Models (GLM) were used to analyze the simultaneous effects of the multiple variables between- and within-participants and to search for differences and interactions. Data were normalized when possible by Box-Cox or Johnson's transformation formulas (Chou, Polansky, & Mason, 1998). The assumptions of homogeneity of variance and sphericity were checked, and the results were adjusted when necessary. The effect size for the Wald chi-square statistics in the ANOVA for repeated measures was calculated by the formula $\omega = \sqrt{W/N}$. Scatterplots, Pearson's and Spearman's correlation coeficients and tests, and simple linear regression analyses were used to represent and measure the relations between variables, according to their levels of measurement (continuous or ordinal). It was important to verify if the groups differed in the levels of p(A) and p(O), if there were reasons to suspect that participants pressed the spacebar if they were more or less frequently rewarded, and if there were different levels of actual contingency (Blanco & Matute, 2015). An alpha level of .05 was used for all statistical tests. Beyond ANOVA methods included in the GLM models, confidence intervals (95% CIs) were determined to specify measures and its differences; bootstrapping was used to calculate CIs for repeated measures. The lower an upper CIs for the median were calculated for ordinal data respectively by formulae 1 and 2 (Bland, 2015).

$$\frac{n}{2} - \frac{1.96\sqrt{n}}{2} \text{ th ranked value} \quad (1)$$

$$1 + \frac{n}{2} + \frac{1.96\sqrt{n}}{2} \text{ th ranked value} \quad (2)$$

About the Signal Detection Theory measures, hit rates and false-alarm rates were calculated for all blocks. The hit rate was the ratio: number of hits in a block / number of S+ trials (green lights) in a block. Similarly, the false-alarm rate was the ratio: number of false alarms in a block / number of S- trials (red lights) in a block. To measure the performance, the parametric *d'*, *β*, ln *β* and *c*, and the nonparametric *A'* and *SI* detectability indices were calculated for each hit/false alarm pair. To measure the bias, the non parametric *B"* and *RI* response bias indices were calculated for each hit/false alarm pair. These SDT measures were calculated as follows (Stanislaw & Todorov, 1999; Talwar & Gerstein, 1999).

$$d' = \Phi^{-1}(H) - \Phi^{-1}(F)\,, \quad (1)$$

$$A' = 1/2 + [(H - F)(1 + H - F)]/[4H(1 - F)]\,, \quad (2)$$

$$B'' = [H(1 - H) - F(1 - F)]/[H(1 - H) + F(1 - F)]\,, \quad (3)$$

$$\beta = e^{\{[[\Phi^{-1}(F)]^2 - [\Phi^{-1}(H)]^2]/2\}}\,, \quad (4)$$

$$\ln \beta = \{[[\Phi^{-1}(F)]^2 - [\Phi^{-1}(H)]^2]/2\}\,, \quad (5)$$

$$c = -[\Phi^{-1}(H) + \Phi^{-1}(F)]/2\,, \quad (6)$$

$$SI = [H - F]/[2(H + F) - (H + F)^2\,]\,, \quad (7)$$

$$RI = [H + F - 1]/[1 - (H - F)^2]\,. \quad (8)$$

$$Y = |[raw\ Hits - raw\ Correct\ Rejections]|/[raw\ Hits + raw\ Correct\ Rejections]\,. \quad (9)$$

In order to to determine the empirical utility of sensibility and bias measures in action response discrimination, the data underwent analyses of variance by GLMs. For this purpose, the most satisfactory measure would minimize within-group (error) variance and hence maximize the corresponding *F* ratios (Talwar & Gerstein, 1999).

The data analysis of response times included the plotting in the program Minitab of eight statistical process control charts (Shewhart's charts) for *RT* means and standard-deviation (X-bar S charts) by subgroups of participants. The sample was divided in four subgroups according to the variables valence and *p*(O), and in other four subgroups according to the levels of judgment of control (*negative*, corresponding to the interval *JC* = [-100; -6]; *null*, *JC* = [-5; 5], *low positive*, *JC* = [6; 24]; and high positive, *JC* = [25; 100]). The charts represented the 100 trials, divided in two sections, corresponding to Blocks 1 and 2; the center line (or mean) and the upper and lower limits of control (corresponding to ± 3 x *SD*) were plotted for each block (cf. Figure 3.8).

The *Xbar-S chart* is commonly used in industry to monitor the mean (represented as $\bar{x}$ or "*X-bar*") and the variation (measured by the standard deviation or *S*) of a process with continuous data (*RT* in the case of the current study) and subgroup sizes of $n = 9$ or more. It is applied to monitor the process stability over time and to identify and correct instabilities in it. Data should be continuous, collected in time order at appropriate time intervals, and observations within each group should not be correlated with each other. Data do not need to be normally distributed. It is recommended to include at least 60 total observations in the sequence, although a smaller number is possible (Breyfogle III, 2003; Shewhart, 1931).

In the case of the current study, the subgroup sizes were around 20. The purpose was not to monitor or to correct instabilities, but to highlight significant changes in the sequence of data, trial by trial, that were beyond a normal, common, and steady random variation of the mean and standard deviation. Thus, the purpose was to use statistical process control charts to provide the study of variation, separating special from common assignable cause issues in data.

In the chart, each plotted point, x_i, represents the mean of the observations for the subgroup, *i*,

$$\bar{x}_i = \frac{\sum_{j=1}^{n_i} x_{i,j}}{n_i} \,. \tag{1}$$

The term $x_{i,j}$ is the *j*th observation in the *i*th subgroup and n_i is the number of observations in subgroup *i.* The center line represents the process mean; if a historical value is not specified, it is calculated by the average from data, $\bar{\bar{X}}$, calculated as follows,

$$\bar{\bar{X}} = \frac{\sum x}{\sum n} \,, \tag{2}$$

where the term $\sum x$ is the sum of all individual observations and $\sum n$ is the total number of observations. The value of the lower control limit (LCL) and the upper control limit (UCL) for each subgroup, *i*, are calculates as follows,

$$LCL_i = \mu - \frac{\mathrm{k}\sigma}{\sqrt{n_i}} \,, \tag{3}$$

$$UCL_i = \mu + \frac{\mathrm{k}\sigma}{\sqrt{n_i}} \,. \tag{4}$$

Where the term μ is the process mean, k is parameter for Test 1 (the number of standard deviations, the usual value is 3.00), σ is the process standard deviation and n_i is the number of observations in subgroup i.

Software Minitab (Version 18.1; Minitab, Inc., 2017) provides eight tests for special causes. By default settings, only Test 1 is activated (selected), but there are seven other additional tests to be selected in a drop-down list and applied, based on user's standards or preferences. Each test has a specific criterion to determine which observations to include, and to identify specific patterns and trends in data. The user can also make each test more or less sensitive by changing a value of *k*, a parameter that specifies the number of σ or points to be used as criterion. In the current analysis, the following tests (and their respective default *k*s) were simultaneously applied to identify subgroups that are unusual compared to other subgroups.

The tests are the following.

- Test 1, 1 point > *k* = 3 standard deviations from center line; this first test is universally recognized as necessary for detecting out-of-control situations.
- Test 2, *k* = 9 points in a row on same side of center line; it is used to identify shifts in the process centering or variation, and to supplement Test 1 in order to create a control chart that has greater sensitivity, if small shifts in the process are of interest.
- Test 3, *k* = 6 points in a row, all increasing or all decreasing; it is used to detect trends, this test looks for long series of consecutive points that consistently increase or decrease in value.
- Test 4, *k* = 14 points in a row, alternating up and down; it is used to detect systematic, not random, predictable variation.
- Test 5, *k* = 2 out of (k+1) = 3 points > 2 standard deviations from center line (in the same side); it is used to detect small shifts in the process.
- Test 6, *k* = 4 out of (k+1) = 5 points > 1 standard deviation from center line (in the same side); it is also used to detect small shifts in the process.
- Test 7, *k* = 15 points in a row within 1 standard deviation of center line (in either side); it is used to detect a pattern of variation that is sometimes mistaken as evidence of good control, when control limits are too wide, often caused by stratified data, which occur when a systematic source of variation is present within each subgroup.

- Test 8, $k = 8$ points in a row > 1 standard deviation from center line (in either side); it is used to detect a mixture pattern, when the points tend to fall away from the center line and instead fall near the control limits.

In general, few tests are applied simultaneously to prevent false-alarms, but in the current study the researchers searched for different types of special variation that could characterize the pattern of the groups. Several charts were run with different tests and the conclusions were the same. Figures presented in the results include all of the eight tests.

Results

In order to analyze the effects of the valence (productive and preventive), of the probability of the outcome (green lights), and of the sequence of blocks on the magnitude of illusion of control, General Linear Models were run for each of the following DVs: the self-reported judgments of control, the associative measures *d*', *Ad*', *A*', *α*, *SI*, *β*, *B*'', *c*, *RI*, and *Y*, the reaction times, and the positive and negative affects (PANAS Scale). The *RT*s for the sequence of trials and subgroups were plotted in statistical process control charts and submitted to eight statistical tests to detect outliers and change points.

Data were normalized when possible and all the analysis were made in normalized and non-normalized measures, however the results information was the same. The variables originally normal were *p*(A), *FJC*, *pJC* (Block 1), *d*', *Ad*,' *A*', *α*, *c*, and *RI*. It was possible to normalize the variable *RT* and the SDT measures, *SI*, *β*, *B*'', and *Y*. The variable *pJC* (Block 2) could not be normalized, because of the greater number of null judgments.

Judgments of Control

In this study there was a sequence of 100 trials divided in two blocks under the same probability of the outcome throughout the whole task. The final judgment of control (*FJC*), assessed after the end of the task, was positive under high *p*(O) and negative under low *p*(O), with a very large effect. Such result was obtained from the GLM for *FJC* with valence (group), *p*(O) and block as factors: there was no significant effect of valence or interaction ($F(1,57) = 29.38$, $p < .001$, $\eta^2 = .34$, $\eta^2_p = .34$, $r = .58$; $FJC = 22$, 95% CI [13, 30], $n = 31$; $FJC = -19$, 95% CI [-31, -6], $n = 30$;).

The partial judgments of control (*pJC*), which were assessed just after each block, were submitted to a GLM with the same variables as factors, and it was also largely affected by *p*(O), besides there was a small effect of interaction *p*(O) vs. block ($F(1, 57) = 35.80$, $p < .001$, $\eta^2 =$

.27, $\eta_p^2 = .39$, $r = .52$; $F(1, 57) = 7.06$, $p = .010$, $\eta^2 = .03$, $\eta_p^2 = .06$, $r = .17$). As it is illustrated in Figure 3.3, the effect of p(O) on the illusion was very large and judgment means got closer to null from block 1 to 2 in both groups, since the judgments got closer to null in the second block.

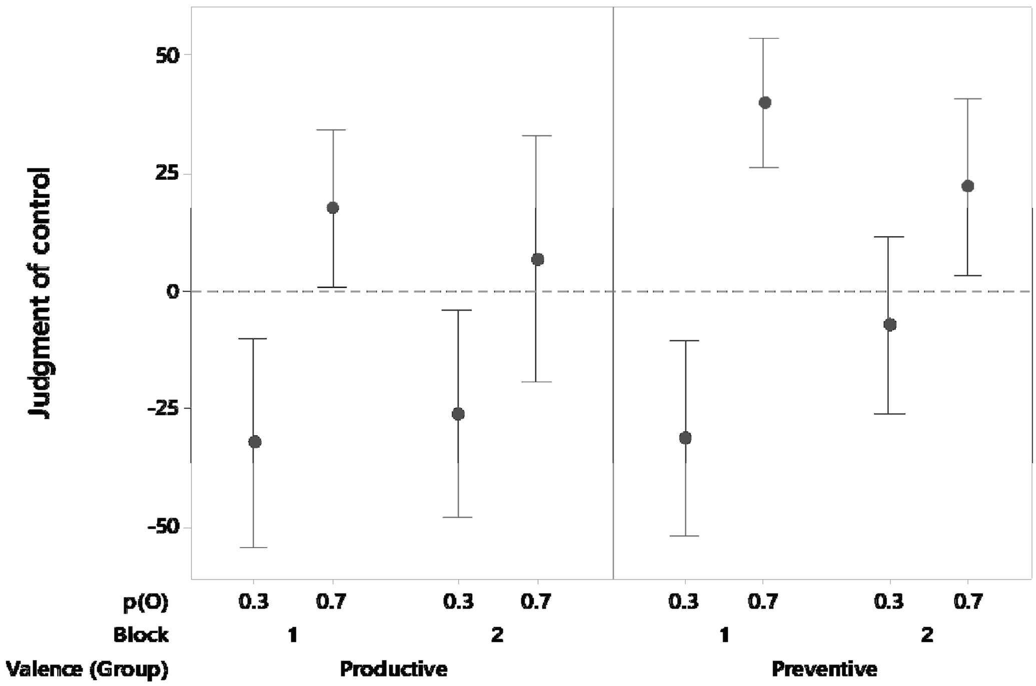


Figure 3.3. Interval plots of the partial judgments of control after Block 1 and Block 2 for low and high probabilities of the outcome (p(O)) in the productive (left) and preventive (right) groups. Illusions were negative in low p(O) and positive in high p(O), and got closer to null in the second blocks.

There was a strong correlation between *pJC* after Block 1 and *FJC*, and another strong correlation between *pJC* after Block 2 and the *FJC*, both correlations had the same statistic intensity ($r(63) = .67$, $p < .001$; $r(63) = .77$, $p < .001$; $z = -1.15$, $p = .125$). There was a moderate correlation between the two *pJC* after each block ($r(63) = .47$, $p < .001$).

The proportion of null partial judgments of control ($-5 \leq pJC \leq 5$) after Blocks 1 and 2 in the productive group were respectively .31 and .38, while in the preventive group the proportions were .16 and .29. There was no significant difference between the proportions of null judgments in the blocks, either under productive and preventive valences ($z = -0.53$, $p = .299$; $z = -1.23$, $p = .109$).

Probability of the Action

The mean probability of the action (p(A)) was .63 (95% CI [.61; .66]), i.e., in 63% of the trials the response was *action*, while 47% were *omissions*. A GLM for p(A) with valence, p(O) and block as factors indicated small effects of two interactions, valence vs. block, and p(O) vs. block, see Figure 3.5 ($F(1, 58) = 5.05$, $p = .028$, $\eta^2 = .02$, $\eta_p^2 = .08$, $r = .14$; $F(1, 58) = 5.11$, $p = .028$, $\eta^2 = .02$, $\eta_p^2 = .08$, $r = .14$). The productive participants emitted higher frequency of action responses (p(A) = 0.68, 95% CI [0.64, 0.73], $n = 31$) in the second block; participants under low p(O) emitted higher frequency of action (p(A) = 0.67, 95% CI [0.62, 0.71], $n = 30$) in the second block, independently of their valence.

A GLM for p(A) with valence, level of the partial judgment of control, and block as factors contributed with a medium effect of the interaction valence vs. judgment. In the subgroup of participants who judged to have high positive control, the productive subgroup had higher frequency of actions, while the preventive subgroup had the lowest frequency and null bias to action, see Figure 3.4 ($W(1, 122) = 13.52$, $p = .004$, $\omega = 0.33$; p(A) = .72, 95% CI [.66, .77], $n = 12$; p(A) = .53, 95% CI [.46, .61], $n = 20$).

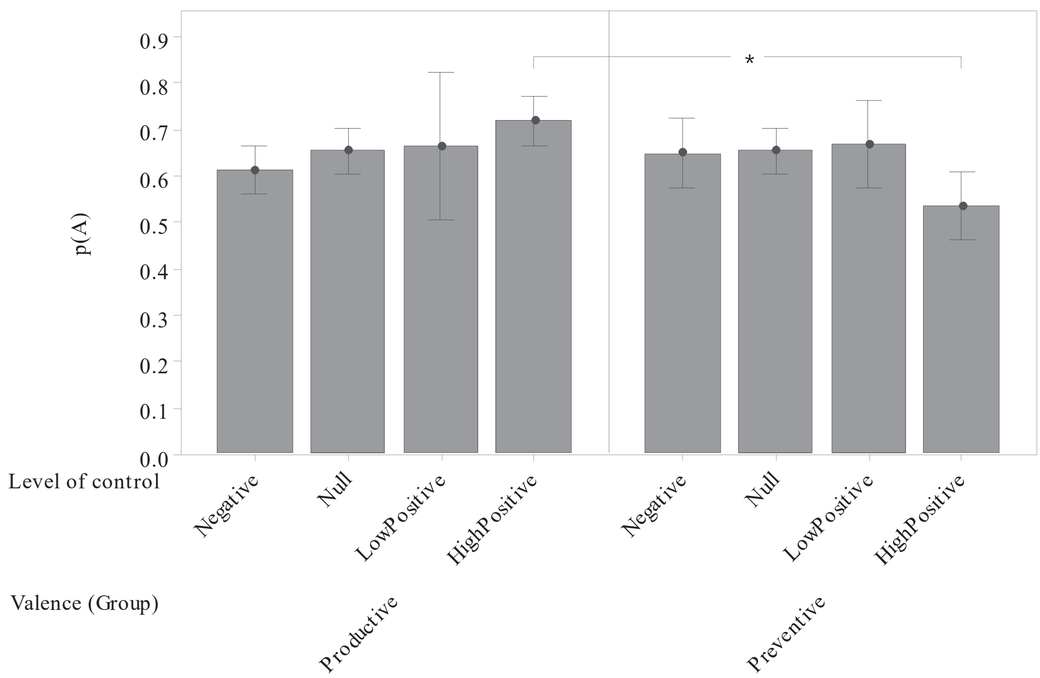


Figure 3.4. Bar chart of the probability of the action response (p(A)) for different levels of self-reported control in the productive (left) and preventive (right) groups. Participants with higher positive illusion pressed the space bar more frequently in the productive group than in the preventive group. * p < .05.

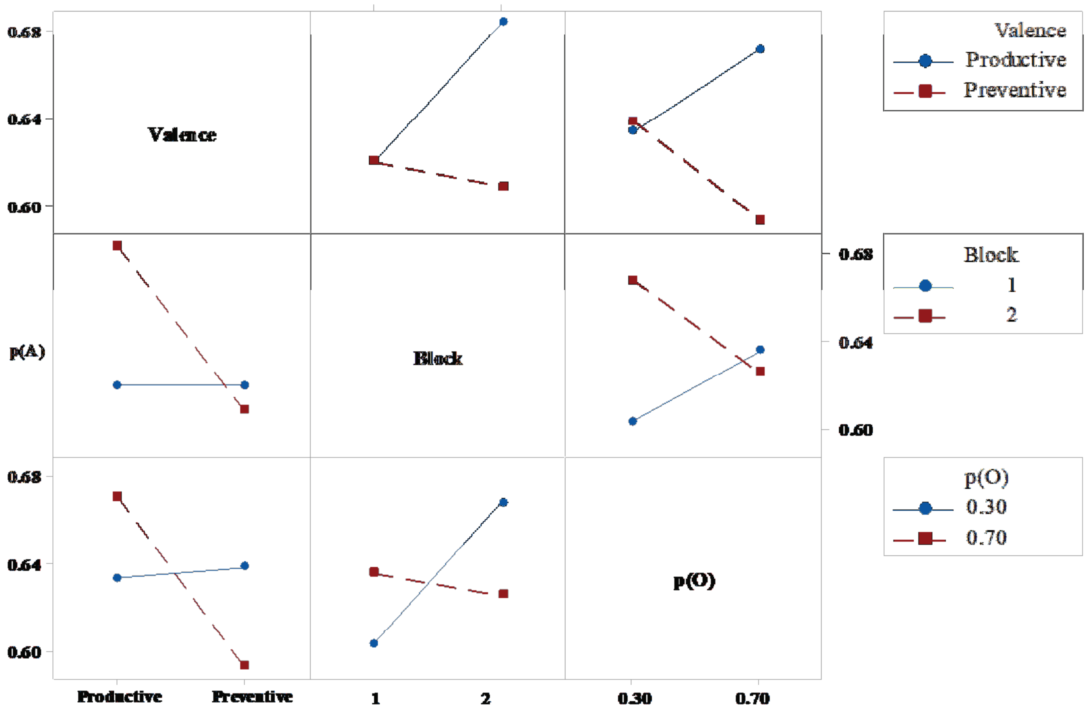


Figure 3.5. Interaction plot for the probability of the action response (p(A)) illustrating two significant interactions: valence vs. block, and *p*(O) vs. block.

Signal Detection Measures

In Study 2 (Chapter 2), it was demonstrated that all the tested sensibility measures from the SDT performed equally, had similar errors in their models to explain variability and were coherent to random outputs, and *SI* was chosen to represent the results. About the response bias measures, the non parametric *c* presented lowest percentage of error in the model and indicated significant differences between groups. So, *c* was the chosen measure to analyze and compare tendencies in the strategies that the current participants used when behaving in order to control the pedestrian traffic light.

Table 3.2

Mean Sensibility And Response Bias Measures And P(A) In The Traffic Light Task

Measure	Mean	95% IC	*SE*	Error (%)
Sensibility				
d'	.06	[-.02, .14]	.04	45
A'	.52	[.49, .55]	.01	46
Ad'	.52	[.49, .54]	.01	45
α	.02	[-.01, .05]	.01	46
SI	.02	[-.01, .06]	.02	45
Response bias				
β	.97	[.93, 1.01]	.02	39
c	-.23	[-.37, -,21]	.04	20
B"	-.05	[-.07, -.03]	.01	36
RI	.22	[.16, .28]	.03	20
Y	.38	[.32, .45]	.03	18
p(A)	.63	[.61, .66]	.01	12

Note: Sensibility was null in all measures and the errors were equivalent. Most response bias measures indicated bias for action response, and the models for *c*, *RI* and *Y* had lower percentage or the error

The sensitivity and response bias results are presented in Table 3.2. There was null sensitivity in all measures and the only significant effect found was in the interaction of *p*(O) vs. block. In a GLM for *SI* with valence, *p*(O) and block as factors ($F(1, 51) = 5.00$, $p = .03$, $\eta^2 = .04$, $\eta_p^2 = .09$, $r = .20$); this effect was detected in all the other sensitivity measures. There is a small tendency to positive sensitivity under low *p*(O) in the second block, but it was not possible to state that sensibility was different from null ($SI = 0.06$, 95% CI [0.00, 0.13], $n = 28$), as expected.

The responses presented a bias to action in all valences, probabilities of outcome, and blocks. However, there was a medium (intermediate) interaction *p*(O) vs. block in the GLM for *c* with the three factors: participants under low *p*(O) presented stronger bias in the second block, see Figure 3.6 ($W(1, 116) = 7.15$, $p = .007$, $\omega = .25$). The effect of block was also significant and medium ($W(1, 116) = 12.43$, $p < .001$, $\omega = .33$), there was a tendency to action in the second block.

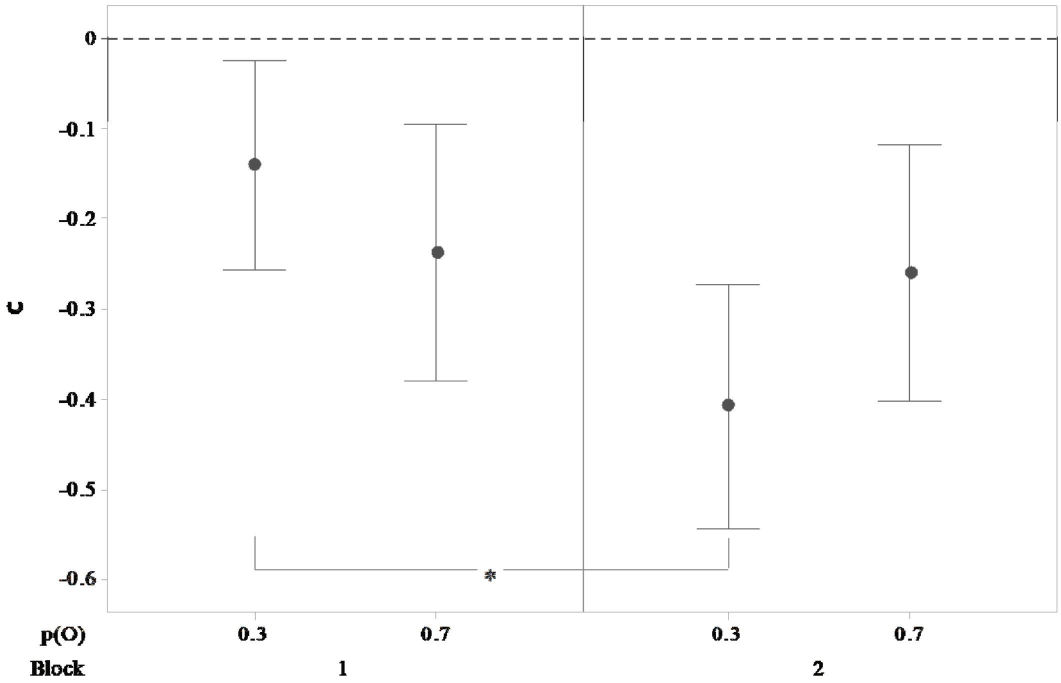


Figure 3.6. Interval plot of the response bias *c* measure for low and high probabilities of the outcome (p(O)) in the first (left panel) and in second block (right) of the experiment. There was an interaction and a block effect: a tendency to action in the second block under low p(O) (W(1, 116) = 7.15, p = .007, ω = .25). The effect of block was also significant and medium (W(1, 116) = 12.43, p < .001, ω = .33).

A GLM for *c* as response and valence, block and the level of the partial judgment of control as factors produced a medium to large intensity interaction effect of valence vs. judgment of control (W(3,116) = 19.17, p < .001, ω = .41), so that preventive participants who judged to have high level of control ($25 \leq pJC \leq 100$) had null bias, i.e., neither a tendency to action nor to omission (see Figure 3.7). The main effects of valence and block were also significant (W(1, 116) = 4.07, p = 0.044, ω = 0.19, and W(1, 116) = 10.01, p < 0.001, ω = 0.29), both valences and the two blocks presented bias to action, but there was a slight bias to more action in productive participants and in Block 2.

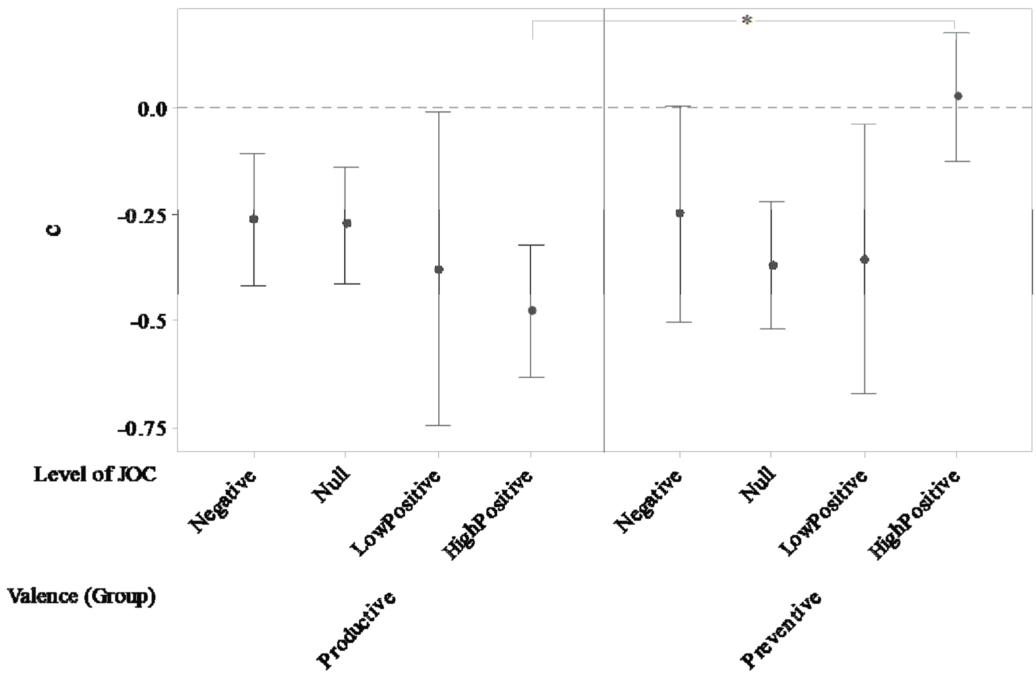


Figure 3.7. Interval plots of the response bias *c* measure for for different levels of self-reported control in the productive (left) and preventive (right) groups. The participants who self-reported high level of control had a bias for the action if they had a productive goal, and null bias to action if they had a preventive goal.

Reaction Time

A GLM for reaction time (*RT*) including all 100 trials and valence (group), *p*(O), and block as factors, resulted that there was only one significant main effect: block. Reaction time mean decreased from the first to the second block (RT = 888 ms, 95% CI [850, 929]; RT = 789 ms, 95% CI [758, 823]; $W(1,63) = 14.84$, $p < .001$, $\omega = .49$, a large effect). There were no differences or significant effects of group, *p*(O) or interactions ($W(1,63) < 2.48$, $p > .115$). Another GLM to search for differences in *RT* among levels of partial judgments of control (*negative*, *null*, *low positive* and *high positive*) presented no effect ($W(3,63) < .53$, $p = .913$). No correlation was found between *RT* and final of partial judgments of control, in any subgroup ($|rs| < 0.32$, $ps > 0.098$).

Reaction times from each of the 100 trials were represented in X-bar S (mean and standard deviation) statistical process control (SPC) charts and submitted to eight different tests to detect outliers, special causes and change points. The charts for the subgroups of valence, p(O), and level of the judgment of control are represented in Figures 3.8 to 3.15.

The SPC chart for Productive-Low *p*(O) group presented an almost random and stable pattern of variation. The group of participants nested under the productive valence and low p(O) = .30 (who usually corresponds to null judgments in illusion of control studies) have their SPC chart represented in Figure 3.8. There were fast decreases of *RT* in the beginning of the two experimental blocks, indicated by Test number 1 in Block 2, in the sample mean chart. The chart had almost a random pattern, except for just one special cause of number 2 in the second block, indicating an stabilization under the center line (sample mean).

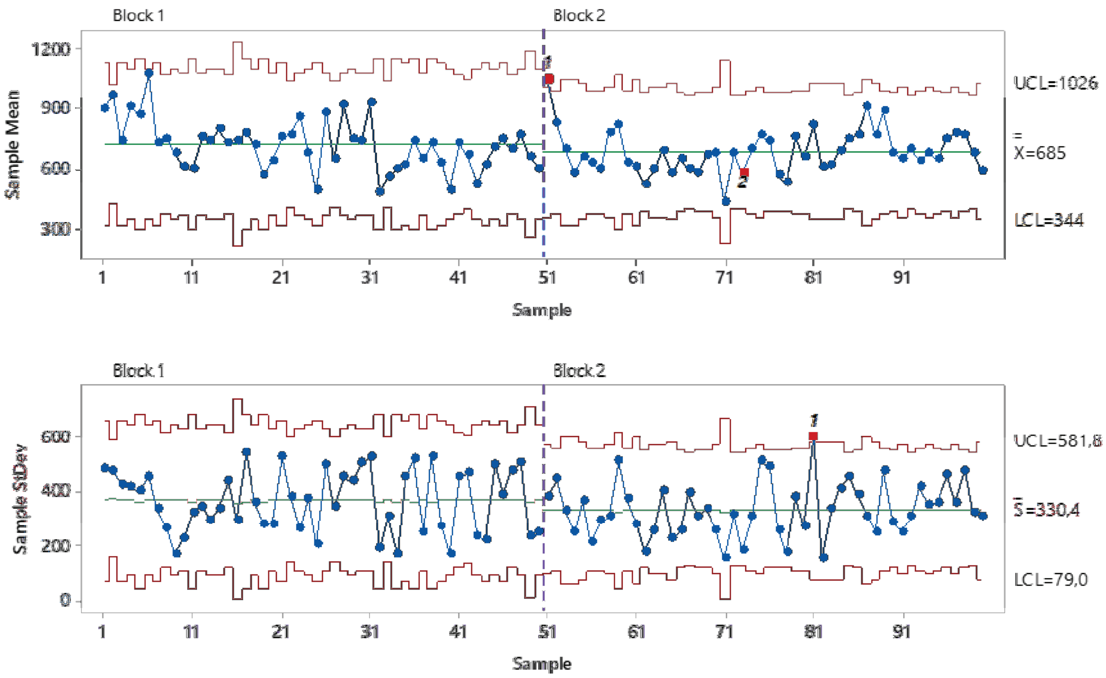


Figure 3.8. Statistical process control chart for response time in the productive group under low probability of the outcome, *p*(O).

The Productive-High *p*(O) group SPC chart presented a permanent pattern of fast *RT* in the second half of both blocks. The group of participants nested under the productive valence and high *p*(O) = .70 (who usually corresponds to people who declare positive judgments of control in illusion studies) has their SPC chart represented in Figure 3.9. There was a fast decrease of *RT* in the beginning of Block 1, indicated by Tests numbers 1 and 5, immediately followed by some stabilization of the *RT* in the next first trials, indicated by Tests numbers 2 and 6, until the 10^{th} trial of the first block. Then *RT* mean kept on close to the sample mean until the middle of the block, and in the second half there was a sequence of special causes of Type number 2, indicating that *RT* mean decreased and stabilized under the center line of Block 1. In

Block 2, the decrease in *RT* in the first trials was faster, indicated by Test number 1, and the *RT* variated randomly for the first half of the block; a similar sequence of many special causes Type number 2 in the second half also indicate a decrease and stabilization of *RT* in the sample mean chart.

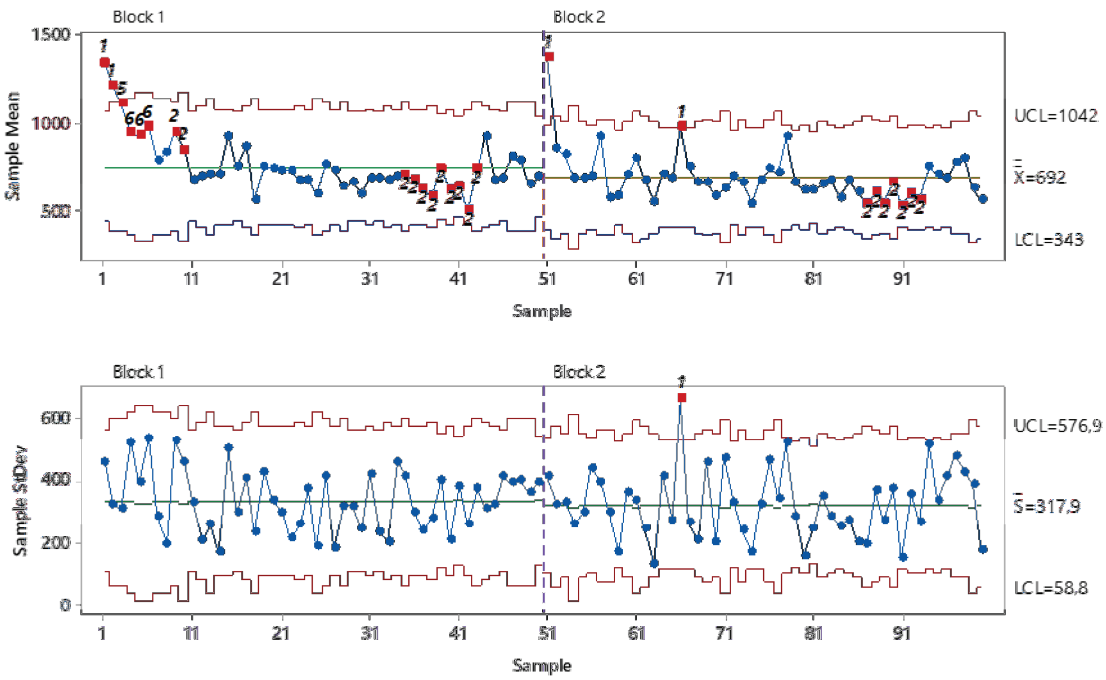


Figure 3.9. Statistical process control chart for response time in the productive group under high probability of the outcome, *p*(O).

The Preventive-Low *p*(O) group SPC chart presented an almost random and stable pattern of variation. The group of participants nested under the preventive valence and low *p*(O) = .30 (who usually corresponds to null of negative judgments in illusion of control studies) have their SPC chart represented in Figure 3.10. Similarly to the first group, there were fast decreases of *RT* in the beginning of the two experimental blocks, indicated by Test number 1 in the two blocks. Both the sample mean chart and the sample standard deviation chart had almost a random pattern, except for two contiguous special causes of number 2 in the first block, indicating an stabilization under the center line (sample mean) in the end of the block.

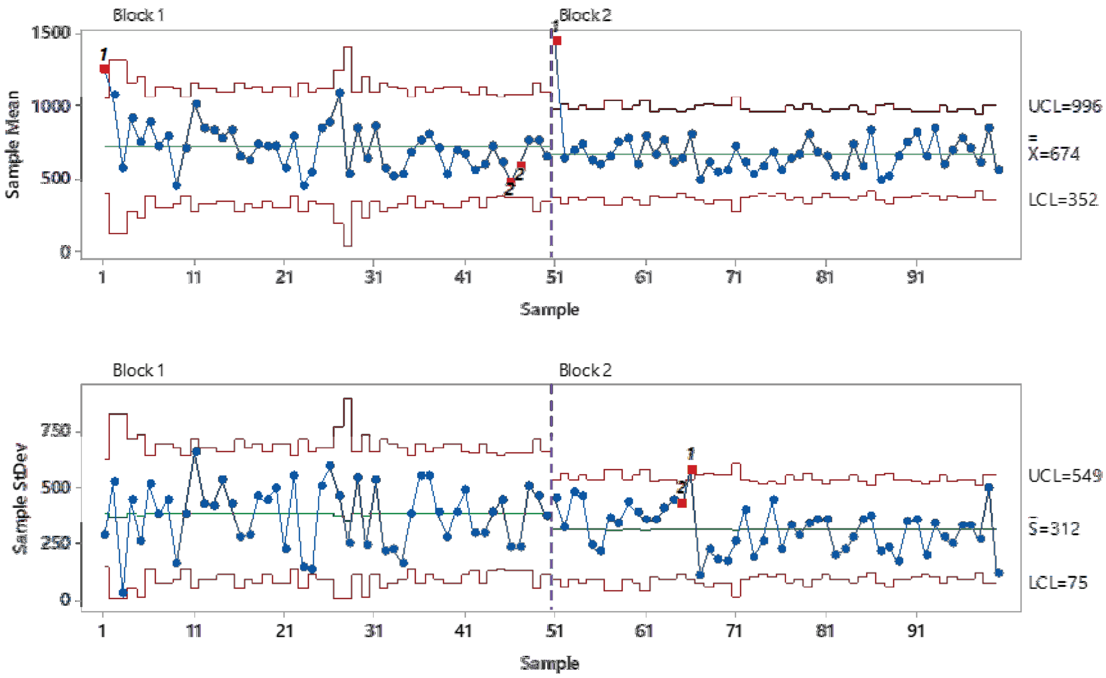


Figure 3.10. Statistical process control chart for response time in the preventive group under low probability of the outcome, *p*(O).

The Preventive-High *p*(O) group SPC chart presented a patter of great oscillation of *RT* in the middle of the two blocks and a random stable variation in the end of the blocks. The group of participants nested under the preventive valence and high *p*(O) = .70 (who usually corresponds to people who declare judgments of control in illusion studies) have their SPC chart represented in Figure 3.11. Similarly to the productive-high group, there was a decrease of *RT* in the beginning of Block 1, indicated by Tests numbers 1 and 5, so that *RT* decreased a bit gradually in the first block. Then *RT* mean kept on close to the sample mean (central line) with small variation for some time, but *RT* started to oscillate by the middle of Block 1; in the second half of the block, a sequence of special causes of Type number 6 indicates that *RT* mean decreased and stabilized more than one *SD* below the center line. In Block 2, the decrease in *RT* through the first trials was faster, indicated by Tests number 1 and 5, and the *RT* variated randomly for the first half of the block; a sequence of many different special causes (Types number 1, 2 and 6) in the second half indicate great oscillation of *RT* around the sample mean (center line), followed by some random stable variation in the end of the task.

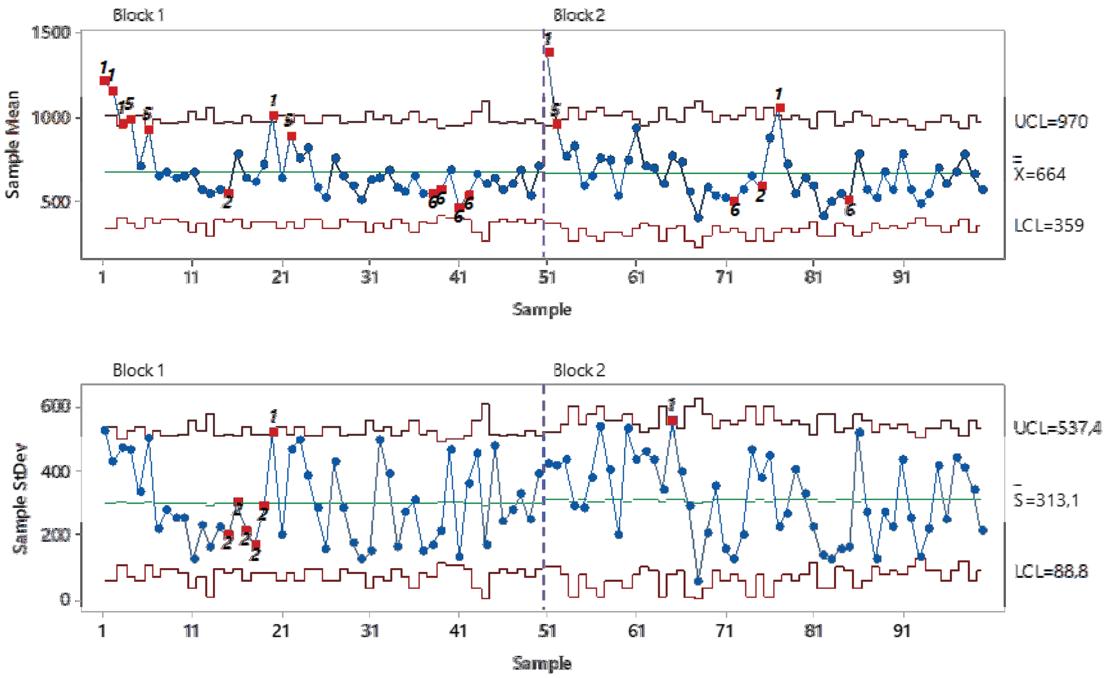


Figure 3.11. Statistical process control chart for response time in the preventive group under high probability of the outcome, *p*(O).

The Negative Illusion SPC chart (Figure 3.12) presented a decrease of *RT* for some time and ended up with greater oscillating variation. The group of participants who responded with negative illusion (i.e., judgment of control from -100 to -5 in the scale from -100 to 100) presented a fast decrease of *RT* in the beginning of the two blocks, indicated by Tests numbers 1, 5 and 6 in Block 1, and Test number 1 in Block 2, in the sample mean chart. There was a decrease and stabilization of *RT* in the middle of the blocks, indicated by sequences of special causes of number 6 (4 out of 5 points farther than 1 *SD* from the chart center line, the mean, in the same side, below the line). Such stabilization occurred earlier in the first block, around trial 35, while it was around trial 60 in the second block (the 10th trial in the block). After the stabilization period, *RTs* increased locally and performed a greater and oscillating variation (indicated by test number 4 in the *SD* chart) till the end of the block or chart.

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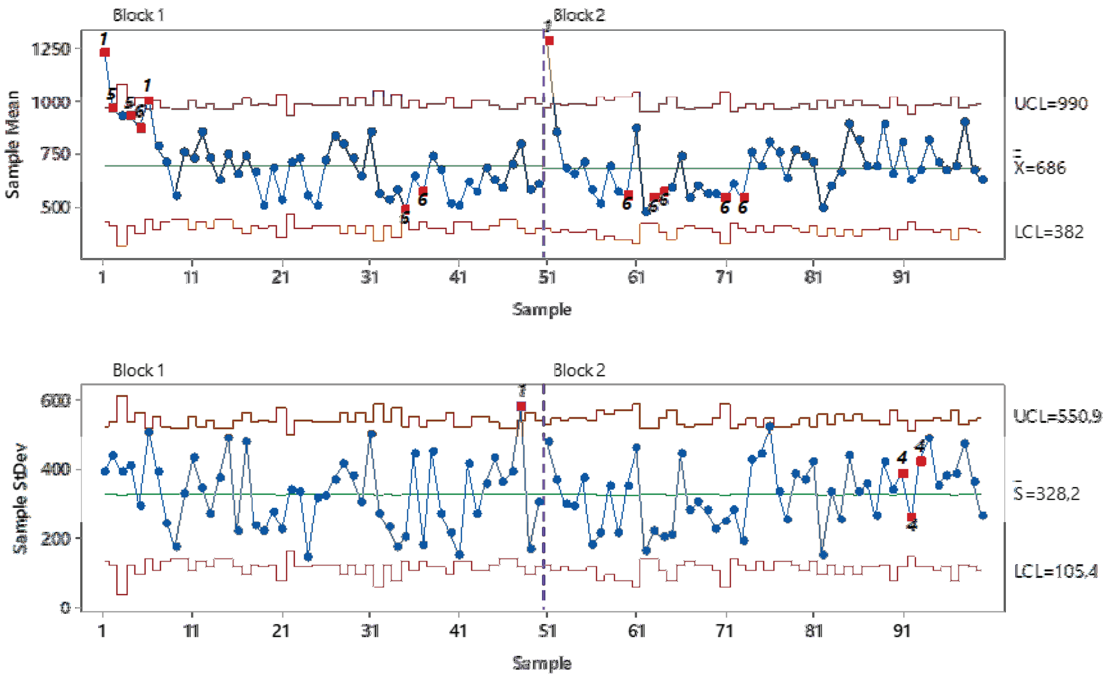

Figure 3.12. Statistical process control chart for response time in the group who self-reported negative judgments of control.

The Null Illusion SPC chart presented permanent decreases of *RT* mean and *SD* in the two blocks, corresponding to stabilizations and minimizations of the variation. The group of participants who responded with null illusion (i.e., judgment of control from -5 to 5 in the scale from -100 to 100; see Figure 3.13) presented a fast decrease of *RT* in the beginning of both blocks, indicated by Test number 1 in the sample mean chart. There was a clear decrease and stabilization of *RT* in the end of the first block, indicated by sequences of special causes number 2 (9 points in a row on the same side under the center line). The same test indicated an earlier stabilization in the second block, before trial 70 (by the 20th trial in the block). In the end of the chart there was a slight but non significant increase of *RT* mean and *SD*.

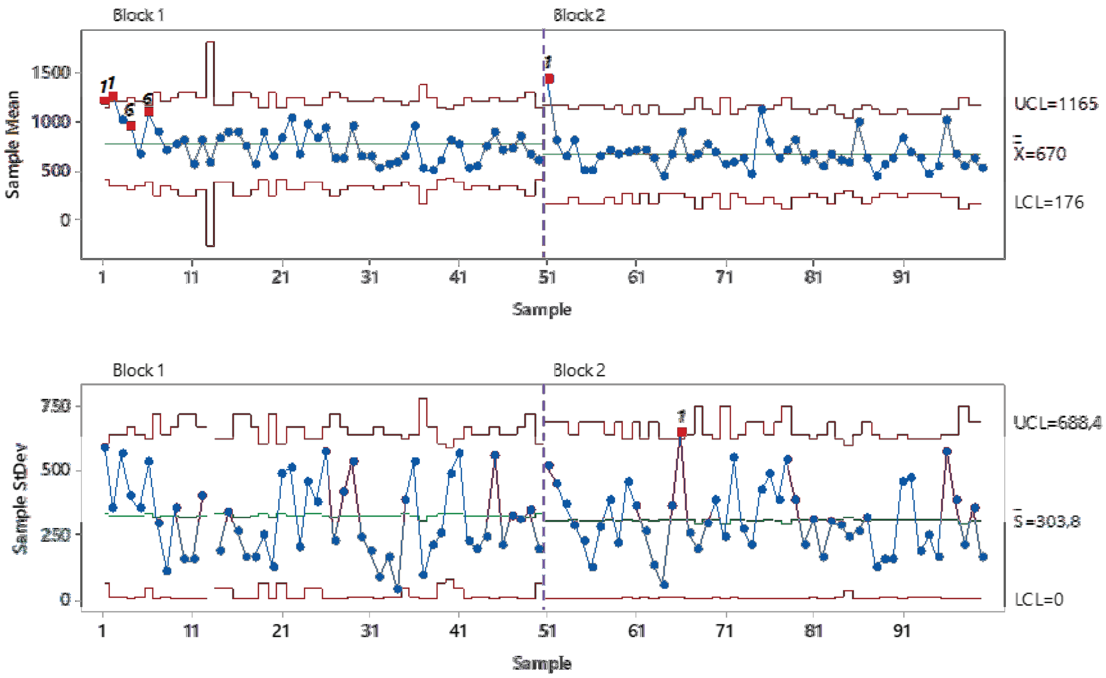

Figure 3.13. Statistical process control chart for response time in the group who self-reported null judgments of control.

The Low Positive Illusion SPC chart (Figure 3.14) presented a random pattern. The group of participants who responded with low positive illusion (i.e., judgments of control from 6 to 24) presented a stable and continuous random oscillation of the mean and *SD*, represented in the sample mean chart and in the sample *SD* chart, respectively; besides the usual fast decrease of *RT* in the beginning of the blocks (indicated by Tests numbers 1 and 6 in Block 1, and Test number 1 in Block 2).

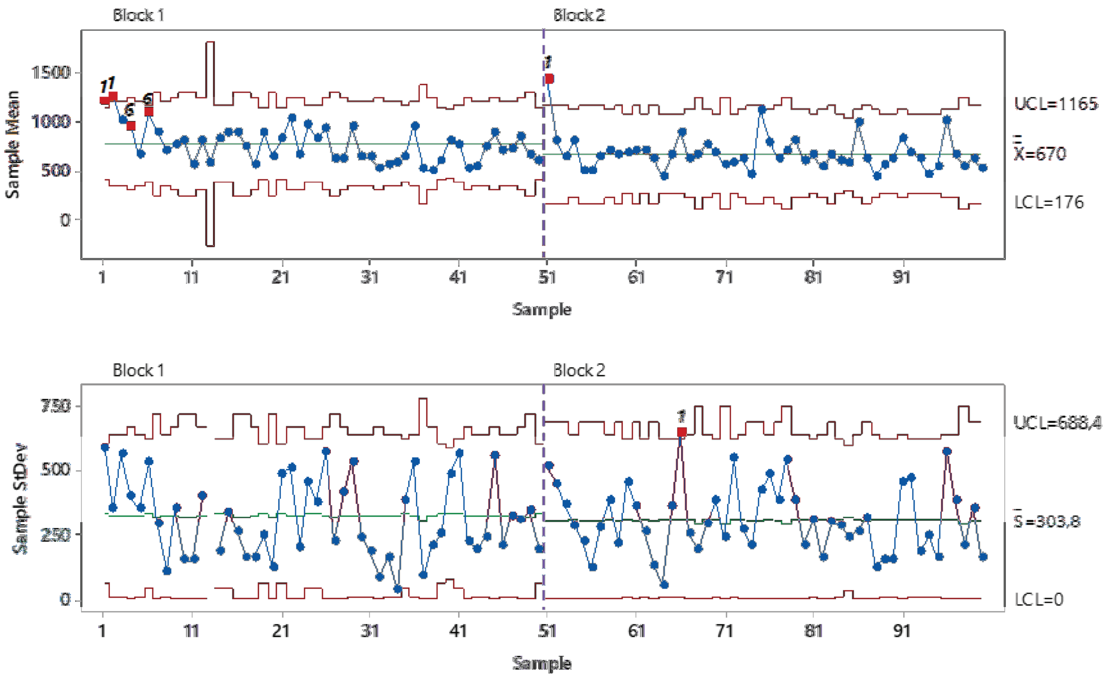

Figure 3.14. Statistical process control chart for response time in the group who self-reported low positive judgments of control.

The High Positive Illusion SPC chart presented a decrease of *RT* for some time and ended up with higher *RT* close to the mean. The group of participants who responded with high positive illusion (i.e., judgments of control from 25 to 100, see Figure 3.15) presented a fast decrease of *RT* in the beginning of both blocks, indicated by tests numbers 1, 5 and 6 in Block 1, and tests number 1 and 5 in Block 2, in the sample mean chart. There was decrease and stabilization of *RT* in the middle of the blocks, indicated by two special causes number 2 (each one indicating 9 points in a row under the chart center line, or mean). Such stabilization occurred earlier in the first block, between trials 20 and 30, while in the second block it took place just after trial 80 in the second block (after the 25th trial in Block 2). *RTs* kept on very close to the mean through the last 5 trails at the end of each block.

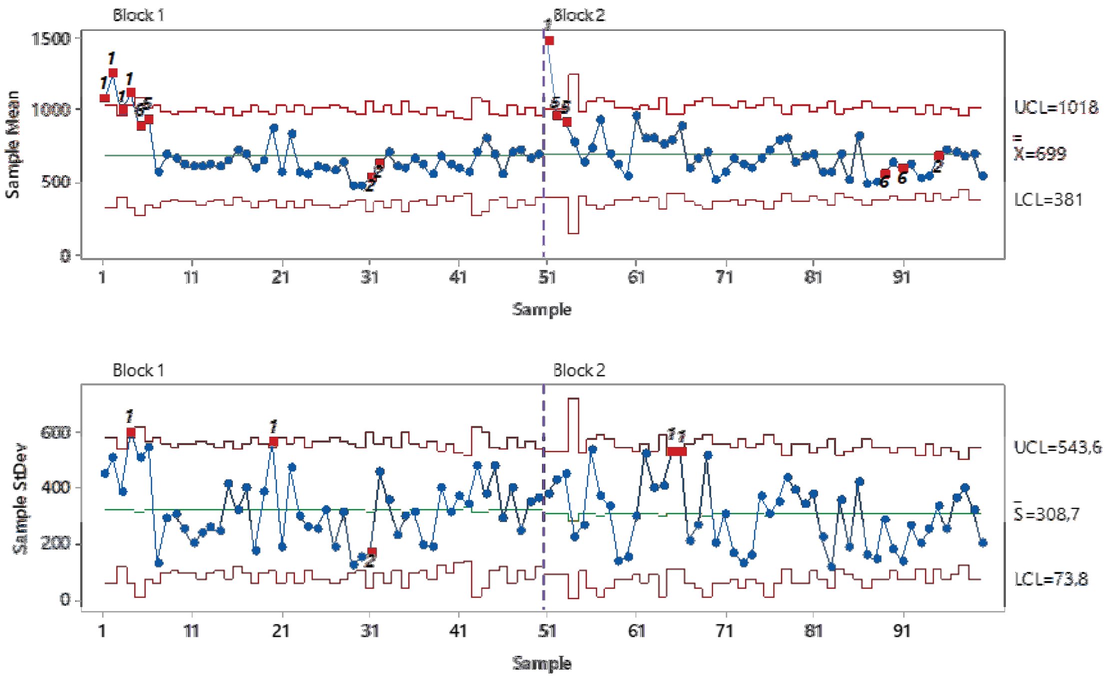

Figure 3.15. Statistical process control chart for response time in the group who self-reported high positive judgments of control.

PANAS Scale

The sum of scores of positive and negative affects in PANAS scale resulted in moderate intensity of positive affects (M = 27, 95% CI [25, 29]) and little intensity of negative affects (M = 16, 95% CI [14, 17]). The productive and preventive groups declared the same intensity in the positive and in the negative affects, as well as under different p(O)s, see Figure 3.16.

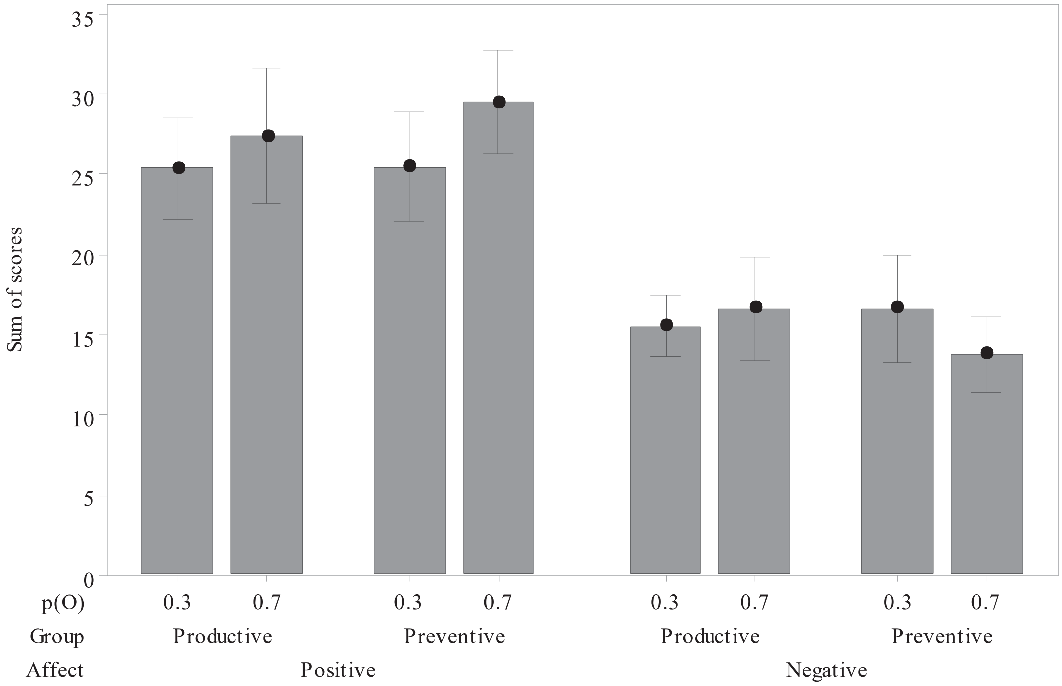

Figure 3.16. Bar graphs of the sum of scores of positive and negative affects in PANAS scale by valence and probability of the outcome. Positive affects were in moderate intensity and negative affects were in little intensity; there was no valence (group) or probability effect.

The intense affects were *alert, attentive,* and *interested.* These categories presented medians statistically greater than 3 in the 5-point scale, i.e., their confidence interval lower limit was 3. Lower probabilities of the outcome presented just one intense affect: *interested* in the productive group and *attentive* in the preventive group. Higher probabilities of the outcome presented two or three intense affects, *alert* in the productive group, and *attentive* and *determined* in the preventive group; *interested* was common to both valences. It seems that the affect *attentive* is typical to the preventive group. All affects were positive. Tables 3.3 and 3.4 list medians for all affects and groups. The results were similar for both valences (groups).

Table 3.3

Medians And Respective 95% Confidence Intervals Of The 20 Affects From PANAS Scale In The Productive Group, By Probability Of The Outcome.

	Productive 0.3			Productive 0.7		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	40	3	[2,4]	41	3	[2,4]
Alert	40	3	[1,4]	41	**4**	**[2,4]**
Attentive	40	3	[2,3]	41	3	[2,4]
Determined	40	3	[2,3]	41	2	[2,3]
Enthusiastic	40	2	[1,4]	41	3	[2,3]
Excited	40	3	[2,3]	41	3	[2,4]
Inspired	40	1	[1,3]	41	2	[1,3]
Interested	40	**3**	**[3,4]**	41	**3**	**[3,4]**
Strong	40	2	[1,2]	41	2	[1,3]
Afraid	40	1	[1,1]	41	1	[1,2]
Ashamed	40	1	[1,1]	41	1	[1,1]
Distressed	40	1	[1,1]	41	1	[1,2]
Guilty	40	1	[1,2]	41	1	[1,2]
Hostile	40	1	[1,3]	41	1	[1,2]
Irritable	40	2	[1,3]	41	1	[1,2]
Jittery	40	2	[1,2]	41	3	[1,3]
Nervous	40	1	[1,3]	41	2	[1,2]
Scared	40	1	[1,1]	41	2	[1,3]
Upset	40	1	[1,3]	41	1	[1,1]
Proud	40	1	[1,2]	41	2	[1,4]

Table 3.4

Medians And Respective 95% Confidence Intervals Of The 20 Affects From PANAS Scale In The Preventive Group, By Probability Of The Outcome

	Preventive 0.3			Preventive 0.7		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	40	2	[2,4]	41	3	[2,4]
Alert	40	2	[2,3]	41	3	[2,4]
Attentive	40	**4**	**[3,4]**	41	**3**	**[3,4]**
Determined	40	2	[2,3]	41	**4**	**[2,4]**
Enthusiastic	40	2	[1,3]	41	3	[2,4]
Excited	40	2	[1,4]	41	3	[2,4]
Inspired	40	1	[1,3]	41	3	[2,3]
Interested	40	3	[2,3]	41	**4**	**[3,4]**
Strong	40	3	[2,3]	41	3	[1,3]
Afraid	40	1	[1,2]	41	1	[1,1]
Ashamed	40	1	[1,2]	41	1	[1,1]
Distressed	40	1	[1,2]	41	1	[1,1]
Guilty	40	1	[1,1]	41	1	[1,1]
Hostile	40	1	[1,2]	41	1	[1,1]
Irritable	40	1	[1,3]	41	1	[1,1]
Jittery	40	1	[1,3]	41	1	[1,3]
Nervous	40	2	[1,3]	41	2	[1,3]
Scared	40	1	[1,2]	41	1	[1,1]
Upset	40	1	[1,2]	41	1	[1,2]
Proud	40	2	[2,3]	41	3	[1,4]

alues statistically greater than 3 are highlighted in bold

The intensities of the 20 affects were also compared to the judgments of control and there were significant differences and correlations. Table 3.5 lists the medians and respective CIs for each affect, by level of judgments (negative, null, low positive and high negative). The positive affects *alert, attentive,* and *interested* are intense in subgroups, and there is a higher number of intense affects when participants assessed to have positive illusions. No negative illusions were assessed with high punctuation by groups. Some positive affects were moderately correlated to the raw scores of the general judgment of control: *determined* ($r_s(61) = .25$, $p = .049$), *enthusiastic* ($r_s(61) = .32$, $p = .011$), *inspired* ($r_s(61) = .29$, $p = .021$), *interested* ($r_s(61) = .35$, $p = .005$), *proud*[6] ($r_s(61) = .30$, $p = .019$). The negative affects *ashamed* ($r_s(61) = -.35$, $p = .005$), *upset* ($r_s(61) = -.39$, $p = .002$), *irritable* ($r_s(61) = -.37$, $p = .003$), *jittery* ($r_s(61) = -.25$, *p*

[6] The affect proud is not included in Brazilian PANAS scale, but the current sample was collected among european students.

= .047) were inversely correlated to the judgments of control, nevertheless they were not significantly strong among the median confidence intervals.

Table 3.5
Medians And Respective 95% Confidence Intervals Of The 20 Affects From PANAS Scale, By Level Of The Judgment Of Control.

	Negative illusion			Null illusion		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	14	3	[2,4]	27	2	[2,3]
Alert	14	3	[2,4]	27	2	[2,3]
Attentive	14	**3**	**[3,4]**	27	3	[2,4]
Determined	14	3	[2,4]	27	2	[2,3]
Enthusiastic	14	2	[1,3]	27	2	[1,3]
Excited	14	2	[2,4]	27	2	[1,3]
Inspired	14	1	[1,3]	27	1	[1,2]
Interested	14	3	[2,4]	27	3	[2,3]
Strong	14	2	[2,3]	27	2	[1,3]
Afraid	14	1	[1,1]	27	1	[1,1]
Ashamed	14	1	[1,2]	27	1	[1,1]
Distressed	14	1	[1,1]	27	1	[1,1]
Guilty	14	1	[1,2]	27	1	[1,1]
Hostile	14	1	[1,3]	27	1	[1,2]
Irritable	14	2	[1,4]	27	1	[1,2]
Jittery	14	3	[2,4]	27	2	[1,3]
Nervous	14	2	[1,4]	27	1	[1,2]
Scared	14	1	[1,3]	27	1	[1,1]
Upset	14	1	[1,3]	27	1	[1,2]
Proud	14	1	[1,3]	27	1	[1,3]

	Low positive illusion			High positive illusion		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	20	3	[2,4]	20	3	[2,4]
Alert	20	**4**	**[1,4]**	20	3	[2,4]
Attentive	20	**3**	**[3,4]**	20	**4**	**[3,4]**
Determined	20	2	[1,4]	20	3	[2,4]
Enthusiastic	20	3	[1,4]	20	3	[2,4]
Excited	20	3	[2,4]	20	3	[2,4]
Inspired	20	2	[1,3]	20	3	[2,3]
Interested	20	**4**	**[2,4]**	20	**4**	**[3,4]**
Strong	20	2	[1,3]	20	3	[2,3]
Afraid	20	1	[1,2]	20	1	[1,2]
Ashamed	20	1	[1,2]	20	1	[1,1]
Distressed	20	1	[1,3]	20	1	[1,1]
Guilty	20	1	[1,2]	20	1	[1,1]
Hostile	20	1	[1,2]	20	1	[1,2]
Irritable	20	1	[1,2]	20	1	[1,2]
Jittery	20	2	[1,3]	20	1	[1,3]
Nervous	20	2	[1,3]	20	1	[1,2]
Scared	20	1	[1,2]	20	1	[1,2]
Upset	20	1	[1,2]	20	1	[1,1]
Proud	20	2	[1,3]	20	3	[2,4]

Discussion

The present study investigated additional techniques to measure IOC. As expected, the illusion has been established in both valence groups with directions and intensities similar to Study 2 (Chapter 2). In both studies the final judgments of control (*FJC*), self-assessed at the end of the task, were positive and with moderate intensities in most conditions of high *p*(O), with a mean value of in the scale where the upper limit was 100. Negative and null illusions also happened under low probabilities. Once more, there were strong correlations between the partials and the final judgment, and there was no significant effect of valence or interaction, suggesting that the mechanism of the phenomenon is possibly universal (Presson & Benassi, 1996; Stefan & David, 2013).

The judgments of control persisted after two blocks and about 15 minutes of experimental task, when the last and final judgment was responded. As each participant was submitted to a same *p*(O) (0.30 or 0.70), under a random but fixed frequency of desired (or undesired) outcomes, one of the hypotheses was that after the second block the illusion would decrease or even disappear and the limit of the paradigm would be achieved. In fact, there was a small interaction between *p*(O) and block that can be noted visually as an approximation to zero in Figure 3.3. In both valences, the intervals of *pJC* in Block 1 are clearly separated in a way that the illusion is negative under *p*(O) = 0.30 and positive under *p*(O) = 0.70; however, in Block 2 the ranges overlap and positioned close to zero, two intervals even cross the null line. There was a non significant tendency of the magnitude of the illusion to be less intense in Block 2. Moreover, the results also indicated that the proportion of null *pJC* was the same between the blocks, either in the productive and in the preventive groups, there was not a significant migration of non-null to null judgments from the first block to the second one.

In Study 2 (Chapter 2), illusions remained after four blocks, the judgments had the same intensity after 200 trials or four blocks, and the conclusion was that the illusion persisted until the end of the task. Yet in that paradigm the *p*(O)s were very different from block to block (*p*(O) = 0.10, 0.30, 0.70 or 0.90, in random order). Blanco, Matute, and Vadillo (2011) found in two experiments that illusions were persistent after 100 trials and they were significantly stronger in their experiment with a longer training phase. After the current experiment, the limit of the current traffic light task was not achieved yet, in the sense that maybe it could not induce illusion after some time and participants would at last get aware of its randomness. Maybe this limit is not much more than the present two blocks of 50 trials under a same probability. One can suppose that the illusion would be annulled through a hypothetical third block under the same probability, this is a suggestion for a future study.

The behavioral measures that reflect the participants' actions when trying to control the task indicated differences and effects that were not found in the previous studies (Chapters 1 and 2). This was clear in the results of *p*(A) and in the response bias *c*. For the first time, participants who judged to have the highest level of control ($pJC \geq 25$, see Figure 3.4) presented different *p*(A), that is, different frequency of pressing, with their actions as if anticipating the control self-response. It is interesting to highlight that productive participants with high illusion emitted more actions (72% of the responses) while the preventive ones emitted less actions

(53%) in a sample that performed similarly to the other studies (63%). The original hypothesis and the idea that people with more illusion would be more active when trying to produce a desired outcome, and would be more "passive" or "missing" when trying to prevent an undesired outcome, was confirmed, at least in the current study.

Such results are also coherent with the interactions found (Figure 3.5). In the interaction between valence and block, the productive participants tended to respond with the highest judgments of control in the sample if they had emitted a higher number of action responses in the first block. In the interaction between *p*(O) and block, participants in general (productive and preventive) under low *p*(O) (the situation of failure) tended to react with a lower number of action responses in the first block and a higher number of actions in the second block, as if they were striving to produce the desired outcome or prevent the undesired one when having a second chance. It is common in literature about illusion of control and sense of agency to find references emphasizing that the higher *p*(A), the more intense the judgement of control, but most studies only had the productive valence (Blanco & Matute, 2015; Blanco et al., 2011; Eitam, Kennedy & Higgins, 2013; Karsh and Eitam, 2015; Matute, 1996). In the present case, it seems that preventive participants were trying to prevent red lights by curbing their actions, as an strategy.

It is worth discussing such block effect. As it was commented, in the self-assessment there was a small effect of the interaction between block and *p*(O). There were also small effects of the interaction between block and the factor for the response *p*(A) and *c*. So in three variables the effect of block was not pure, it depended on the change of *p*(O) to become significant. One could ponder the effect of the block in larger samples or longer experiments, when the judgments and the actions could possibly change in the last block no matter the valence or the probability.

The complementing associative and signal detection measures were also calculated in order to detect differences, response bias or patterns of strategies affected by the factors manipulated to study the illusion. *SI* and all the other sensibility measures indicated null sensibility, as expected and similar to the results of the previous study. All the response bias measures indicated mean bias to action, except for the null bias in β (Table 3.2), the same conclusion than the analysis of *p*(A) and *c*. The model for bias *c* was chosen because the assumptions for the other measures have not been achieved (e.g., normality) and specially because of the lower percentage of errors in the model. An equivalent measure was *RI*, which presented the same results of *c* with inverted signals. The measure Y is in fact a sensibility and bias measure, it varies with p(O), thus it is not adequate to the present case.

It is worth to note that the interaction in bias *c* was numerically more intense (medium) than in *p*(A) and there was also a medium main effect of block: from *c* it is possible to say that there is a tendency to higher probability of actions response in the second block, as it is indicated in the central column of Figure 3.6. On the contrary to *p*(A), there was no significant interaction involving valence and block. So the measures p(A) and c presented similar results but with slight differences, it is worth to include both in IOC studies.

Another behavioral measure related to action responses and that is probably for the first time included in the analysis of illusion of control was reaction time. As expected, there was a significant large decrease in *RT* mean in the second block, the only effect that was found, easy to explain, since participants might get practice through the task. Not only, as there was also an effect of block in response bias of action, one can imagine that proportional to pressing more frequently is pressing faster. There was no difference in *RT* means among the levels of the judgments of control so that it was not possible to detect any increase of *RT* when there was more cognitive activity. Maybe for this reason it is rare to find RT analyses in IOC studies.

Beyond the *RT* mean of the blocks, it is important to use other tools that can detect differences that maybe exist in such an important variable in cognitive studies. For the first time in literature, statistical process control (SPC; Breyfogle III, 2003; Shewhart, 1931) charts were applied in a psychological study, so that the *RT*s from the individual trials could be analyzed as a sequence or process. The charts were built for groups and conditions in order to detect characteristic patterns, and to complement block mean analyses. SPC for *RT* provided interesting and rich findings either about the behavior while trying to control a random situation, and about the use of such technique in the study of sequences of experimental trials.

In all the *X*-bar *S* charts plotted for subgroups of data under different conditions, there was a similar decrease of *RT* during the first trials of the two blocks, and such decrease was visually faster in the second block. As there was no period of previous training, participants began immediately trying to control the light, and actually they needed to adapt themselves, as if they were exploring the task in the first trials of the sequence.

It was possible to identify patterns for each group chart. Groups manifesting illusion of control (high positive *JC*s and negative *JC*s) presented frequent changes around the baseline of *RT* through the sequence of trials, higher number of special causes, and the same variation in chart as a whole (Figures 3.12 and 3.15). The characteristic of the high positive illusion was that the *RT*s tended to stabilize close to the center line (*RT* mean) in the end of both blocks, while in the negative illusion chart the oscillation of the points was continuous till the end of the blocks. As if in the high illusion the participants migrated to a stable and focused scheme of responding, as they believe the traffic light is at least partially controlled, and with more intense cognitive activity, as the *RT* mean is the highest of all (*M* = 700 ms, *SD* = 540 ms), they keep on trying intensively. While in the negative control the participants acted as if there was a kind of control (where the lights would behave against the actions of the participant), and they keep on trying different strategical schemes, still believing that some control is possible.

The null illusion chart (Figure 3.13) presents a stable and continuous decrease of *RT*, with few special causes, probably because the changes are gradual, as if the participants were progressively giving up searching a way to control the lights; both mean and *SD* are the lowest of all (*M* = 660 ms, *SD* = 540 ms) and there is a visible decrease in variation in Block 2. This group apparently gives up of the task, on the contrary of the participants with negative illusion. The low positive illusion chart (Figure 3.14) presents a continuous, stable random variation with no significant change (no special cause) except for the starting adaptation, as if low sense of control is almost null control, a withdrawal that becomes a constant variation profile of attempting.

The charts for productive and preventive groups were very similar, how could it not be, as there were almost no difference between groups under opposed valences in the previous analyses. The charts built for these groups under high *p*(O) (Figures 3.9 and 3.11) presented the greater number of significant changes (special causes) of all charts, and clear oscillations in the middle of the two blocks, plus a typical decrease in *RT* in the second half of the blocks. The charts for both valences under low p(O) presented very few special causes, a random profile of points with stable variation (Figures 3.8 and 3.10). It is interesting how close the means and *SD*s were, in the same valence, independently of *p*(O), but the productive groups had their statistics slightly larger than the preventive groups ($M \approx 680$ ms and *SD* = 580 ms; $M \approx 665$ ms and *SD* = 545 ms).

In the current study the PANAS scale was used to evaluate positive and negative affects, and the specific 20 affects self-assessed by the participants after the last block of the experimental task. The positive affects were measured by the sum of the 10 positive items in PANAS scale. They prevailed over the sum of the 10 negative affects, without significant differences among groups and factors, as represented in Figure 3.16. The mean intensity of the positive affects can be considered moderate, it reached around 25 points in a maximum of 100 theoretical points, corresponding to a mean score of 2.50 out of 5.00 per item; negative affects were small, around 15 in 100 points, a mean score of 1.50, so the negative affects were not despicable. There were very few (two or three) specific affects which score was greater than 3 under high p(O), and just one affect under low p(O) (Tables 3.2 and 3.3). It is not possible to compare these results with other experimental studies in literature, only with the previous Study 2 (Chapter 2), where Brazilian students also presented more positive illusions, but in a much greater number. Spanish students did not score affects as high as Brazilians.

As expected, the affects varied according to the levels of control and were correlated with the self-assessed judgments. Positive illusions were accompanied by positive affects, while intense affects were absent when the illusions were null or negative. Positive affects were usually associated with appetitive motivation were directly correlated with the judgments of control: determined, enthusiastic, inspired, interested, proud. Although not very intense, negative affects that can be associated with failure and boredom were inversely correlated with the judgments: ashamed, upset, irritable, jittery. It would be interesting to explore motivation and traits during IOC tasks in future experiments through the use of other specific scale for such purpose.

CHAPTER 4

STUDY 4 – THE WORST WAY TO REDUCE THE ILLUSION OF CONTROL IS THROUGH EXPERIENCING AN UNNECESSARY ACCIDENT

Illusion of control is an inherent phenomenon to human animals, as demonstrated in more than one hundred studies where it generally presented moderate to strong effect sizes and was affected by situational and psychological factors (Presson & Benassi, 1996; Stefan & David, 2013). Most of the experiments were conducted with samples from the students universe, some from general or clinical populations. The usual task contexts are gambling, decision making, risk taking in games, clinical symptoms, superstition, pseudoscience, learning, motivation, cognitive bias and even maternal responses (Donovan, Leavitt, & Walsh, 2000). However, illusion of control might be highly relevant to understand unsafe behaviors and accidents in the workplace.

Safety Behavior

It is reasonable to expect that the interpretation that workers make about hazards, risks and accidents, also affects workers' safe behaviors. Studies showed that external causal attributions mediated the relationship between work accident experience and unsafe behaviors. On the other hand, workers belonging to companies with stronger safety cultures (e.g., with effective risk assessment, intense safety training and efficient communication) interpret and explain work accident causes with more complex approaches, attributing causes to many internal and external factors. Therefore, causal attributions are not only a matter of individual perception biases, but they are influenced by the organizational context and by the role that safety plays in the company's daily activities (Gonçalves et al., 2008).

About the internal factors that would affect unsafe behaviors, studies on the relationship between accident involvement and the Big Five personality dimensions (extraversion, neuroticism, conscientiousness, agreeableness, and openness), including a meta-analytic review, found that individuals presenting the predictors low conscientiousness and low agreeableness were found to be more liable to be occupationally accident-involved. Different personality dimensions were associated with occupational and non-occupational accidents: in occupational settings, the significant predictors were low agreeableness and neuroticism, while for traffic accidents they were high extroversion, low conscientiousness and low agreeableness. Some studies also pointed to neuroticism as a predictor for occupational accidents (Cellar, Nelson, Yorke, & Bauer, 2001; Clarke & Robertson, 2005; Sümer, Lajunen, & Özkan, 2005).

Another way to investigate internal factors and individual differences in behaviors related to control is through the study of temperament and personality. In order to contribute significantly to safe behavior research, personality measures should encompass learning and motivational components, as both are associated with the acquisition and maintenance of the safety culture and habits.

The Behavioral Approach and the Behavioral Inhibition Systems

A promising personality theory for the study of occupational behavior is the Reinforcement Sensitivity Theory (RST; Gray & McNaughton, 2003). According to RST, the learning of new behaviors and the tendency to approximate or avoid stimuli (i.e., motivation) depends on the activation of specific neuroanatomical systems, according to appetitive or aversive environmental characteristics (Corr, 2010; Gray & McNaughton, 2003; Mcnaughton & Corr, 2008; Mcnaughton & Corr, 2014). The RST includes three systems: the Behavioral Approach System (BAS), the Behavioral Inhibition System (BIS), and the Fight-Flight-Freeze System (FFFS; Gray & McNaughton, 2003). The BIS/BAS Scale is a 20-item self-report questionnaire that was designed to measure the motivation systems, participants respond to each item using a 4-point Likert scale.

BAS would be related to motivational approach behavior and is mediated by the activation of the reward system and the release of dopamine to conditioned and unconditioned positive reinforces. It is divided in the three following components, derived from factor analysis. BAS Drive measures the motivation to follow one's goals through the sum of four items that contribute to this score (e.g., "When I want something I usually go all-out to get it"). BAS Reward Responsiveness measures the sensitivity to pleasant reinforces in the environment, five items contribute to this score (e.g., "It would excite me to win a contest"). BAS Fun Seeking measures the motivation to find novel rewards spontaneously, and four items contribute to this score (e.g., "I crave excitement and new sensations").

BIS would be mediated by the septo-hippocampal region of the brain and is activated in the presence of a conflict between more than one stimulus, independent of the motivational characteristic of such stimuli (i.e., appetitive-appetitive, appetitive-aversive or aversive-aversive). The activation of BIS would generate motivational behaviors of conflict or defensive approach, characterized by an increase in attention to hazard signs and anxiety symptoms (Leue & Beauducel, 2008; Mcnaughton & Corr, 2014). After some reviews of RST, the BIS was divided into two components. One of which is called BIS BIS, that reacts to stimuli related to performance, four items contribute to it. The other is FFFS, that reacts to stimuli with aversive characteristics, it is responsible for fear reaction and produces avoidance responses such as fight or flight, three items contribute to it; however, FFFS has not been validated as an independent factor in some countries. The so-called Gray and McNaughton's revised Reinforcement

Sensitivity Theory (r-RST) is unique among personality models because it is based on neuroscience and experiments in animal learning. It could be more widely used as a strong basic model of temperament and be applied in educational, clinical, work, and other domains (Gray & McNaughton, 2003; Walker, Jackson, & Frost, 2017).

For RST, personality is a reaction pattern of the BIS and BAS systems, divided into two dimensions: reward sensitivity and sensitivity to punishment. The intensity and frequency of BAS activation is the component of reward sensitivity, while the intensity and frequency of activation of BIS and FFFS are therefore the components of sensitivity to punishment. Several psychometric instruments have been created to evaluate the two personality dimensions of RST (Corr, 2016). The predictive capacity of reward sensitivity and sensitivity to punishment in behavioral tasks has already been verified in several experiments (Leue & Beauducel, 2008). Results from previous studies suggest that motivation and conditioning of appetitive stimuli occur more easily in individuals with reward sensitivity, whereas motivation and learning for aversive stimuli occurs more easily for individuals with greater sensitivity to punishment (Corr, Pickering & Gray, 1995; He, Cassaday, Bonardi & Bibby, 2013; Smillie et al, 2006). The term “temperament” is also frequently used to refer to the sensitivity factors of RST and it is related to a biological basis of personality, while the term “character” refers to a socio-cognitive basis (Walker, Jackson, & Frost, 2017; Walther & Hilbert, 2015).

Sensitivity to reward and sensitivity to punishment may influence safety behavior and attitudes toward occupational safety. For example, people with greater reward sensitivity may have appetitive behaviors for productivity tasks and aversion to tasks where hazards are present and failures are imminent. In addition, most work activities are performed for productivity and loss prevention purposes at the same time: the operator must deliver a product that meets the specifications of quality and cost, with low losses and no accidents. However, there is often a conflict between productivity and safety, and the professional has to deal with both goals: would there be a better temperament profile to deal with both goals? Evidence indicates that reward sensitivities and punishment are not orthogonal, and may vary together in the explanation of motivation and learning (Corr, 2016). In this sense, the reactivity of the BAS system to appetitive stimuli, for example, can both potentiate and antagonize FFFS reactivity to aversive stimuli (Corr, 2004).

Illusion of Control, Risk Maturity, and Mining Industry Workers

Mines are extractive industries, a type of enterprise classified as 4 (maximum health and safety risk level) in the *Classificação Nacional de Atividades Econômicas* (*CNAE;* National

Classification of Economic Activities of the Ministry of Labor and Employment of Brazil; Equipe Atlas, 2013, p. 24-25). Surface or underground mining remains one of the most intrinsically hazardous occupations in the world, despite major improvements in this industry safety; human error is almost certainly the most prevalent causal factor of accidents (Simpson & Horberry, 2018). Research on IOC with workers, specially from industrial sites and living far from large cities, are non-existent. There is a need to better understand the ways in which cognitive bias, irrationality and false beliefs can affect risk assessments and decision making at all levels, and operational control or monitoring in organizations (McLeod, 2015). Operators at the front line perceive hazards, assess safety risks, interpret accidents and generate real-time mental awareness of such risks associated with the actions and decisions they are about to take. Studies on IOC may be useful not only to confirm results in traditional sets (experimental laboratories) and populations, as investigated in the previous chapters: anywhere, people exposed to occupational risks could benefit from knowledge about how they try to control a dangerous situation.

It is important to try to identify safety culture attributes that could affect safe behavior and to study differences in the responses of workers from organizations with different levels of *safety risk management maturity*. Audit domain offers methods to classify the maturity of organizational risk management. Over the years, organizations recognized the need to manage risks as an essential part of good corporate governance practice, and became under increasing pressure to identify all the business risks they face and to explain to the board, to society, to the government and to stakeholders how they manage them. The Institute of Internal Auditors (IIA) defines risk based internal auditing (RBIA) as a methodology that links internal auditing to an organization's overall risk management framework, and allows classical internal audit to provide assurance that risk management processes are managing risks effectively (IIA UK and Ireland, 2005). As every organization is different, with a different attitude to risk, different structure, different processes and different language, even experienced internal auditors need to assess the level or stage of maturity of the risk management before conducting an audit. If the risk management framework is not very strong or does not exist, the organization is not ready for RBIA, because it is likely that there are few evidences that risks are efficiently identified, assessed, treated (i.e., controlled and monitored) and that all this processes have become formally documented and communicated to the interested parts.

In order to assess the organization's risk maturity, the audit team keep meetings with the board and senior managers, when the understanding of risk maturity is discussed. Based on documents, information and evidences, the risk maturity is assessed by using the form "Assessing the organization's risk maturity" (see Appendix C) and classified in one out of five stages, in increasing order: risk naïve, risk aware, risk defined, risk managed, and risk enabled. Audits are possible if the organization is classified in any of the first higher stages (IIA UK and Ireland, 2005). The higher the stage, the more mature the organization's risk management is, and probably the stronger the safety culture. Researchers can use the same instrument to classify corporate units according to risk maturity, which would reflect risk culture.

Objectives of the Study

The objective was to analyze the effects of the probability of the outcome and of the probability of the action performed by the participant on the illusion of control, measured by self-assessments (judgments), response bias *c*, and the reaction time in mining workers The study will also search for differences between mining sites, affective states, and motivating systems.

Based on the literature and on the previous Studies 1, 2, and 3, the predictions were that:

- the *p*(O) would affect the judgment of control and the response bias in the SDT c measure, but would not affect the sensitivity; the high *p*(O) would be associated with stronger illusion and lower bias for action;
- *RT* would be higher in low *p*(O), in the last block and in null illusion;
- the SPC charts for *RT* would present more special causes in high *p*(O) and strong illusion;
- strong positive illusions would be associated with lower response bias, positive affects, Behavior Approach System (Reward Responsiveness), and less mature risk culture, personal experience without accidents; young, male, longer career time, leader position workers;
- null and negative illusions would be associated with action bias, positive and negative affects, Behavior Inhibition System, higher risk maturity, personal experience with accidents, workers who execute risky activities at work (operators).

Method

Participants

One hundred and three workers (*n* = 16 or 16% were women), 19-54 years old (*M* = 34.33, *SD* = 7.84) from two gold mining sites in the northeast and west-central regions of Brazil participated as volunteers. This sample size can provide an α_{error} = 0.05 and power > .90 in an Analysis of Variance (ANOVA) with repeated-measures and within-between interaction design to detect small to medium effect sizes, as calculated in G*Power software (version 3.1.9.2); the parameters were based on the results from the previous studies (Chapters 1 to 3).

Apparatus, Instruments and Materials

One notebook computer with one 15-inch screen was installed on tables in meeting and training rooms in the facilities of the two industrial sites. Participants sat one at a time in a chair and wore hearing protectors (ear muffs). As the areas of both sites were very large and work teams were installed far from each other, the apparatus had to be moved to different rooms and buildings one or more times a day. Because some rooms were used for different purposes (e.g., to store office supplies) people sometimes knocked on the door and entered the room, although there was a "do not enter" sign posted outside the door. The task was developed in *E-Prime* for *Windows,* version 2.0.

Some printed forms in Portuguese were available: the consent form (Appendix D); the validated Brazilian version of PANAS scale form (de Carvalho et al., 2013); and the BIS BAS form, which also included questions about religiosity, sense of luck, work experience and accident experience (see Appendices D and E).

Trait-positive affectivity and trait-negative affectivity were measured in the present study with the PANAS scale, and subjects were asked to respond how they felt at the time of the task in a 5-points Likert scale (see Appendix D). The systems and mechanisms of motivation and temperament were measured with the 20-item BIS/BAS Scale, as well as religiosity and sense of luck, using a 4-points Likert scale (see Appendix E), from 1 (*Totally false*) to 4 (*Totally true*). The sums of positive and negative affects, and the sums of BIS and BAS components (i.e., each sum of the items of BAS Drive, BAS Fun Seeking, BAS Reward Responsiveness, BIS BIS, and BIS FFFS) were treated as continuous variables and the 95% CIs of the means are represented in plots. The individual affects (e.g., *active*, *alert*), the 20 items of BIS and BAS scales, religiosity and sense of luck were treated as ordinal variables; their 95% CIs of the medians were calculated for the same reasons and through the same equations than Studies 2 and 3 (see Chapters 2 and 3), or they were automatically plotted in program Minitab.

The instrument "Assessing the organization's risk maturity" by the Institute of Internal Auditors of United Kingdom and Ireland (see Appendix C) was used to classify the two units in one of the five stages (*risk enabled*, *risk managed*, *risk defined*, *risk aware* and *risk naïve*). As risk is a general term and there are many types of risks from different natures, the questionnaire was adapted to safety by substituting the original term "risk" with "safety risk".

The Traffic Light Task

The experimental task was the same traffic light task used in Study 3 (see Chapter 3). It consisted of a sequence of instruction slides displayed on the computer screen, followed by two blocks of 50 trials. The stimulus was the figure of a traffic light for pedestrians. Figure 3.1 represents one trial and the sequence of blocks and measurements. All the participants were allocated to the preventive valence, since the objective was to study the illusion in a safety context and the analyst wanted to increase the statistical power of the experiment. Unlike Study 3, the task started immediately after the instructional screens).

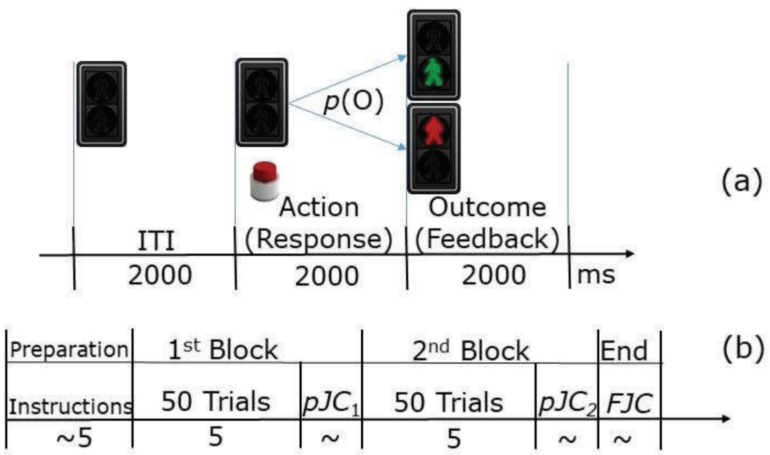

Figure 4.1. Diagram of the sequence of events in each trial of the experiment (a) and the sequence of blocks (b). Above (a, left), the image of the traffic light *off* during the inter-trial interval (ITI); a button appeared and the participant had the opportunity to press (or not) the spacebar on the keyboard in response (center); then one of two images could appear, *walk* (in green color) or *stop* (in red) image (right). Below (b), the sequence of four blocks with 50 trials followed by the self-reported partial judgments of control (pJC_1 and pJC_2), and the final judgment (*FJC*).

A set of written instructions specifying the goal for the participant appeared on the computer screen. The text included a description of a shopping center with two exits (each one corresponding to one of the experimental blocks) with traffic lights that the participant should try to control in the context of a crowded shopping day. As there was only the preventive valence, the red light was described as the undesired outcome that participants should try to prevent, because pedestrians could be struck by crossing during a red light when there is heavy traffic of cars.

Each participant had a sequence of two blocks of 50 trials (see Figure 4.1b) and one out of two probabilities of the outcome (counted as probability of green lights), $p(O) = 0.24$ (12 of 50 trials) or 0.76 (38 of 50 trials) in random order. So the blocks were under a same $p(O)$, depending on the participant. The probability was randomly assigned to the participant.

Each trial was exactly the same as Study 2 (Chapter 2). It consisted of a sequence of three events, as illustrated in Figure 4.1a. Event 1 was the 2-second inter-trial interval (ITI), during which an image of a traffic light that was turned *off* appeared on a white background on the computer screen. Event 2 was the first half of the 2- second trial, during which a picture of a traffic light that was turned *off* accompanied by a red button below and a text box appeared on the white background on the computer screen, stating "You may press the button now" and indicating to the participant the opportunity to perform one of two actions: To press the button by pressing the spacebar on the keyboard immediately; or not to press the button and just wait. The button remained available on the screen for 2 seconds before disappearing. If the participant responded by pressing the button, the pressing of the spacebar was recorded once during Event 2. Event 3 lasted 2 seconds, during which either a picture of a traffic light that was green or red appeared on the white background on the computer screen as the outcome. Note that the duration of the events was different from Study 3 (Chapter 3) because the current experiment included only behavioral measures, there was no psychophysiological measurement.

After each block, participants reported self-judgment of control, responding to the question "What is the influence of your actions on the traffic light in Exit No.# of the shopping center?" Responses were given by clicking with the mouse on a continuous scale, represented as a yellow horizontal bar with inscriptions near the left corner ("The results were totally the opposite of my actions"), to the center ("The results were not influenced by my actions") and to the right ("The results were totally according to my actions"). There was no numerical reference on the screen, but the software registered the response on a scale from -100 (extreme left) to 100 (extreme right). Thus, the partial judgment of control was a repeated measure taken immediately after each block. After the second rating, there was a final judgment of control on the same scale, by responding to the question "What was the influence of your actions on the whole set of traffic lights in the shopping center?"

Procedure

The procedures were registered and approved in *Plataforma Brasil* (number 52037115.0.0000.5334) and in research ethics committee (Appendix H). Before the experimental data collection at the two sites, the questionnaire “Assessing the organization's risk maturity” (Appendix C) was responded by three key safety employees of the gold mining company: the Health, Safety, Environment and Community (HSEC) regional manager (Brazil); and the HSEC local coordinators in Unit 1 (in State of Bahia, Northeast Region of Brazil) and Unit 2 (in State of Goiás, West-Central Region of Brazil). Then, the safety risk maturity was classified for each industrial mining unit.

Participants were recruited by invitation of the local HSEC coordinator, who organized the calendar day by day. One safety technician helped the experimenter to call each participant in his workplace and to introduce them. The workers were invited to participate in an experiment about controlling a safety situation on a computer. After reading and signing the consent form and sitting on the chair inside the room, the participant listened to standardized oral instructions and started the traffic light task individually. The researcher remained inside the room and spent the entire time observing the participants quietly, he positioned himself out of the participant's view and behaved as if he was working on another task, as if he was not observing the session. If he realized something was wrong, he intervened and explained the task again. These cases were registered in the lab-book. As the experimenter noticed that some participants had not understood the task, at some stage of the data collection he changed the procedure and started reading and explaining the on-screen instructions along with the participant, and then, just before the first trial, he walked away and observed. After the experimental task, participants were invited to respond to the PANAS and to the BIS/BAS scales, including questions about religiosity, sense of luck, work experience and accident experience. Sessions lasted about 45 minutes. Data were collected for five working days at each site.

The 15-item questionnaire “Assessing the organization's risk maturity” (Appendix C) was responded using a 5-point Likert scale: 1 (*nothing has been implemented*), 2 (*early implementation, in few areas*), 3 (*in the intermediate state of implementation, on most occasions*), 4 (*in a high degree of implementation, in most areas*), and 5 (*fully implemented in the unit*). The median of the 15 responses to the items was used to classify the safety risk maturity of each unit in one of five levels: 1 (*risk naïve*), 2 (*risk aware*), 3 (*risk defined*), 4 (*risk managed*), and 5 (*risk enabled*).

Data Analysis

The current study was a 2 x 2 x 2 mixed experimental design. The independent variables (IVs) were the mine *unit* (*A* and *B*) and the probability of the outcome (p(O) = .24 and .76), as the between-participants factors; the blocks (the sequence of exits 1 and 2 of the shopping center) was the within-participant factor. The dependent variables (DVs) were the partial and final judgments of control (*pJC*, *FJC*, scale from -100 to +100), the probability of action (p(A), the number of trials in which the participant pressed the spacebar over 50 trials, calculated per block), the reaction time (*RT*), the sensitivity index (SI) and the response bias index (c) from Signal Detection Theory, the scores in the PANAS and BIS/BAS scales.

The analyses were performed using IBM SPSS version 20.0.0, Minitab version 18.1, and Microsoft Excel 2013. Boxplots, interval plots and General Linear Models (GLM) were used to analyze the simultaneous effects of the multiple variables between- and within-participants and to search for differences and interactions. Data were normalized when possible by Box-Cox or Johnson's transformation formulas (Chou, Polansky, & Mason, 1998). The assumptions of homogeneity of variance and sphericity were checked, and the results were adjusted when necessary. Scatterplots, Pearson's and Spearman's correlation tests and simple linear regression analyses were used to represent and measure the relations between variables, according to their levels of measurement (continuous or ordinal). It was important to verify if the groups differed in the levels of p(A) and p(O), if there were reasons to suspect that participants pressed the spacebar if they were more or less frequently rewarded, and if there were different levels of actual contingency (Blanco & Matute, 2015). An alpha level of .05 was used for all statistical tests. Besides ANOVA methods included in the GLM models, confidence intervals (95% CIs) were determined to specify measures and its differences; bootstrapping was used to calculate CIs for repeated measures.

The data analysis of response times included the plotting in the program Minitab of eight statistical process control charts (Shewhart's charts) for *RT* means and standard-deviation (X-bar S charts) by subgroups of participants. The subgroups were divided according to the variables p(O) (0.24 and 0.76), the level of judgment of control (*negative*, corresponding to the interval *JC* = [-100; -6]; *null*, *JC* = [-5; 5], *low positive*, *JC* = [6; 24]; and high positive, *JC* = [25; 100]), and mine unit (*A* and *B*). The charts represented the 100 trials, divided in two sections, corresponding to Blocks 1 and 2; the center line (or mean) and the upper and lower limits of control (corresponding to ± 3 x *SD*) were calculated for each block. Data were submitted to the eight standard tests available in Minitab to detect special causes (outliers and change points) by the different criteria described in the introduction of Chapter 3.

Results

In order to analyze the effects of the probability of the outcome (green lights), of the mining unit, and of the sequence of blocks on the magnitude of illusion of control, General Linear Models were run for each of the following DVs: the self-reported judgments of control, the associative measures *c*, the reaction times, the positive and negative affects (PANAS Scale), the approach and inhibition temperament components (BIS/BAS Scales). The *RT*s for the sequence of trials and subgroups were plotted in statistical process control charts. The differences among subgroups of work experience, accident experience, religiosity and sense of luck were also analyzed.

First of all, the safety risk maturity was classified through the questionnaire "Assessing the organization's risk maturity" (Appendix C) responded by the HSEC regional manager and the two HSEC local coordinators. The safety risk maturity was classified as 3 (*defined*) for Unit 1 and as 4 (*managed*) for Unit 2: the second unit had higher risk maturity, and so its safety culture can be considered as stronger.

Judgments of Control

In this study there was a sequence of 100 trials divided in two blocks under the same probability of the outcome throughout the whole task. When illusion was self-assessed either by the final judgment of control or by the two partial judgments after each block, high p(O)s induced illusion while low p(O)s induced null illusion, see Figure 4.2 (*FJC* = 28, 95% CI [17, 40], $n = 53$ against *FJC* = 4 [-9, 17], $n = 50$; $F(1,99) = 8.15$, $p = .005$, $\eta^2 = .08$, $\eta_p^2 = .08$, $r = .28$) and there was no significant effect of unit (mining site), block, sex or age ($F < 2.62$, $p > .107$).

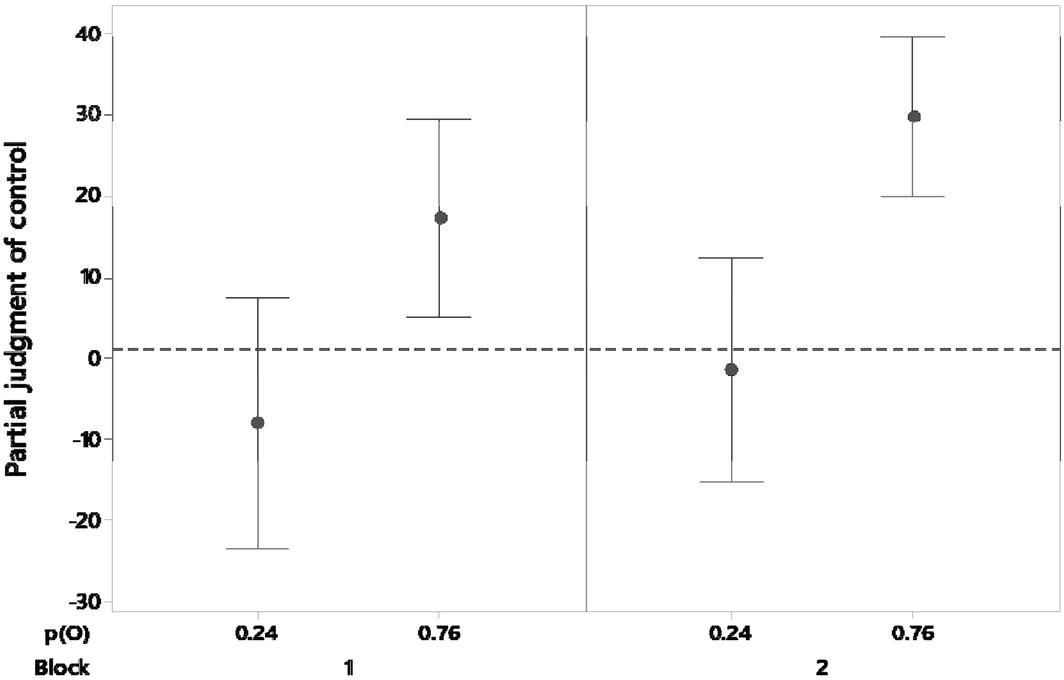

Figure 4.2. Interval plots of the 95% confidence interval of the mean of the partial judgments of control (*pJC*), for low and high probabilities of the outcome (*p*(O)) in the two blocks. The illusion was null in low *p*(O) and positive in high *p*(O in both blocks.

There were large correlations between the partial judgment after Block 1 and the final judgment, and after Block 2 and the final judgment, both correlations had the same intensity ($r(103) = .61$, $p < .001$; $r(103) = .58$, $p < .001$). There was a moderate correlation between the two judgments after each block ($r(103) = .42$, $p < .001$). There was no correlation between age and the judgments of control ($r(103) < .61$, $p > .225$).

Participants who responded that had already suffered *n* severe accidents presented null illusion of control after the last block, under any *p*(O), when compared to those who never had a severe accident (*pJC* = -6, [-23, 12], *n* = 22; *pJC* = 22, [12, 33], *n* = 74; effect of severe accident vs. block was $F(1,91) = 5.52$, $p = .021$, $\eta^2 = .05$, $\eta_p^2 = .06$, $r = .22$; effect of *p*(O) was $F(1,91) = 13.22$, $p < .001$, $\eta^2 = .12$, $\eta_p^2 = .13$, $r = .34$). The result is represented in Figure 4.3. Moreover, there was a significant inverse correlation between the number of accidents and the judgment of control after the last block, and a marginally significant correlation with the final judgment of control ($r(101) = -.28$, $p = .005$; $r(101) = -.18$, $p = .087$). Judgement of control was under no significant effect of gender, unit (mining site), job, scholarity level, year of work, years in company, occurrence of accidents to loved people, or testifying of accidents ($F < 3.30$, $p > .101$).

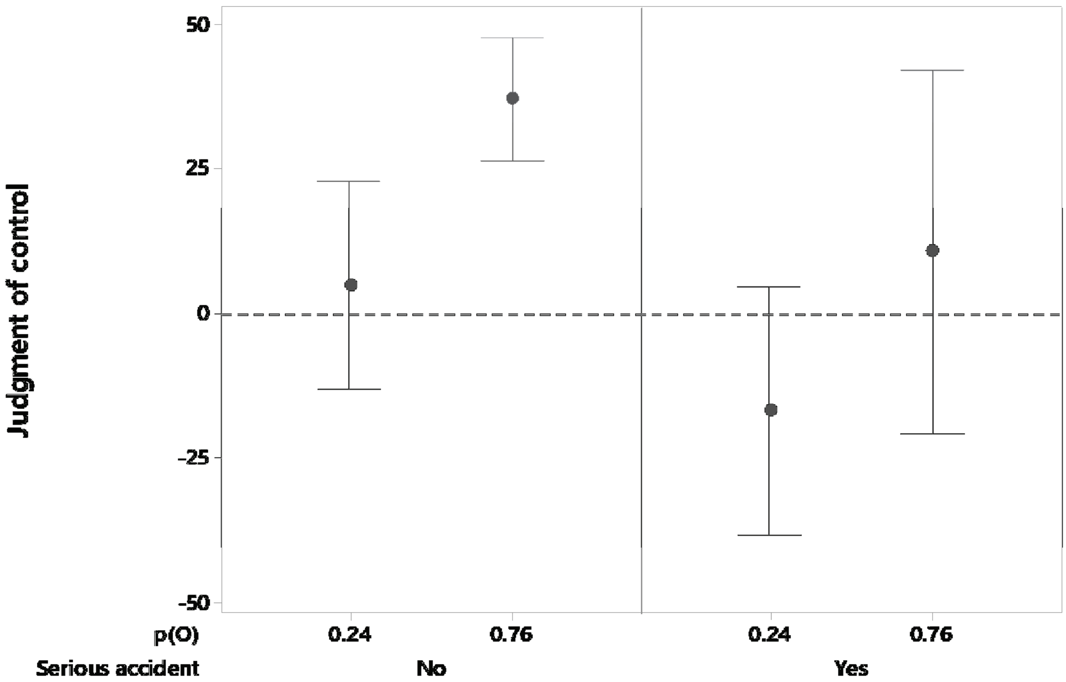

Figure 4.3. Interval plots of the 95% confidence interval of the mean of the partial judgments of control (*pJC*), for low and high probabilities of the outcome (*p*(O)) in the two groups: workers who had suffered no severe accident in life (left) and workers who had suffered one of more severe accidents in life (right). The group that has already experienced an accident develop null illusion under any condition.

After all, miners declared more illusion than most of the other groups that were submitted to experiments of the traffic light task. The proportion of null illusion in miners (Study 4) was significantly lower than all students in Study 2 ($z = 2.19$, $p = .029$, $r = .16$), than the preventive group in Study 2 ($z = 2.60$, $p = .009$, $r = .22$) and than the preventive group in Study 3 ($z = 2.00$, $p = .046$, $r = .17$). The proportion of participants declaring null illusion for each study and group are represented in Table 4.1.

Table 4.1.
Proportion Of Participants Self-Relating Null Judgment Of Control In The Four Studies, Per Valence And Unit

Study	Valence	Unit	*n*	*P*	95% CI
1	Productive	-	40	.28	[.15,.44]
	Preventive	-	41	.24	[.12,.40]
	All	-	81	.26	[.17,.37]
2	Productive		39	.26	[.12,.42]
	Preventive	-	41	.39	[.24,.55]
	All	-	80	.33	[.22,.44]
3	Productive		32	.22	[.09,.40]
	Preventive	-	31	.35	[.19,.55]
	All	-	63	.29	[.18,.41]
4	Preventive	1	50	.20	[.10,.34]
	Preventive	2	53	.17	[.08,.30]
	Preventive	1+2	103	.18	[.11,.27]

Signal Detection Measures

As in the previous Study 3 (Chapter 3), the non parametric bias *c* response indicated differences between groups, blocks and *p*(O): participants of the first mining unit presented more intense bias, specifically in the second block of the experiment, see Figure 4.4. The sensibility and response bias measures for the whole sample are listed in Table 4.2: there was no sensibility as expected; there was some bias indicated by *c*, *B*" and *RI*, and *c* presented the lowest error (18%) in the model.

A GLM for *c* as response and unit, block and *p*(O) as factors produced a small to medium intensity interaction effect of the three factors ($W(1, 92) = 4.75$, $p = 0.029$, $\omega = 0.23$); the main effect of unit was also significant and the interaction between unit and block was marginally significant (respectively, $W(1, 92) = 4.30$, $p = .038$, $\omega = .22$, and $W(1, 92) = 3.74$, $p = .053$, $\omega = .20$). The 95% CIs of SDT *c* measure indicated that there was bias in the subgroups who declared some illusion of control, and nil bias in the case of null illusion (Figure 4.5). The measure *c* also indicated that participants from mining Unit 1 presented bias to action both in negative and positive judgments of control, while participants from Unit 2 only presented bias in positive control.

Table 4.2.
Mean Sensibility And Response Bias Measures In The Traffic Light Task, Including The Error Of The Model

Measure	Mean	95% IC	*SE*	Error (%)
Sensibility				
d'	.00	[-.06, .06]	.03	40
A'	.46	[.43, .50]	.02	40
Ad'	.50	[.48, .52]	.01	40
α	.00	[-.03, .02]	.01	40
SI	.00	[-.02, .03]	.01	40
Response bias				
β	.99	[.96, 1.01]	.01	31
c	-.25	[-.32, -,18]	.04	18
B"	-.04	[-.05, -.02]	.01	35
RI	.18	[.13, 24]	.03	19
Y	.52	[.47, .56]	.02	17

Note: Sensibility was null in all measures and the errors were equivalent. Most response bias measures indicated bias for action response, and the models for *c*, *RI* and *Y* had lower percentage or the error.

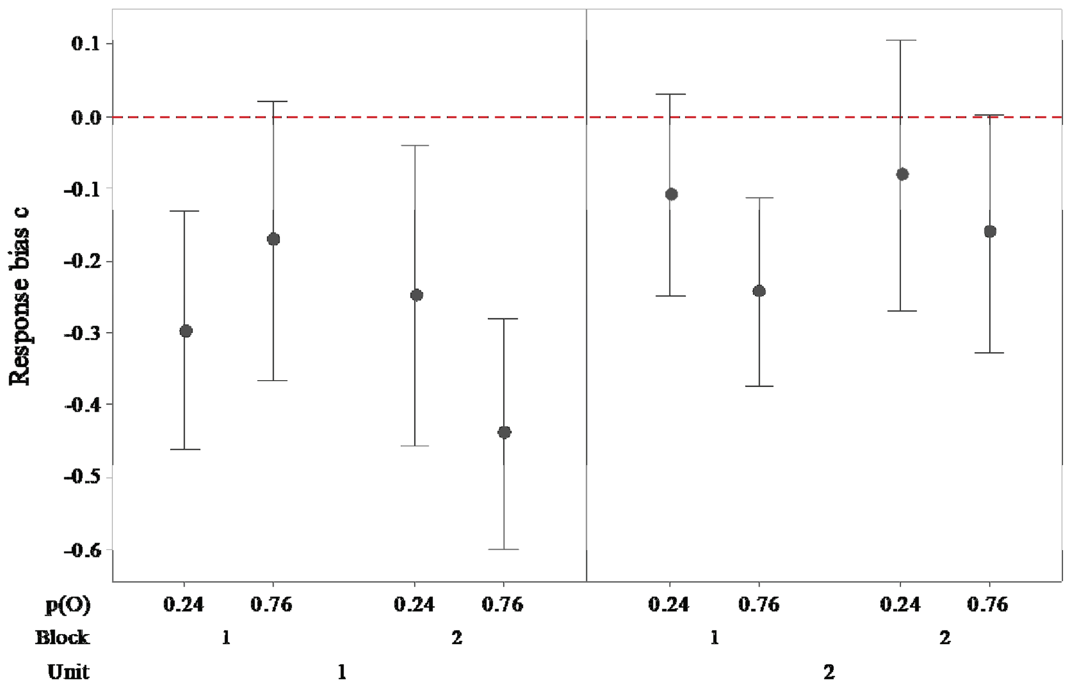

Figure 4.4. Interval plots of the 95% confidence interval of the mean of the response bias *c* measure, for low and high probabilities of the outcome (p(O)) in the two blocks and in the two

mining units. Participants from Unit 1 presented negative bias (to action) while participants from Unit 2 presented null bias, in almost all conditions.

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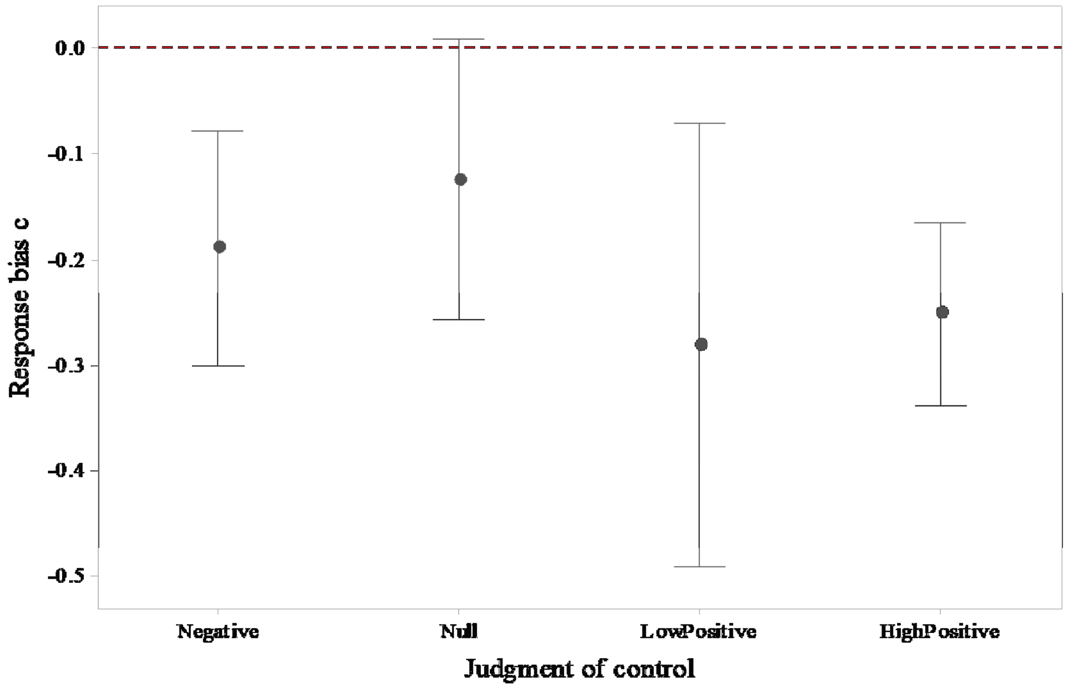

Figure 4.5. Interval plots of the 95% confidence interval of the mean of the response bias *c* measure, for the levels of judgment of control. Participants presented negative bias (bias to action response) except for participants who self-reported null illusion, who presented null or small bias.

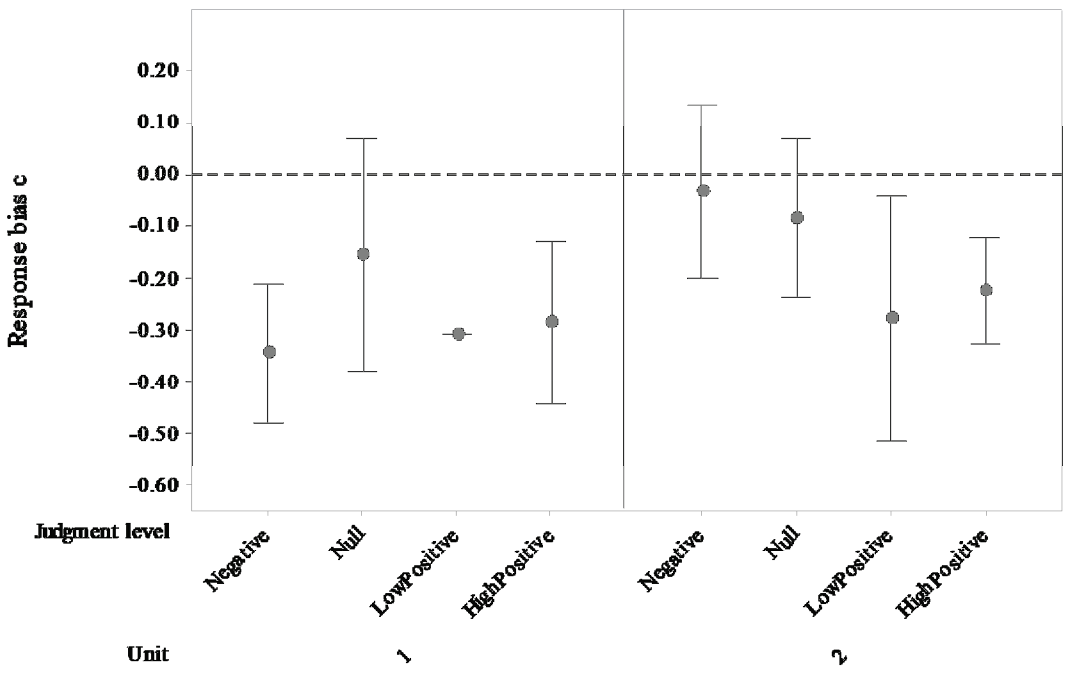

Figure 4.6. Interval plots of the 95% confidence interval of the mean of the response bias *c* measure, for the two mining units and four levels of control. Participants from Unit 1 presented more bias when self-reported control.

Reaction Time

A GLM for *RT* including all 100 trials with sex, *p*(O), and block as factors, and age as covariate, resulted that there were significant main effects only of block and age, and an interaction between site and block ($W(1,102) = 19.61, p < .001$, ω = .44, medium to large effect; $W(1,102) = 5.50, p = .019$, ω = .23, small to medium effect; $W(1,102) = 16.29, p < .001$, ω = .40, medium to large effect). In Unit 1, reaction time mean decreased from the first to the second block (from *RT* = 986, 95% CI [963, 1009] to *RT* = 844, 95% CI [824, 865]). In Unit 2 there was no difference in *RT* from one block to the other (*RT* = 930, 95% CI [911, 950] to *RT* = 925, 95% CI [903, 946]); such mean was lower than the *RT* in the first block and greater than *RT* in the second block of Unit 1, and it was the same as the global *RT* mean in Unit 1 (see Figure 4.7). There were no differences or significant effects of sex, *p*(O) or interactions ($W(1,102) < 0.99, p > .319$ in main effects).

A GLM for *RT* including all 100 trials and the final and partial levels of the judgment of control as factors indicated no significant difference in *RT* among the different levels judgment ($W(1,102) < 1.39$, $p > .709$). In the same way, there was no correlation between *RT* and the raw values of final and partial judgments of control ($|r(101)| < .07$, $p > .310$).

A GLM for *RT* with the factors scholarity (*elementary* or *middle school*, *high school*, or *higher education*), type of job (*administrative*, *operational*, or *technical job*), "participant had already suffered severe accident" (*yes* or *no*), "loved people had suffered accidents" (*yes* or *no*), and "participant had witnessed severe accident" (*yes* or *no*) resulted in significant main effects of type of job, scholarity, and loved people had suffered accidents ($W(2,93) = 14.97$, $p < .001$, $\omega = .40$, medium to large effect; $W(2,93) = 3.76$, $p = .008$, $\omega = .20$, small effect; $W(1,93) = 18.44$, $p < .001$, $\omega = .44$, medium to large effect). Figure 4.7 represents the *RT* 95% confidence intervals for each subgroup in which differences were found. Participants with higher education, administrative jobs and who had close people who suffered severe accidents presented faster *RT*s. The only difference between participants who had and had not loved people who suffered severe accidents was $p(O)$: by chance, the first subgroup was exposed to higher $p(O)$s ($\chi^2(1, 97) = 6.53$, $p = .011$, $r = .26$, intermediate effect); however, there was no effect of $p(O)$ on *RT*.

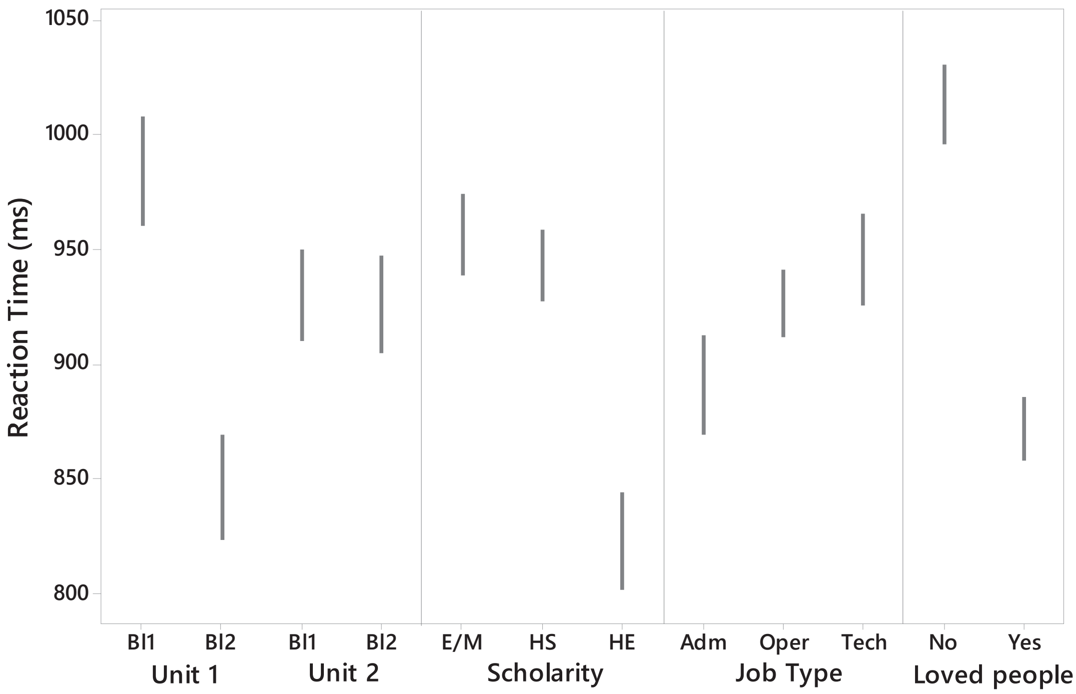

Figure 4.7. Interval plots of the 95% confidence interval of the mean of reaction time (*RT*), for both units (mining sites), levels of scholarity, job type and loved people. Participants from Unit 1 presented great difference between site units; there was low *RT* in Higher Education and in participants whose loved people suffered severe accidents. Bl1 = Block 1; Bl2 = Block 2; E/M = Elementary and Middle School; HS = High School; HE = Higher Education; Adm = Administrative; Oper = Operational; Tech = Technological.

Reaction time from each of the 100 trials were represented in *X*-bar *S* statistical control charts and submitted to eight different tests to detect outliers, special causes and change points. The charts for the subgroups of *p*(O) and level of the judgment of control are represented in Figures 4.8 to 4.15.

The Low *p*(O) group SPC chart presented an almost random and stable pattern of variation. The group of participants nested under *p*(O) = .24 (who usually corresponds to null judgments in illusion of control studies) have their SPC chart represented in Figure 4.8. There were fast decreases of *RT* in the beginning of the two experimental blocks, indicated by Tests number 1, 5 and 6 in Block 1, in the sample mean chart. The chart had almost a random pattern, except for just one special cause of number 5 in the first block, indicating an oscillation of *RT* around the center line (sample mean).

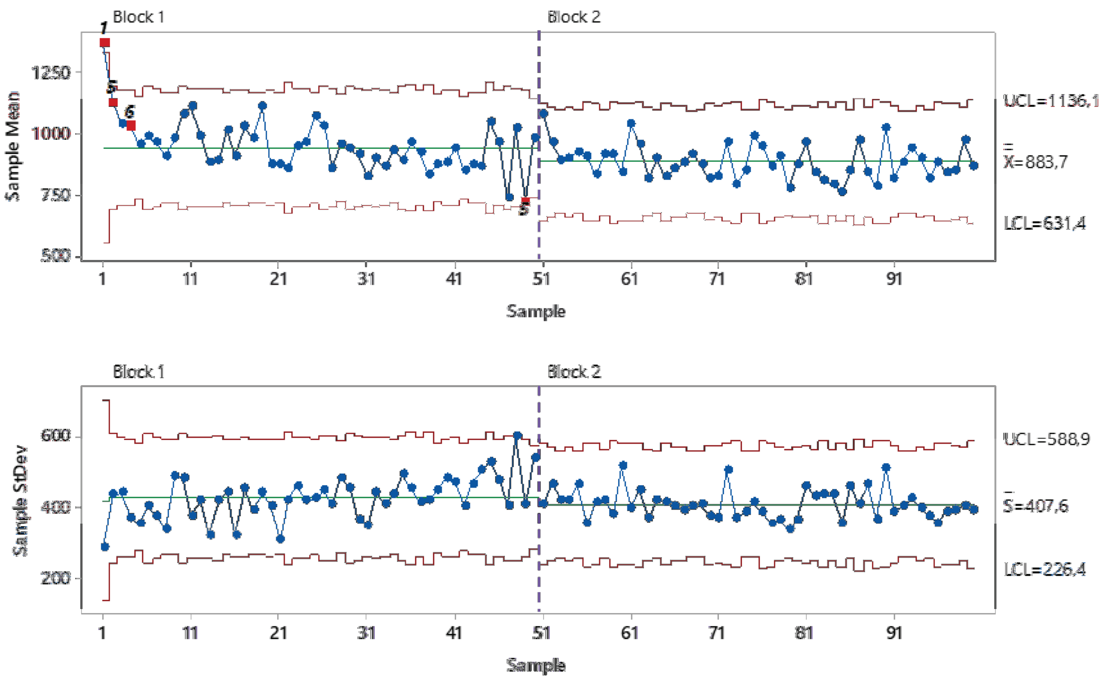

Figure 4.8. Statistical process control chart for response time in the group with low probability of the outcome (*p*(O) = .24)). $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

The High *p*(O) group SPC chart presented a permanent pattern of fast *RT* in the second half of both blocks. The group of participants nested under high *p*(O) = .76 (which usually corresponds to people who declare positive judgments of control in illusion studies) have their

SPC chart represented in Figure 4.9. There was a fast decrease of *RT* in the beginning of Block 1, indicated by Tests numbers 1 and 5, immediately followed by some stabilization of the *RT* in the next first trials, indicated by tests numbers 2. Then *RT* mean kept on close to the sample mean till the middle of the block, and in the end of the block a sequence of special causes of Type number 2 indicate that *RT* mean decreased and stabilized under the center line. In Block 2, the decrease in *RT* in the first trials was faster, indicated by Test number 1, and the *RT* variated randomly in the first half of the block; special causes number 2 and 6 in the second half also indicate a decrease and stabilization of *RT* in the sample mean chart .

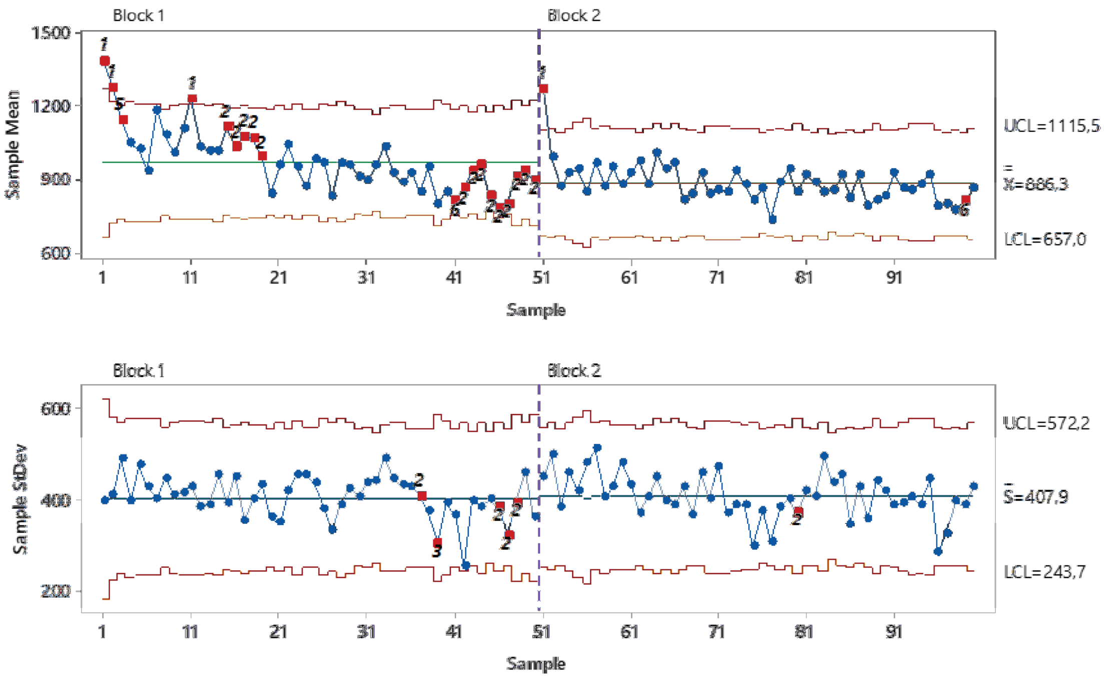

Figure 4.9. Statistical process control chart for response time in the group with high probability of the outcome (p(O) = .76)). $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

The Negative Illusion SPC chart presented a decrease of *RT* for some time and ended up with oscillating variation. The group of participants who responded with negative illusion (i.e., judgment of control from -100 to -5 in the scale from -100 to 100; see Figure 4.10) presented a fast decrease of *RT* in the beginning of both blocks, indicated by Tests numbers 1 and 5 in Block 1, in the sample mean chart. There was a decrease and stabilization of *RT* in the middle of the blocks, indicated by sequences of special causes numbers 6 and 2. After the stabilization period, *RTs* increased locally and performed a greater and random variation.

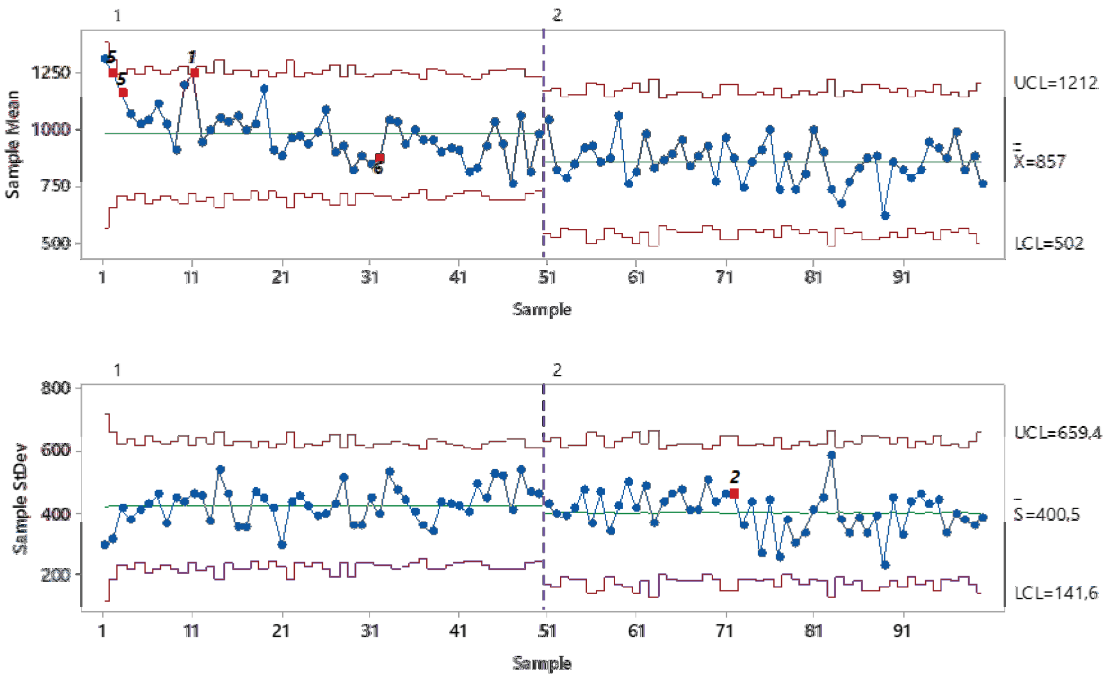

Figure 4.10. Statistical process control chart for response time in the group with negative illusion of control. $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

The Null Illusion SPC chart presented stabilization of *SD* in both blocks, an stabilization of variation. The group of participants who responded with null illusion (i.e., judgment of control from -5 to 5 in the scale from -100 to 100; see Figure 4.11) presented a fast decrease of *RT* in the beginning of both blocks, indicated by Test number 5 in Block 2 of the sample mean chart. There was a decrease and stabilization of *RT* in the middle of the first block, indicated by sequences of special causes number 2 in the *SD* chart, and the same test indicated an earlier stabilization in the second block. In the end of the chart there was a temporary decrease of *RT* mean, indicated by test number 6.

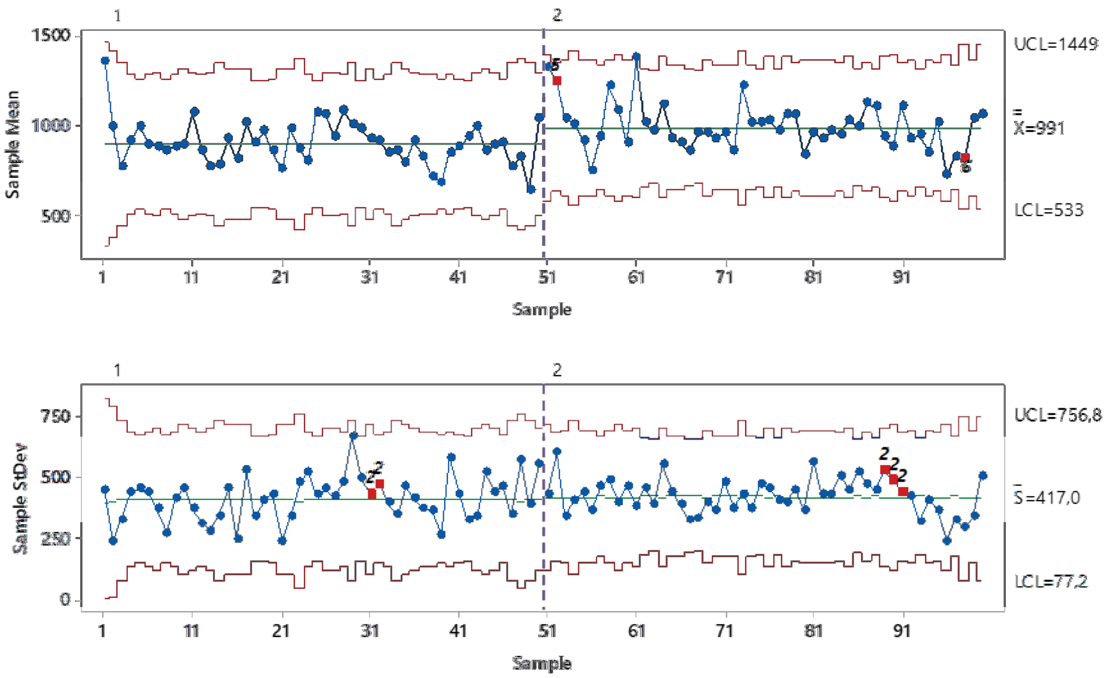

Figure 4.11. Statistical process control chart for response time in the group with null illusion of control. $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

The Low Positive Illusion SPC chart presented a random pattern and a strong minimization of variation of *RT* in the second block. The group of participants who responded with low positive illusion (i.e., judgment of control from 6 to 24, see Figure 4.12), presented a great decrease in the *SD* of *RT*, although the mean did not change, especially in the end of the second block, indicated by test number 6.

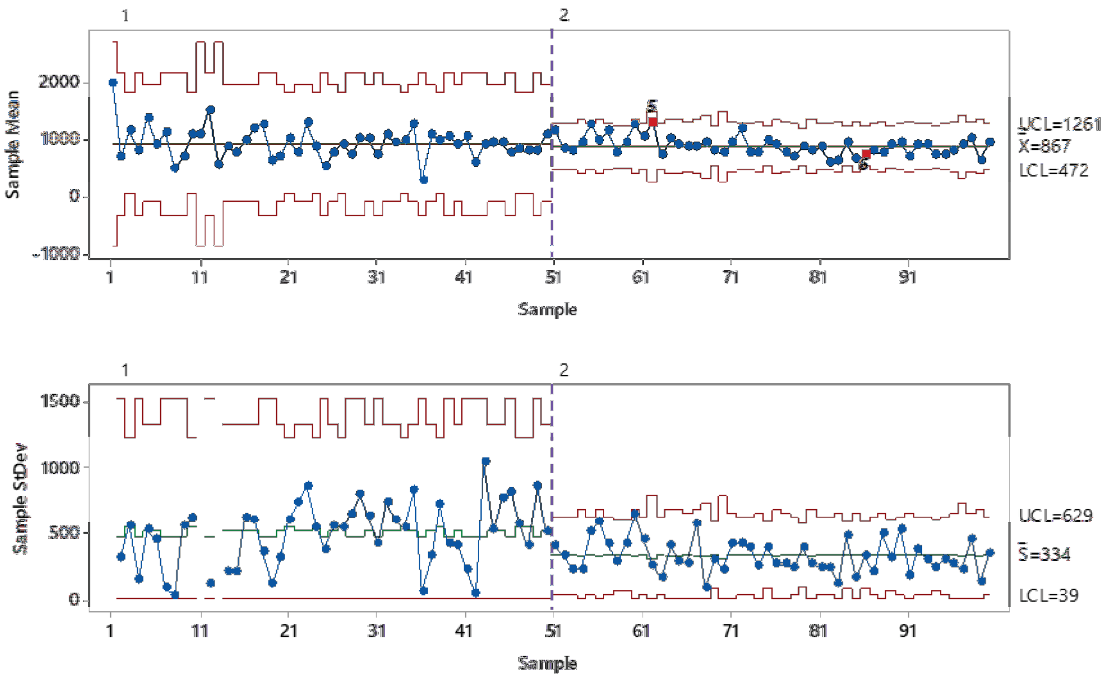

Figure 4.12. Statistical process control chart for response time in the group with low positive illusion of control. $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

The High Positive Illusion SPC chart presented a decrease of *RT* for some time and ended up with higher *RT* close to the mean. The group of participants who responded with high positive illusion (i.e., judgment of control from 25 to 100, see Figure 4.13) presented a fast decrease of *RT* in the beginning of both blocks, indicated by tests numbers 1 and 6 in Block 1, and Test number 1 in Block 2, in the sample mean chart. There was a decrease and stabilization of *RT* in the middle of the first block, indicated by seven special causes number 2, and it happened earlier in the second block, indicated by four special cause number 7, as oscillation of *RT* around the mean but less than one *SD* far from the center line. Such stabilization occurred in the end of the first block, and in the first half of the second block. *RTs* oscillated randomly around the mean till the end of the chart.

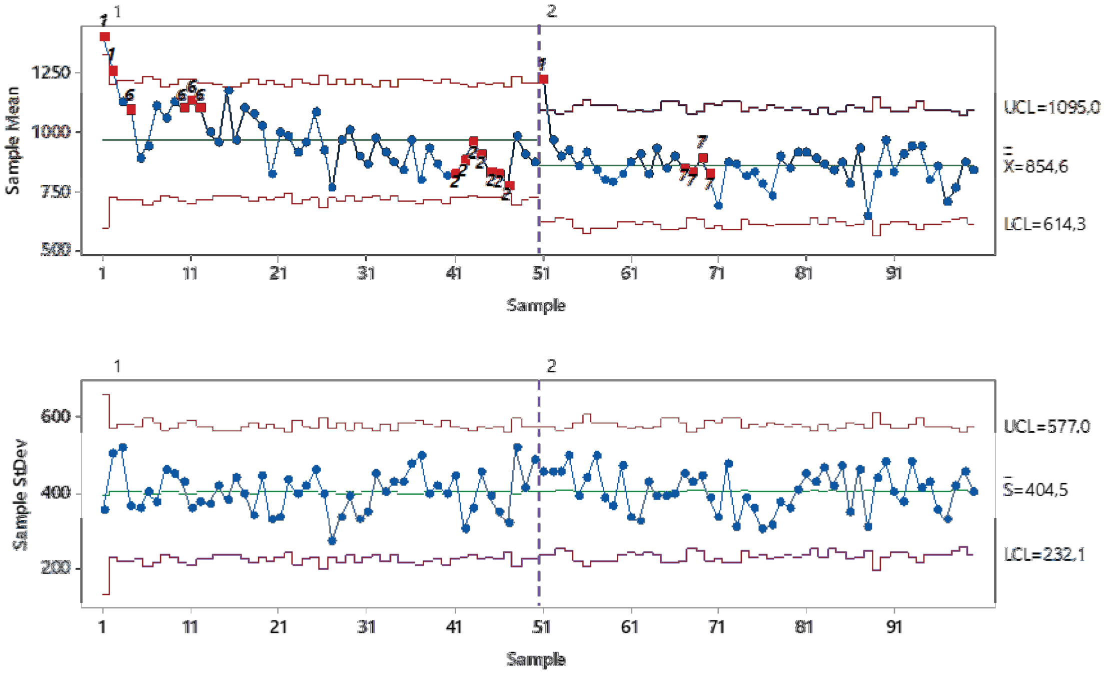

Figure 4.13. Statistical process control chart for response time in the group with high positive illusion of control. $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

As there was an interaction of mining site and block in the analysis of *RT* means, it is important to visualize the sequence of measures represented in the charts for both sites in Figures 4.14 and 4.15. The Unit 1 SPC chart presented a slow decrease of *RT* in the first trials, because not only special causes 1 and 6 are present, but also two points number 5. There was a decrease and stabilization of *RT* in the end of the first block, indicated by five special causes of number 2, and one number of number 6. Block 2 presented a stable and random pattern of *RT* and a clear decrease of the mean (center line). If one compares this sample mean and sample *SD* chart, it seems to have a mixed patter: the first block resembles the high *p*(O) or the high positive illusion chart, while the second block resembles the low *p*(O) or the negative illusion chart. The Unit 2 SPC chart has a different profile: its first block also resembles the high *p*(O) and the high illusion charts, and its second block also resembles the high *p*(O) chart, similarly to a group under positive illusion of control.

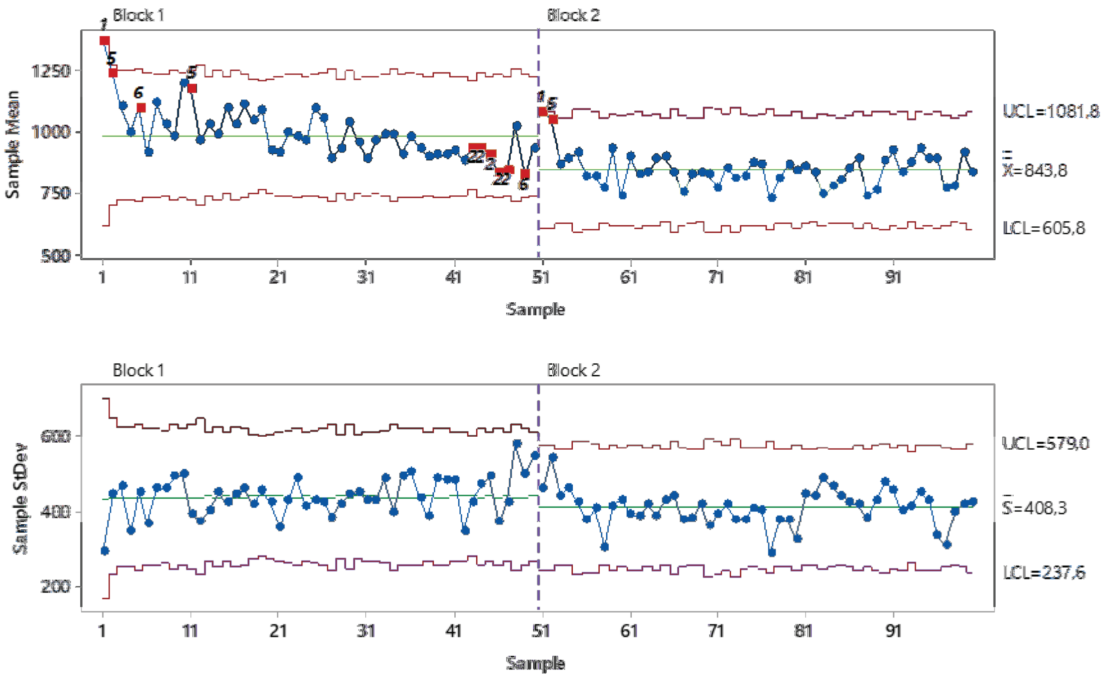

Figure 4.14. Statistical process control chart for response time in Unit 1. $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

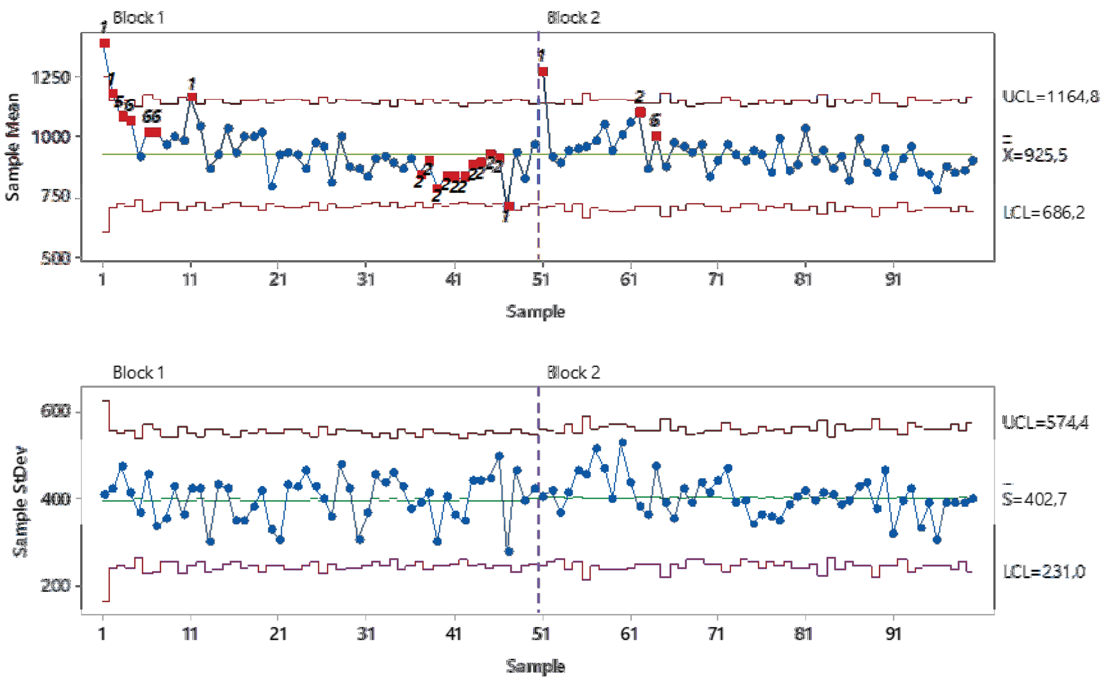

Figure 4.15. Statistical process control chart for response time in Unit 2. $\bar{\bar{X}}$ = mean of the means of the groups; $\bar{S}$ = mean standard deviation of the groups; UCL = upper control limit; LCL = lower control limit.

PANAS Scale

The sum of positive affects measured in PANAS scale prevailed over the sum negative affects in the results (t = 17.67, p < .001, d = 2.61, r = .79; M = 31, 95% CI [30, 32.]; M = 16, 95% CI [15, 17]). There was no difference between sites or p(O)s, job or educational attainment, see Figure 4.16 (W(1,101) < .33, p > .566). A GLM for the response sum of negative affects and the factors sex, age, p(O) and site produced a marginally significant small to medium effect of sex, men tended to declare more negative affects (specifically, *jittery* and *guilty*) than women (W(1,101) = 3.82, p = .051, omega = .19; M = 16., 95% CI [15, 17]; M = 14, 95% CI [11, 15]).

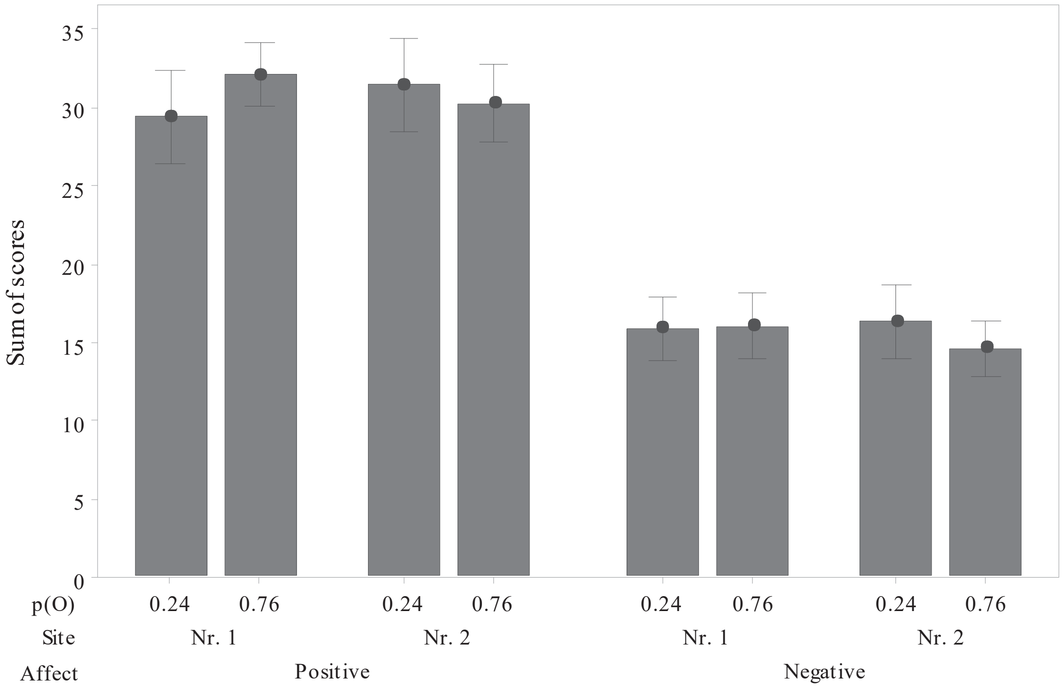

Figure 4.16. Bar graphs of the sum of scores of positive and negative affects in PANAS scale by unit (site) and probability of the outcome. Positive affects were in moderate intensity and negative affects were in little intensity.

One ANOVAs for the sum of positive affects and another one for the sum of negative affects resulted in significant differences according to the level of the judgment of control: participants with high positive judgment of control presented more intense positive affects, while null judgments are associated with more intense negative affects, see Figure 4.17 (F(3, 97) = 3.09, p = .031, η^2 = .09, η_p^2 = .09, r = .30; F(3, 97) = 4.00, p = .010, η_p^2 = .11, η_p^2 = .11, r = .33). There was a small correlation between the sum of positive affects and *FJC*, and there was a marginally significant small inverse correlation between the sum of negative affects and |*FJC*| (*r*(101) = 0.29, *p* = 0.004; *r*(101) = -0.19, *p* = 0.064).

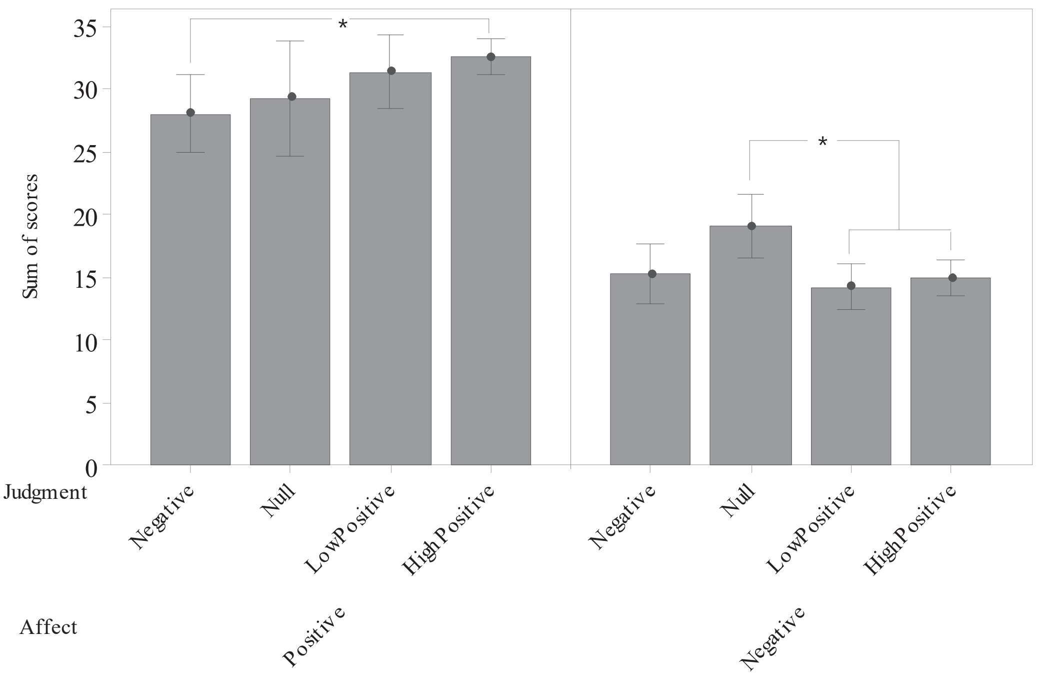

Figure 4.17. Bar graphs of the sum of scores of positive and negative affects in PANAS scale by affect and level of judgment of control. Positive affects were higher in the group who self-related high positive judgment of control. Negative affects were higher in the group who self-related null judgment.

Many positive affects (i.e., active, alert, attentive, determined, inspired, interested, strong) were intense (score 3 or more in a 5-points scale) associated with low and high positive illusions, the only difference was enthusiastic which was present in high positive illusion participants; no negative affects appeared, see Table 4.3.

Some positive affects were moderately correlated to the raw scores of the final judgment of control, while some negative affects were inversely correlated to the judgments of control. There were direct correlations between the final judgment of control and positive affects: active, enthusiastic, inspired, strong (respectively, *r*(101) = .23, *p* = .017), *r*(101) = .31, *p* = .001, *r*(101) = .21, *p* = .037, *r*(101) = .21, *p* = .034).

There were marginally significant correlations between the final judgment of control and the affects alert, attentive, determined, and nervous (*r*(101) = .19, *p* = .058; *r*(101) = .18, *p* = .067; *r*(101) = .18, *p* = .062; *r*(101) = -.17, *p* = .082).

Table 4.3
Medians And Respective 95% Confidence Intervals Of The 20 Affects From PANAS Scale, By Probability Of The Outcome.

	0.24			0.76		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	50	4	[3,4]	52	4	[3,4]
Alert	50	4	[4,4]	52	4	[4,4]
Attentive	50	4	[4,5]	52	4	[3,4]
Determined	50	4	[4,5]	52	4	[4,4]
Enthusiastic	50	3	[3,4]	52	3	[3,4]
Excited	50	1	[1,2]	52	2	[2,3]
Inspired	50	4	[3,4]	52	3	[3,4]
Interested	50	4	[4,5]	52	4	[4,4]
Strong	50	4	[3,4]	52	3	[3,4]
Afraid	50	1	[1,1]	52	1	[1,1]
Ashamed	50	1	[1,2]	52	1	[1,2]
Distressed	50	1	[1,2]	52	1	[1,2]
Guilty	50	1	[1,1]	52	1	[1,1]
Hostile	50	2	[1,2]	52	1	[1,2]
Irritable	50	1	[1,1]	52	1	[1,1]
Jittery	50	1	[1,2]	52	2	[1,2]
Nervous	50	1	[1,2]	52	2	[1,2]
Scared	50	1	[1,1]	52	1	[1,1]
Upset	50	1	[1,1]	52	1	[1,1]
Proud	50	2	[1,3]	52	3	[2,3]

Table 4.4
Medians and respective 95% confidence intervals of the 20 affects from PANAS scale, by level of the judgment of control.

	Negative illusion			Null illusion		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	22	3	[3,4]	19	3	[2,4]
Alert	22	3	[3,5]	19	4	[3,5]
Attentive	22	4	[2,4]	19	3	[3,5]
Determined	22	4	[2,5]	19	4	[3,5]
Enthusiastic	22	3	[2,4]	19	3	[2,4]
Excited	22	1	[1,2]	19	2	[1,3]
Inspired	22	3	[2,4]	19	3	[1,4]
Interested	22	4	[3,4]	19	4	[3,5]
Strong	22	3	[2,4]	19	3	[2,4]
Afraid	22	1	[1,2]	19	2	[1,3]
Ashamed	22	1	[1,2]	19	2	[1,2]
Distressed	22	1	[1,2]	19	2	[1,3]
Guilty	22	1	[1,1]	19	1	[1,2]
Hostile	22	1	[1,2]	19	2	[1,2]
Irritable	22	1	[1,1]	19	1	[1,2]
Jittery	22	1	[1,2]	19	2	[1,3]
Nervous	22	1	[1,2]	19	2	[2,3]
Scared	22	1	[1,1]	19	2	[1,2]
Upset	22	1	[1,1]	19	1	[1,2]
Proud	22	3	[1,4]	19	3	[1,3]

Table 4.5
Medians And Respective 95% Confidence Intervals Of The 20 Affects From PANAS Scale, By Level Of The Judgment Of Control.

	Low positive illusion			High positive illusion		
Affect	*n*	*Md*	95% CI	*n*	*Md*	95% CI
Active	15	4	[3,4]	47	4	[3,4]
Alert	15	4	[3,5]	46	4	[4,4]
Attentive	15	3	[3,5]	46	4	[4,4]
Determined	15	4	[4,5]	47	4	[4,4]
Enthusiastic	15	3	[2,4]	46	4	[3,4]
Excited	15	2	[1,3]	46	2	[1,3]
Inspired	15	4	[3,4]	46	4	[3,4]
Interested	15	4	[4,5]	46	4	[4,5]
Strong	15	4	[3,4]	46	4	[3,4]
Afraid	15	1	[1,2]	46	1	[1,1]
Ashamed	15	2	[1,2]	46	1	[1,2]
Distressed	15	1	[1,2]	46	1	[1,1]
Guilty	15	1	[1,2]	46	1	[1,1]
Hostile	15	1	[1,2]	46	2	[1,2]
Irritable	15	1	[1,1]	46	1	[1,1]
Jittery	15	1	[1,2]	46	1	[1,2]
Nervous	15	1	[1,2]	46	1	[1,2]
Scared	15	1	[1,1]	46	1	[1,2]
Upset	15	1	[1,1]	47	1	[1,1]
Proud	15	2	[1,3]	46	2	[1,3]

The affects were also correlated to some of the miners' characteristics related to work experience. There were inverse correlations between scholarity and the positive affects (attentive and inspired; $r(101) = -.33$, $p = .001$; $r(101) = -.22$, $p = .027$). There were inverse correlations between years in company and the positive affects active, and determined); and direct correlations with two negative affects, afraid and scared ($r(101) = -.21$, $p = .036$; $r(101) = -.29$, $p = .003$); $r(101) = .23$, $p = .023$; $r(101) = .22$, $p = .027$).

The affects were also compared to the miners' occupational safety experience. One GLM for the sum of negative affect as response and the factors "I have already suffered *n* severe accidents in my life", "I have already had loved people who suffered *n* severe accidents", and "I have already witnessed, seen, or watched *n* severe accidents in my life" produced a significant small to medium effect of "I have already suffered *n* severe accidents in my life" ($W(1,93) = 6.30$, $p = .012$, *omega* = .26). So ANOVA, Tukey and Bonferroni methods indicated that those who had suffered severe accidents presented higher sum of negative affects than those who had not, although the CIs were slightly overlapped (*M* = 19, 95% CI [15; 21], *n* = 22; *M* = 15, 95% CI [14; 16], *n* = 72). The response sum of positive affects was not affect by the workers' experience with own or other's accidents (*W(1,93)* < 1.16, *p* > .281).

Behavioral Inhibition System (BIS) and Behavioral Activation System (BAS)

There were great differences between the motivation systems and its mechanisms. The main mechanism of motivation was under control of the approach system (BAS), the reward responsiveness factor; the factors BIS BIS and BIS FFFS, under the inhibition system, were sequentially the factors with the greatest intensities in the sample; the lowest intensities were in factors BAS Drive and BAS Fun Seeking ($F(4, 399) = 142.40$, $p < .001$, $\eta^2 = .52$, $\eta_p^2 = .59$, $r = 0.72$). The results of the factors from the BIS/BAS scales are represented in Table 4.5. The factors are calculated by the sums of 4-points items; depending on the factor, the end of scale is 16 points, except for BAS Reward Responsivity (20 points) and BIS FFFS (12 points). Comparing the inhibition and the approach systems as a whole and relatively to the end of the scales, the proportion of BIS presented a little more intensity than BAS ($F(1, 96) = 15.89$, $p < .001$, $\eta = .08$, $\eta_p = .14$, $r = 0.29$; $M = 0.77$, 95% CI [0.75, 0.79]; $M = 0.71$, 95% CI [0.70, 0.73]).

Table 4.5
Medians Of The Raw Values And Relative Means Of The BAS And BIS Factors For The Whole Sample

Factor	*n*	*Md*	*Md* 95% CI	EOS	$\bar{X}$	$\bar{X}$ 95% CI
BAS Drive	98	9.89	[9.44, 10.33]	16	.59	[.55, .62]
BAS Fun Seeking	101	8.88	[8.47, 9.29]	16	.54	[.52, .57]
BAS Reward Responsiveness	102	18.25	[17.94, 18.57]	20	.90	[.88, .93]**
BIS BIS	102	12.89	[12.51, 13.27]	16	.80	[.77, .83]**
BIS FFFS	102	8.77	[8.45, 9.10]	12	.72	[.69, .75]**

Note: EOS = End Of Scale (maximum punctuation for each factor); $\bar{X}$ is the mean of the relative punctuation to the EOS (*X*/EOS). ** = significant difference ($p < .001$)

A GLM of BAS Drive with the demographic variables as factors (sex, age, site, *p*(O), job type, and scholarity level produced a significant intermediate main effect of age: there was an inverse correlation between age and drive ($F(1, 89) = 5.73$, $p = .019$, $\eta^2 = .06$, $\eta_p^2 = .06$, $r = -0.24$).

A GLM of BAS Reward Responsivity with the demographic variables as factors (sex, age, site, *p*(O), job type, and scholarity level produced a significant intermediate main effect of scholarity ($F(2, 92) = 4.77$, $p = 0.011$, $\eta^2 = .09$, $\eta_p^2 = .09$, $r = .29$); the participants with lower scholarity level (*elementary* or *middle school*) presented higher behavioral approach by reward responsivity than the ones with intermediate level (*high school*; $M = 18.94$, 95% CI [18.41, 19.46], $n = 32$; $M = 17.67$, 95% CI [17.25, 18.10], $n = 49$).

The GLM of BIS BIS with the same factors resulted in a small to intermediate effect of p(O) ($F(2, 92) = 5.47$, $p = .022$, $\eta^2 = .05$, $\eta_p^2 = .05$, $r = .23$); the participants under lower probability of the outcome presented a little higher inhibition ($M = 13.4$, 95% CI [12.9, 13.9], $n = 49$; $M = 12.4$, 95% CI [11.9, 12.9], $n = 53$).

The third motivational factor in intensity was BIS FFFS, related to feelings of fear and to be alert, which GLM with demographics and p(O) produced significant effects of sex: women tended to declare higher fear to unpleasant outcomes ($F(1, 92) = 4.42$, $p = .038$, $\eta^2 = .04$, $\eta_p^2 = .05$, $r = .21$). There was an interaction between having or not witnessed one or more accidents and having or not loved people who suffered accidents, illustrated in Figure 4.18: participants who witnessed and did not have loved people involved in accidents presented higher BIS FFFS than those who declared having not witnessed any accident in life; such difference was not present among the subsample of participants who had loved people victims of accidents, and presented intermediate BIS FFFS ($F(1, 88) = 4.62$, $p = .034$, $\eta^2 = 0.05$, $\eta_p^2 = .05$, $r = .25$). BIS FFFS was also affected by the covariate reaction time, higher *RT* corresponded to higher fear ($F(1, 77) = 3.99$, $p = 0.049$, $\eta = 0.04$, $\eta_p = 0.05$, $r = 0.19$).

There was a small inverse correlation between *RT* and behavior approach by drive (*BAS Drive*; $r(95) = -.26$, $p = .011$). There was also a small direct correlation between *RT* and behavior impulsivity by fear (*BIS FFFS*; $r(99) = .21$, $p = .032$).

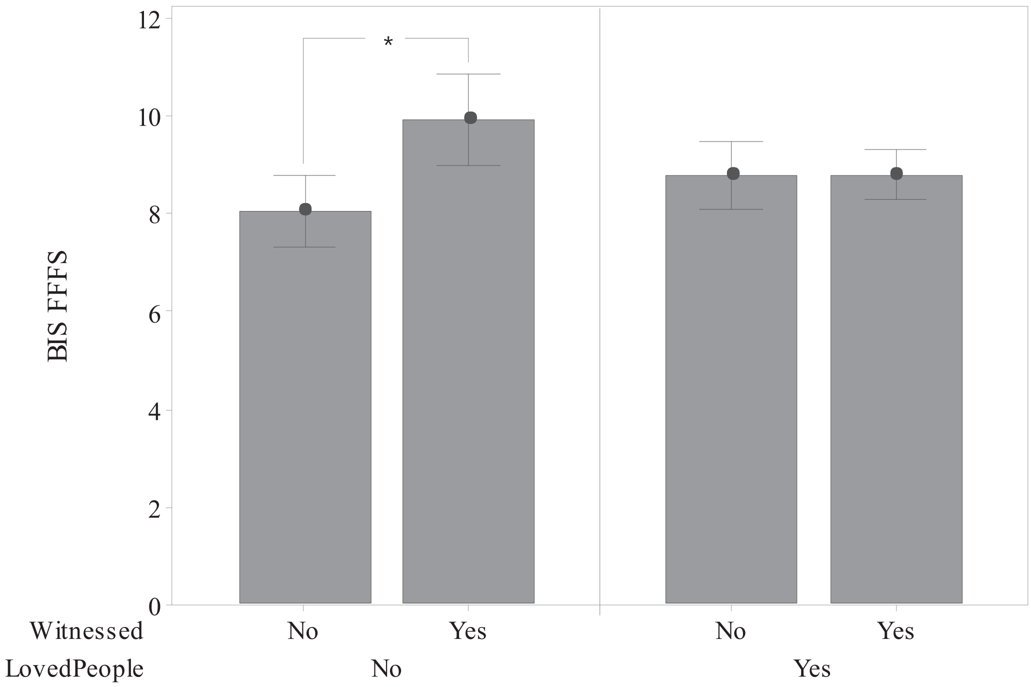

Figure 4.18. Bar charts of the 95% confidence intervals of the scores of the Fight-Flight-Freeze System (FFFS) in the participants who did not have close (loved) people who suffered a severe accident (left) or had close (loved) people who suffered a severe accident (right), and who had not or had witnessed a severe accident.

About religiosity, there were small direct correlations between the score of "I am a religious person" and the final judgment of control, and the PANAS sum of positive affects, although the Kruskal-Wallis' Test did not indicate significant differences among the four judgment of control levels ($r(101) = .20$, $p = .047$; $r(101) = .22$, $p = .031$; $H(3,101) < 4.63$, $p > .201$).

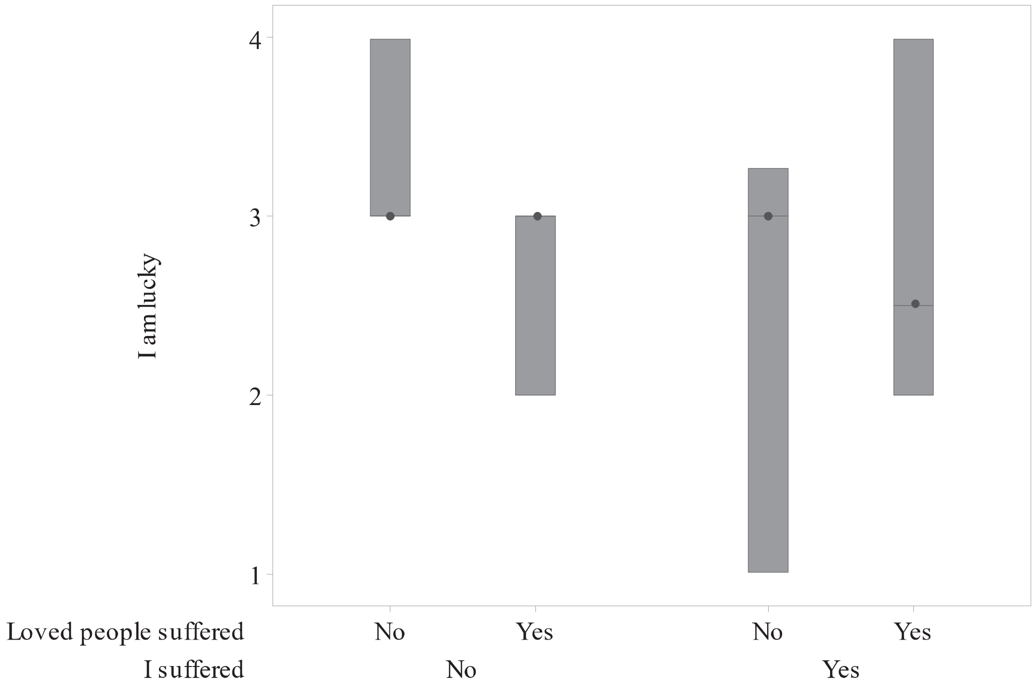

Figure 4.19. Median 95% confidence interval of the scores of the sense of luck in participants who had or not loved people who suffered a severe accident and who had or not suffered a severe accident. There is a tendency of people without any experience of suffering severe accident to feel more lucky. There was a significant effect of the interaction (p = .043).

About luck sense of luck, the participants who considered themselves luckier tend to be the ones who never had suffered an accident and whose loved people neither, as illustrated in Figure 4.19; the GLM for the response "I am lucky" presented an effect of the interaction between having suffered an accident themselves (*yes* or *no*) and having loved people who suffered severe accidents (*yes* or *no*; $F(1,87) = 4.07$, $p = .047$, $\eta^2 = .04$, $\eta_p{}^2 = .04$, $r = .21$). There were small direct correlations between the score of "I am lucky" and age, the final judgment of control, and the absolute values of the final judgment of control, and marginally with the BAS Reward Responsiveness, although the Kruskal-Wallis' Test only indicated marginally significant differences among judgment of control levels ($r(101) = .27$, $p = .006$; $r(101) = .20$, $p = .044$; $r(101) = .21$, $p = .039$; $r_s\,(101) = .22$, $p = .024$; $H(3,101) < 6.58$, p > .087). There was not difference between the median scores of religiosity and sense of luck ($\chi^2 = 0.56$, $p = .46$).

Discussion

This study aimed to analyze the magnitudes of illusion of control and emerging affects and motivation systems during the traffic light task in a sample of workers from two mining sites. Specifically, the experiment searched for effects of the probabilities of the outcome and the probability of action response, safety culture (related to two different maturities and efficacies of safety risk management), job types, scholarity levels, and other factors that could help to explain why participants under the same contingency scenarios declare different judgments of control and affects. As valence had been enough studied in the previous studies and safety was the field to be explored, the positive valence of the scenario was not included in this study, so the sample could have a greater size. The phenomenon also could be better explored in a sequence of 100 trials divided in two blocks under a same *p*(O).

Whatever the mining site, sex, age or experimental block was, the illusion was induced in participants under high *p*(O), while null illusion was the typical self-assessment in low *p*(O) either in the final or in the partial judgments of control; similarly to literature about the effect of the probability of a successful outcome on IOC (Blanco & Matute, 2015; Langer & Roth, 1975; Rudski, Lischner, & Albert, 1999; Sweeney, Benassi, & Drevno, 1980, as cited by Presson & Benassi, 1996), see Figure 4.2. In fact, the effect size of the probability of the outcome was one of the strongest measured in the study ($r = 0.28$, i.e., a Cohen's intermediate effect). These measures could not confirm the hypothesis that different safety cultures, represented by the two mining sites with different maturities of their safety risk management systems, would express different degrees of IOC. Similarly to previous studies (chapters 2 and 3), the intensity of the illusion did not decrease significantly even after 100 trials of the traffic light task. Other experiments were as long as the present paradigm, for instance, Blanco et al., 2011, but neither the division into two blocks, presented as different situations (exits of a shopping center), would make participants get aware of the randomness. That was not the case and it once again corroborates the strength of phenomenon once it is established.

It is important to analyze individual characteristics that could explain variation which can not be assigned to objective stimulus such as valence or *p*(O). Culture, individuals' personality and experience, and affects may help to understand why members of a group under the same stimuli and contingencies report different degrees of control. In this experimental task, participants responded to different psychological scales in order to assess affects and motivational systems (PANAS and BIS and BAS, respectively). Some questions were also presented to evaluate the degrees of religiosity and sense of luck, and to identify educational level, job type, work experience and accidents experience (with themselves, with their loved people, and as witnesses), see Appendix E.

One of the most interesting findings was that individuals' experience with severe accidents could explain differences in the dependent variables measured during or after the task. Participants from both sites who declared having already suffered one or more severe accidents tended to declare self-judgments of null illusion of control even under high probability of the outcome (Figure 4.3), and there was a moderate and inverse correlation between judgments and the number of accidents that have been experienced. This relationship resembles that of two self-report studies, one performed in an industrial company, and the other in a research and development service organization in Portugal. They compared different levels of gravity of work accidents with the results of safe and unsafe behavior scales (measured by questions such as "I communicated the existence of dangerous situations in my workplace"; Gonçalves, da Silva, Lima, & Meliá, 2008). The studies concluded that greater work accident experience was directly associated with higher unsafe behavior and with external causal attributions, and had a negative association with internal causal attribution.

The percentage of the workers who participated in the study and judged to have control on the task (82%) was the greatest of the four studies. The difference was significantly greater than students under preventive valence in Study 2 (61%), and marginally greater in Study 3 (71%, z = 1,48, p = .07) which had number of trials and blocks equal and values of p(O) very close to the current study. Maybe such difference can be explained by the critic and skeptical way of thinking of the academic population; while professionals are usually more charged for performance and fast results, and have to dedicate themselves to effective procedures, their routine makes them prevent randomness and variation, what probably induces them to think that any proposed task with targets to be objectively achieved is controllable.

Beyond the self-assessments of control, the study also explored if associative and signal detection measures can detect differences in response bias or strategies which can be attributed not only to successful outcomes, but to characteristics of the sites and workers. The response bias measure c indicated that there was bias in the subgroups who declared some illusion of control, and nil bias in the case of null illusion (Figure 4.5). This result is similar to Study 3.

Comparing the two mining units, Unit 1 presented more intense bias to action response than Unit 2 in the second block of the experimental task under high probability of the outcome (Figure 4.4), corresponding to higher judgments and stronger illusions. Regardless of the same judgments of control, which did not differ between units, it seems that participants from the first unit *behaved* as if they had (or were trying to have) greater control through their actions, but did not declare that in their judgments. That is the unit with less maturity of safety risk management.

According to a vast literature, in order to adjust their behavior to the environment, animals and people face the challenge of finding the difference between effective and ineffective actions, a question related to contingency learning. A positive contingency (i.e., $\Delta p = p(O|A) - p(O|\tilde{A}) > 0$ or $c < 0$) means that the probability of the outcome occurrence (whether desired or undesired) is higher when the action is performed than when it is not, and a negative contingency (i.e., $\Delta p < 0$ or $c > 0$) reflects the opposite situation (Allan, 1980). In a preventive scenario it was demonstrated that the action prevents the occurrence of the outcome, whether desired or undesired (Blanco & Matute, 2015). Illusion of control happens in those programmed situations in which hypothetically there is no contingency between action and outcome (i.e., $\Delta p = 0$ or $c = 0$), but still people believe that their actions affect the outcome (Langer, 1975).

Some studies found that the effect of $p(A)$ entails a similar illusion when the participant's action is performed very frequently (Blanco et al., 2011; Matute, 1996). Since participants were free to choose when to act, their actual contingencies might have slightly departed from zero and in this case it is possible to find small variability in the response bias of the sample. But the results from Studies 2 and 3 indicated that there was no depart from zero, and it was discussed that students probably tried many patterns of actions through the sequence of trials and that causes were in fact sets of changing combinations of pressing and non-pressings, so that they cancelled and Δp could not significantly depart from zero. One can suppose that workers from Unit 1 had less complex strategies, so that in this group the "cause" or action for controlling was closer to the simple pressing. Another possible explanation could be a clearer detachment between actions during the task and the self-reporting of the judgment of control after the end of the sequence: maybe workers from Unit 1 behaved and judged as having control, while workers from Unit 2 tended to behave as if they did not have control or used strategies that cancelled response bias, even declaring the presence of control. The result that Unit 1 presented bias both when they judged negative and positive control, while Unit 2 presented bias only when they judged positive control (Figure 4.6), also suggests that participants from Unit 2 behaved less intensively in the pressing of the spacebar when trying to control the traffic light, although declaring the same degree of control than Unit 1.

Another behavioral measure that was analyzed for the first time in illusion of control experiments was response time. Differently from judgments of control, *RT* mean decreased in the second block in Unit 1 (as in the previous Study 3), but it was the same in Unit 2, see Figure 4.7. It was as if participants from Unit 1 were less skilled and in the first half of the task and improved a lot in the second one. Or they got eager, but it was not possible to compare affects or motivation between blocks, affects were evaluated only after the end of the task. As a characteristic of aging, *RT* was longer in the eldest participants. As it was also expected, *RT* was shorter in participants with higher education and administrative jobs, as they are more skilled in the use of computers and keyboards.

A curious finding was the great difference in *RT* between participants having loved people who suffered severe accidents and the ones who never had a relative, partner or close friend who suffered an accident. Participants from this last study did not give a final feedback due to the restricted timeline at the workplace so it is not easy to explain the result. As it was discussed about the judgments of control in participants who had suffered severe accidents themselves, maybe the experience of accidents with loved people make workers aware of the importance of controlling a traffic light that can prevent harm to other people, and so they are eager to perform their responsibility in safety as authorized in the instructions of the experiment. However, the final judgments of control indicate that the groups felt equally successful in the goal of controlling the safety equipment. Thus, it is possible that the experience of other's accident makes the person eager to control the traffic light during the task, even if at the end the conclusion and the judgment is that he could not control it.

Statistical control charts of *RT* once again provided interesting and rich findings about the use of such technique in the study of sequence of experimental trials, and about behavior related to illusion of control. In the same way as in the previous study (Chapter 3), in the *X*-bar *S* charts there was a typical decrease of *RT* during the first trials of each block, and the decrease was faster in the second block. As there was no period of previous training so that participants began immediately trying to control the light, actually they needed to adapt themselves, as if they were exploring the task in the first trials of the sequence.

It was possible to identify clear patterns for each group chart. In short, it seems that groups manifesting illusion of control presented frequent changes in the baseline of *RT* through the sequence of trials and the same variation in chart as a whole, except for the group with low positive illusion, which presents greater stability and less variation in Block 2. In the same way as in Study 3, the patterns in SPC chart for low probabilities of the outcome (Figure 4.8) and for null level of judgments of control (Figure 4.11) were characterized by stability in randomness, in mean and in variation (standard deviation). Likewise, the charts built for the groups under high *p*(O) (Figure 4.9), and also for the high positive control (Figure 4.13), presented many significant changes (special causes) in Block 1 and more stability, with few changes in Block 2. The chart for the negative illusion group (Figure 4.9) has some characteristics of the null illusion chart (the few special causes and the stability in Block 2), and some characteristics of the high positive illusion (the decreasing of *RT* with some special causes during Block 1). The low positive illusion chart (Figure 4.12) resembled the typical stability of the low *p*(O) and null illusion chart, but presenting an intense decrease variation in Block 2, with great stability of mean and *SD*.

Comparing both mining sites (Figures 4.14 and 4.15), the chart for Unit 1 resembles the profile of *RT* for high positive illusion in Block 1 and the null or negative illusion profile in Block 2, with a decrease in *RT*, as it was already discussed about *RT* means per block. The chart for Unit 2, on the other hand, presents a similar profile of high illusion *RT* in both Blocks. Comparing these results about the charts to the discussion on response bias *c* and Figures 4.4, 4.5 and 4.6, it seems that Unit 1 behaved (i.e., acted as expressed in bias *c* and *RT*) as if they had negative illusion, while Unit 2 behaved similar to high positive illusion, they tried to control intensively; in the end, the judgments of both Units were the same. Perhaps that is the difference of a staff under higher maturity of safety risk management: They do not behave nor judge as if they could have control in a clearly uncontrollable situation.

Illusion of control has traditionally been studied from the behavioral and cognitive points of view, few studies explore emotional, mood or affective factors or consequences during IOC or judgment of contingency tasks. Some few studies included the effects of affects not related to normal emotional states, like stress (Bogdan, Pringle, Goetz, & Pizzagalli, 2012; Friedland, 1992) and depression (Alloy & Abramson, 1979; Alloy, Abramson & Viscusi, 1981; Vázquez, 1987). In the current study the PANAS scale was used to evaluate the valence and types of the affects self-assessed by the participants just after the last judgment of control in the experimental task. Also related to motivation, the Behavioral Inhibition System (BIS) and the Behavioral Activation System (BAS) and their factors were included to analyze how such conceptual nervous systems would emerge in the sample at the personality level, either as trait anxiety or as impulsive action to look for rewards, respectively.

The positive affects, as measured by the sum of the items in PANAS scale, prevailedover the negative affects equally in all groups and factors. Although there was no spoken feedback by the end of the session, in all previous studies participants declared to be interested in the task and expressed positive terms for the affects, especially under the scenarios of positive illusion.

But negative affects were not despicable, as described in the previous chapters, and many participants complained of the monotony of the task. Consistently, the prevailing mechanism of motivation was under control of the approach system (BAS) and related to the reward responsivity factor. Inhibition, expressed by BIS (BIS and FFFS), was also not despicable.

In the present study the only difference in affects was found among different levels of control, but there was no relationship with judgments of control and motivation systems. As expected, the more intense illusion of control, the more intense positive affects and the less intense the negative affects, note Figure 4.17, Table 4.4 and the small correlation between the sum of the positive affects and the values of the final judgments of control, and the inverse but marginally significant correlation between negative affects and the final judgments. Only positive affects received higher scores under positive illusions: active, alert, attentive, determined, inspired, interested, strong, enthusiastic. There were also only positive but fewer affects with higher scores under null or negative illusion: active, alert, attentive, determined, and interested. One can conclude that the workers did like to participate in the task, and apparently they were sincere, even when evaluated in their workplace and under some pressure for productivity, as it is usual in companies, especially in industry.

About the comparison of the miners' affects and demographic attributes, there were small inverse correlations between some positive affects and scholarity, and years in company: the higher the scholarity and the longer in company, the lower the rates of some positive affects (e.g., attentive, inspired, determined), as if these participants were not so happy with their work. Higher scholarity also was associated with less BAS Reward Responsivity as the motivation mechanism. On the other hand, the longer in company, the less afraid and scared, as if workers get more confident as time goes by in company. And the older the participants, the less BAS Drive as the motivation system, a finding that does not contradict literature.

Participants who had experienced severe accidents to themselves presented a bit more negative affects than who had not experienced any severe accident, still positive affects had preponderated equally in both subgroups. Maybe the context of a task related to safety (of pedestrians facing a semaphore under intense car traffic) was enough efficient to induce some negative affects on those who had experienced accidents, another clue that such factor is important to understand differences in behaviors and emotions related to prevention of future undesirable events. The inhibition FFFS, also related to negative motivations, was higher in those who had witnessed a severe accident (if the participant' loved people had not suffered severe accidents), another type of experiencing an accident, as an observer.

Gonçalves et al. (2008) discussed that accident experience probably changes workers' behavior, at least during a certain period of time after the accident, although that was not the case of a longitudinal study. In the current study, the year of the last accident was registered, but it was not possible to find a significant effect of the period after the accident. Gonçalves also argued that, from a cognitive approach, it is reasonable to expect that accident experience does not only affect employees' behavior, but also the interpretation that workers make about accidents. Not only, in their study the external causal attributions (and not the own personal factors) mediated the relationship between work accident experience and unsafe behavior.

Safety training might have a special role in this process. Lingard (2002) conducted a first aid training intervention introduced to different workplaces in a small business construction industry employees sample. She found that safety training affected the motivation in avoiding occupational injuries and illnesses, and reduced participants' "self-other" bias, making them more aware that their own experience of occupational safety and health risks is not beyond their control. Their own behavior is an important factor in the avoidance of occupational injuries and illnesses. First aid training increased the participants' safety scores (e.g., the use of personal protective equipment, and the safe use of tools) and appeared to increase the perceived probability that the workers could suffer a work-related injury or illness.

Beyond Lingard's emphasis in the perception of the probability of accidents, the current study complements that experience affects the perception of control over a dangerous situation. As if past experience can make the person aware that random, unknown and external factors affects one's level of control and agency. In other words, experience makes him/her be more skeptical or suspicious during the task. Safety culture and safety training may determine attributions to accident factors and perhaps a better safety training of the employees could accurate causal attributions of an accident to inner factors, like the sense of agency or control over a dangerous task.

As Gonçalves et al. (2008) also stated, a complex set of relationships indicates that the specific characteristics of the organizational setting may play an important role in this process, for example, the organization's activity sector, the safety and preventive culture and structures of the organization, or the demographic composition of the work force. Nonetheless, in the present study it was not possible to find differences in self-assessed judgments of control between mining sites which presented different historical accident rates and different maturities of their safety risk managements as assessed by the company managers. As a limitation of the study, maybe there were not great differences between the strength of safety cultures in the units, regardless of the number of local accidents and the different maturities. In a 5-point scale, Unit 1 had maturity 3 and Unit 2 had maturity 4, the difference was very small. After all, the mining units are part of the same corporation and the acquisition of Unit 1, in 2006, is not so recent.

Other limitations of the study were the difficulties in the data collection due to the short time available in agendas, the new environment to the researcher, the novelty of conducting an experiment inside industrial facilities, and different researchers went to different units. It is not possible to check if or how much errors and biases occurred due to these factors.

CHAPTER 5

DISCUSSION

The primary aim of this thesis was to explore the factors that modulate the illusion of control in productive and preventive scenarios in the context of safety risks. This idea was inspired by more than 40 years of experimentation on illusion of control, the tendency to overestimate the probability of personal success in random situations, a phenomenon that helped to understand productive and preventive superstitions and pseudocientific thinking. So we thought that it might help to understand how people react in situations where chance contributes to stronger or weaker sense of control in a hazardous task, and contribute to better understand the ways in which cognitive bias, irrationality and false beliefs can affect risk control, a gap in human factor studies (McLeod, 2015).

Four experiments were run. The first one was a replication of a light bulb experiment (Blanco & Matute, 2015) in order to have a first contact with the method. The other experiments were run with the traffic light task, an improvement of the first paradigm including a stimulus that should be more adequate to both productive and preventive scenarios. A semaphore provides either appetitive and aversive scenarios, and it is an apparatus intrinsically associated to safety risk decisions, traffic performance and accident prevention; depending on the contextualization and on the goal established in instructions, one valence or the other can be enphasized.

The external factors to be studied were the valence of the scenario (productive and preventive), the probability of the outcome (a light bulb on or off, or a traffic light green/go or red/stop). The internal factors the were probability of the action response by the participants, and the positive and negative emerging affects. In the last experiment with a sample of workers, the external factors of safety culture (measured by the degree of the maturity of risk management), the motivational or personality systems, religiosity, sense of luck, job type, scholarity level, experience with accidents, and other internal factors were included in the study. The studies also looked for additional behavioral indexes and statistical techniques for the measurement and monitoring of IOC besides the self-reported scales of judgment of control, such as signal detection indexes, reaction times, and statistical process control charts.

Both the light bulb and the traffic light generated illusion in most participants, mainly in the mining workers, even after 100 or more trials and almost half an hour of session. It was not possible to identify a time limit for the tasks, when supposely the majority of the sample would get aware of the inherent randomness of the task. The degree of illusion was self-reported on a graffic bar that helped the participant to evaluate the judgment of control only with semantic references; except for the first study, where the numeric reference of the -100 – 100 scale was visible. The original scale from Blanco and Matute's study was bidimensional in order to serve as a judgment scale for productive goals in its positive side, or for preventive goals in its negative side. The scale used in the three experiments with the traffic light task unified the valences: its negative side evaluated how much the outcomes would be on the contrary of the users' actions, i.e., for the cases which the judgment was that the traffic light behaved in opposition to the participant's actions, in a situation of absence of personal control or the possibility of control by hypothetical external factors, beyond the simple randomness of the outcomes.

All the experiments confirmed the hypothesis that the probability of the outcome has a large effect on judgments of control. Higher probabilities of the sucessful outcome (p(O)s between .70 and .90 of *on* or *green* lights) generated illusion in most participants submitted to such stimuli, and in this cases the mean values of the judgments were around 25 in the -100 – 100 self-report scale. On the other hand, lower probabilities (p(O)s between .10 and .30) generated null or negative illusions, depending on the study and on the valence. Lower probabilities in the productive scenario tended to produce null illusions, except for extreme values (p(O) = .10) and in Study 3, in which illusions were negative. Maybe european students tended to assign absense of control to external factors (and such interpretation did not affect their emotions positively or negatively, once they also declared lower positive and negative scores in the affective PANAS scale), while brazilians interpretated the unsuccessful outcomes as null control. Lower probabilities of success in the preventive scenario tended to produce negative illusions in students and null illusions in workers, for whom it is possibly difficult to assign the absence of control to external factors, since they are more demanded for control and performance results in their corporate routine.

The oscillation of the probability of the outcome produced a "kangoroo effect", the strongest illusions of all, in the cases in which the sequence of trials started with a block under low probability of sucesses, whatever the valence, and the following probabilities oscillated in an ascending sequence of successful events; continuous ascending probabilities also produced strong illusions. By the other side, null illusions were obtained when there was a descending oscillation with the lowest p(O)s in the end. Negative illusions, assessed when the outcome was opposite to the participant's actions, occurred when *p*(O) descended continuously throughout the sequence of blocks, like a jumping ball losing its energy. These experimental fallouts resemble everyday life periods when people perceive that things go right or wrong, and they can help to understand the senses of good or bad luck, when people regard themselves or other entities or chance as the causal agents of successes and failures. Such mechanism may explain why illusions are persistent in life as an evolucionary resource that keeps people motivated in most cases, and helplessness in others.

Illusions were generated in both valence scenarios with the same intensity, except for Study 2, in which valence had a medium effect on the overall final judgment of control. After the long sequence of 200 trials divided in four blocks under diverse *p*(O)s, the productive group reported a mean judgment of 20 (positive illusion), while the preventive group reported a mean of 3 (equivalent to null illusion). However, the partial judgments after each block were not affected by valence in Study 2, only by *p*(O). So the traffic light task can be used in experiments in preventive scenarios, for instance, in the studies of safety, security, health and loss prevention in general.

The effect of probability of the action response is a controversial issue in the literature on illusion of control (Stefan & David, 2013), and the current experiments confirm that sometimes it is significant and sometimes not. The *p*(A) had a significant and medium effect only in Studies 3 and 4, both with long sequences of 100 trials under a same *p*(O). The effect could not be replicated in Study 1, and in Study 2 we explained that the instructions encouraged participants to change their way of responding through their actions and omissions, and in fact they declared to have to "change the logic" [sic] of the pressings and non pressings of the space bar. It is reasonable to suppose that they have tried different strategies from time to time, e.g, performing different subsequences and varying the repetitions an proportions of pressings, omissions, moments to press, and reaction times. The experiments in literature have reported simple *yes* or *no* actions as response (e.g., Eitam et al., 2013; Karsh et al., 2016). Thus, one possible explanation is that only the last two studies provided the statistical power to detect different proportions of action among groups: the strategies changed throughout the task, but finally it was possible to detect that *p*(A) changed because there were in fact more concentration of strategies based on actions, so different bias to action were revealed in groups. After all, the conceptual model proposed in Chapter one (Figure 1.10) includes a correlation between *p*(A) and *JC*, theoretically weaker because it is not a direct cause and effect relation.

Study 3 was the first one in this thesis to find significant effects of the *p*(A) on the judgments. Despite the smaller sample size and perhaps due to the long sequence of 100 trials under a same *p*(O), whatever the strategy was used by the participants, there was a significant tendency to higher frequency of actions in the second block, particularly in the productive group and also in the lower *p*(O), as if participants were striving to control the traffic light in an unfavorable condition for control. Students who declared high level of control performed higher *p*(A) in the productive group and lower *p*(A) in the preventive group (Figure 3.4), suggesting that the mechanism of illusory control is richer in actions if someone tries to produce a desired outcome, and omissions gain importance if one tries to prevent an undesirable outcome. In Study 4, workers from Unit 1 who were under lower p(O) and workers who judged negative control responded with higher *p*(A) in the second block, similarly as in Study 3, as if they were striving for control, while workers from Unit 2 behaved in a more stable manner.

Signal Detection Theory provided to Studies 3 and 4 a set of sensitivity and response bias measures to be tested in order to assess IOC through behavioral measures other than self-reports. Diverse measures were tested with the aim of finding the two best indexes that are both sensitive to differences between groups and which error variances are minimum. In the two studies all the sensitivity measures (*d*', *A*', *Ad*', *α*, and *SI*) indicated null sensitivity, as expected in random tasks, and equivalent errors in the model (between 40% and 46%). Almost all response bias measures (*β*, *c*, *B*", *RI*, and *Y*) indicated bias to action in general and in most subgroups, and lower errors in the model (between 18% and 39%). The sensitivity index (*SI*) and *c* were chosen because they met the assumptions for non-parametrical distributions and their models produced the lowest percentual errors. It is important to comment that the differences between groups were not the same in the response bias measures, but *c* presented very strong inverse correlation with *RI*, and indicated the same group differences than *B*", and it is the preference of many researchers (Green & Swets, 1966; Stanislaw & Todorov, 1999), so it seemed to be a reliable measure for IOC studies. The analysis of *Y* resulted that this index was strongly dependent on *p*(O) and so it should be used only with samples under a fixed probability, which is not the case of the current studies.

The measure *c* complemented *p*(A), it usually brought the same information and indicated the same significant main effects and interactions, and similar effect sizes. In Study 3, the *c* was negative and so it indicated a general response bias to action in the second block, mainly under low *p*(O) (low probability of success), the same result as *p*(A). Besides that, *c* also indicated a bias to more actions in the students who declared high positive illusion in the productive scenario, while it indicated fewer actions (an equilibrium between actions and omissions, $c = 0$) in the preventive participants with high positive illusions, a confirmatory result to $p(A)$. In Study 4, c indicated that there was a bias in the subgroups who declared some illusion of control, and nil bias in the case of null illusion. Unit 1 presented more intense bias to action response than Unit 2, an action profile which should correspond to higher judgments and stronger illusions. However it seems that participants from Unit 1 (with less risk maturity) behaved *as if* they had control, or as if they were trying to have more control through their actions, although such control was not refleted in their judgments; in other word, in the end they failed. Another difference between participants from Unit 1 and 2 was the bias in the workers who declared negative judgments (see Figure 4.6): in Unit 1, they had a bias to action, while in Unit 2 there was no bias. For some reason that will be discussed later, it seems that Unit 1 strived for control when the traffic light behaved in *opposition* to the participant's actions.

On the other hand, the action contingency Probabilistic Contrast Model (PCM) and Cheng's Power of the PCM produced no significant contributions to the explanation of the different judgments of control, confirming literature (Blanco & Matute, 2015; Collins & Shanks, 2006; Lober & Shanks, 2000; Perales & Shanks, 2003), and possibly because these models are based in actions structured as simple binary sequences of *yes* or *no* responses. In the light bulb and in the traffic light instructions, it was suggested to participants to perform more complex strategies for the goal of controlling the outcome. It was important to try other measures to evaluate block results, other than the PCM and Power PC which were not useful in the first two studies.

Nevertheless, the Rescorla-Wagner's causal, associative and mathematical model, conceived to explain the quantity of learning that occurs on each trial along the sequence of trials, did contribute to model the development of the judgments of control, even in a situation where learning is impossible. So it is also reasonable to think that the cumulative association of the pairings between the random stimuli with the primary motivating event (and the resulting action), produced a total amount of associative strengths or "learnings" from the sequence of trials, the so called expected reward value V, which is useful to represent the generation of the illusion. As full prediction is impossible, the sequence of errors, concurrent "surprises", and following error corrections, build up a sense of control that can be estimated by the last V of the sequence, and that will be explicited in the self-reported judgment of control by the participant. The resemblance between the asymptotic patterns of the judgments of control (JC) and the expected value (*V*) was partial in Study 1 (Figure 1.9) and almost perfect in Study 2 (Figure 2.5), both may possibly be improved by changing the parameters of the equation model. Resulting contributions of the RW's model are the conceptual model conceived by the author to understand the development of the judgments of control (Figure 1.10), and the decision to study the measures not only from block means, as it is usual in Experimental Psychology, but also from the trial by trial means in each condition group. In case, the chosen measure was *RT* and the technique was the Shewhart's Statistical Process Control charts for means and standard deviations ("X-bar S" charts).

The analysis of the mean values of reaction times in Studies 3 and 4 resulted medium to large main effects of the blocks: The *RT*s were lower in the second block and were independent from valence, *p*(O), or from the level of self-reported control. This is probably an effect of training or adaptation to the task. However, the analyses of *RT*s through the sequence of trials in the SPC charts provided different patterns depending on the groups of valence and *p*(O), and on the level of the judgment of control. Charts of participants under low *p*(O) (Figures 3.8, 3.10, and 4.8), or who reported null illusion (Figures 3.13 and 4.11) presented a stable and continuous random variation. Charts of participants under high *p*(O) or under negative or high positive control (Figures 3.9, 3.11, 3.12, 3.15, 4.10, 4.13) presented many special causes (change points) indicating spot shifts (due to cognitive activity) and reductions in *RT*, with a continuous reduction of *RT* in the high positive illusion. This last group presented the highest mean *RT* of all in Study 3, probably indicating greater cognitive activity (Bechara & Damasio, 2005). Groups manifesting illusion of control presented frequent shifts in the baseline of *RT* through the sequence of trials and the same variation in the chart as a whole, except for the group with low positive illusion in Study 4, which presented greater stability and less variation (lower *SD*) in Block 2 (Figure 4.12). Mainly in Study 4, the second blocks presented fewer special causes, suggesting an effect of training, adaptation to the task, and consequent stability; but maintaining the illusion.

In Study 4, there was also a medium effect of the interaction between industrial unit (site) and block (see Figure 4.7, left): The *RT* mean was higher in the first block and lower in the second block in Unit 1, but it remained constant and with an intermediary value from the first to the second block in Unit 2. Comparing the mining sites, the SPC chart for Unit 1 resembled the profile of *RT* for high positive illusion in Block 1 and the null or negative illusion profile in Block 2; on the other hand, the chart for Unit 2 presented a similar profile of high illusion *RT* in both Blocks.

It is intriguing the great differences in the profiles not only of *RT*, but also of *p*(A) and *c* bias between Units 1 and 2 of the mining company. The decreases of *RT* and *c*, and the increase of *p*(A) can not be explained only by training and adaptation of the workers, because it was too intensive in Unit 1 and did not happen in Unit 2, in which the procedure and instructions were the same. The three measures seem to denote a strive of participants in trying to control an uncontrollable situation of safety risk in the computer. The safety risk maturity of Unit 1, as evaluated by the manager and the coordinator, resulted level 3 (*defined*) in the 1 – 5 scale, while Unit 2 was at level 4 (*managed*, see the questionnaire in the Appendix C). This means that, in the first unit, risk management was formally defined and documented, but the safety procedures, practices and thus safe behaviors were not completely implemented in all areas of the site; while in the second site most organizational health and safety (OHS) objectives, authorizations, responsibilities, methods, controls, monitorings, and performance are in advanced state of implementation in the majority of the areas.

Not only that, the regional corporate manager reported the performance indicators from both units when data were being collected. For instance, the Lost Time Injury Frequency Rate (LTIFR) for the last 12 months in reference to 200,000 hours in August, 2018, were around 0.15 and 0.11, respectively in Units 1 and 2. The mines have been in operation since 1982 and 2006, respectively, and both were bought by the corporation in 2006. The LTIFR of Unit 1 had been continuously improving since the beginning of 2018 (when it was 0.47), while in Unit 2 it was null from April 2017 till April 2018. So Unit 1 has much older facilities and it has not the same HS performance, but its recent improvements are remarkable, while Unit 2 had already a very good and stable safety performance. Unit 1 is a workplace in a process of changing safety culture. One possible explanation for the different patterns of reaction times and action biasses is that the staff in Unit 1 have been in a tremendous struggle to perform betterly in safety, and such profile was reproduced during the challenge of trying to control a safety equipment. Mainly when the instructions emphazised the responsibility of the participant for the safe outcome in a hazardous scenario.

Our interpretation is that participants in Unit 1 started the task very carefully, once they had been recently very worried with safety performance, specially in low probabilities of success, so the *RT* were higher and there was almost an equilibrium between actions and omissions. When they noted that it was actually difficult to control the traffic light in the first block already, their urge and commitment made them eager for control and so they went to Block 2 faster and more intensive in their actions, so the *RT* and the *c* decreased and *p*(A) increased (Figures 4.4, 4.6, and 4.7). By its side, participants from Unit 2 were not so worried and performed the task in a more stable way. Thus, we may conclude that illusion of control, whatever the judgment after the task, has to be evaluated also in terms of the *urge for control* demanded by the scenario, culture, and social desirability that surrounds the participants. Such pressure and resulting struggle for the control can be measured by the reaction time and the action bias. Future studies designed for the purpose and including psychophysiological measures are promising to the knowledge of safety cultures in change.

One of the most important findings was that the *RT* was also shorter in participants having loved people who suffered severe accidents. It seems that the past experience of other's accident makes the person eager to control the traffic light during the task, even if at the end the conclusion and the judgment was that he/she could not control it. Not only that, Figure 4.3 shows that participants from both sites who declared having *already suffered* one or more severe accidents tended to declare self-judgments of null illusion of control even under high p(O), and there was a moderate and inverse correlation between judgments and the number of accidents that have been experienced. It seems that the worst way to reduce the illusion of control in a dangerous situation is through having experienced accidents in life.

People who suffered accidents or who had loved people with such experience probably went through an cognitive and emotional process of surprises which facilitates a kind of learning, as it was represented in the Rescorla-Wagners' model. Experiments developed in laboratories can simulate or at least stimulate participants to experience or remember accident situations. For instance, the results of a study on the fear of falling with mountain climbers have confirmed that participants who practiced the style *rope climbing*, in which there is no risk of falling, were less self-effective (self-efficacy is the perception that one has of oneself as capable of achieving what is proposed; Bandura et al., 1999) and more anxious than those of the style *lead climbing*, in which there is a significant risk of fall and a severe accident. In the first style the patterns of heart response and electrical conductance of the skin suggested that there was emotional modulation before the visualization of four categories of images (Pleasant, Neutral, Unpleasant and Climbing Falls), and the female group presented the typical response of phobic individuals. Another conclusion was that climbers who had experienced a fall accident or quasi-accident (a fright or scare) presented more emotional modulation in comparison to participants who had never had such experience.

What is to suffer an accident is not addressed in present safety learning practices. Currently, most prevention approaches geared to improving OHS derive from teaching paradigms (e.g., lectures, awareness campaigns, behavioral modeling) rather than learning paradigms (e.g., situation learning, community of practices; Burke, 2006; Konijn, 2016). Most practices are disconnected from the work context and have the only purpose of cumplying with legislation and avoiding panalties. Safety training programs usually include integration (information supply about the environment and working conditions), awareness (benefits of accompanying established safety rules, usually done through motivational lectures aimed at teaching appropriate equipment procedures and the use of personal protective equipment), risk analysis (anticipation techniques and prevention legislation), and ergonomics (functional training on the importance of maintaining correct physical posture during work). There is a need to explicitly address strategies for rule transgression and self-regulatory processes in teaching (Laberge, MacEachen, & Calvet, 2014).

On the other hand, incidental learning appear to play an important role in OHS. In a research with young workers (Laberge et al., 2014), several apprentices reported that feeling pain or experiencing an injury, even minor, led them to develop new techniques or strategies to avoid reoccurrences, while the experienced co-workers also admitted that such injuries were a frequent but unfortunate way to learn, and probably more efficient that being taught to take care (Gonçalves et al., 2008). These results help to understand the effect of the experience of suffering an accident on the IOC and suggest a solution to improve safety performance.

First aid practical training interventions in the workplace can affect the safety learning and motivation in avoiding occupational injuries and illnesses (Lingard, 2002), and it also can make workers' sense of control adjusted to a more reasonable level. Another technique that has been much researched and is in rapid progress is virtual reality (VR), including safety learning (Deb et al., 2017; Grabowski & Jankowski, 2015; Guo, Yu, & Skitmore, 2017; Leder et al., 2019; Li et al., 2018; Ronchi et al., 2015; Schwebel et al., 2016). For example, there are studies that include simulation of fire accident scenarios in order to train field operators and car drivers to respond effectively to abnormal situations in industrial plants and traffic tunnels (Kinateder et al., 2013; Manca, Brambilla, & Colombo, 2013). These paradigms could be enhanced to include cognitive biasses beyond safe response performance.

And there are the so-called *experiential techniques* in the context of psychotherapies, that have been recently applied to interventions in the workplace. For instance, Jeffrey Young's Schema Therapy has become popular and appeared to overcome some of the difficulties of cognitive-behavioral therapy in relation to the treatment of personality disorders and difficult patients. It proposes the use of cognitive techniques and experiential or life techniques that have been absorbed from other therapeutic lines, such as Gestalt therapy and psychodrama. Some of them are the experiential techniques of *mental images* (in its many variations), *letters to parents*, *body work*, *dialogue with parents*, and *chairwork dialogues*. One of the objectives of these techniques is to activate emotions conected to maladaptive schemes through imagination, acting and role playing of traumatic situations (Young, Klosko, & Weishaar, 2003). Some of these techniques could be used in interventions where workers imagine the situation of an accident and the affects that arise during and after the harmful event. Nevertheless, the experential techniques still require scientific evidence. Recent reviews report therapeutic interventions (e.g., yoga and mindfulness) and their results in the workplace (da Costa, Greco, & Alexandre, 2018). Some findings suggest that they have physical and psychological effects on workers from different professional categories; however, there is no benefit for some conditions nor the same positive effects on all practitioners. Examples of the difficulties are the workers' adherence to the programs, and the poor description and mensuration of the implemented programs.

Conclusions

At last, we conclude that the experiments on illusion of control in productive and preventive scenarios and in the context of safety risks produced interesting results that help to understand many of the external and internal factors that modulate the illusion, e.g., the probabilities of the outcome and of the action responses, the valence and contextualization of the instructions, the experience of accidents with oneself and other people, the maturity of the safety risk management in the organization, and the process of safety culture change. We evaluated complementary and useful behavioral measures for the phenomenon, besides self-assessment scales, like action response bias and reaction time. And we introduced in psychological experiments the analysis of the sequence of trials through statistical process control charts, which provide complementary information to the block means and standard deviations.

One of the limitations was the use of a very generic and simple stimulus, too far from dangerous tasks usually operated by users and workers in workplace. The participants in three studies were the typical in psychological studies (undergraduate students), only the last experiment included works, from two industrial sites, but from the same company and under a same regional manager; it would be more representative to choose different enterprizes with greater differences in safety performance. In the last study, two different analysts collected data; they were experienced and well trained in the procedure, but characters may have affected the differences in some results. A lot is to be learned in data collection in industrial sites (especially the large ones) where facilities and routine were not planned for experiments.

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APPENDIX A - INSTRUCTIONS

Instructions of Experiment 1 (the light bulb task) in English and in Portuguese

Note: the fields in square brackets separated by slash refer respectively to the productive and preventive scenarios, i.e., [PRODUCTIVE/PREVENTIVE].

At the beginning of this experiment, a lamp bulb will appear on this screen. Your task is to learn a way to make the lamp bulb turn [ON/OFF] (your final score will depend on how many times the lamp bulb has lit).

As time passes, a button will appear on the screen below the lamp. This button indicates to you the beginning of a new attempt, that is, the moment to take some action. While the button is appearing on the screen, you have the option to push the button or do not push the button. If you decide to push the button, press the SPACEBAR ONCE. If you decide not to press the button, do not press any key on the computer.

From the moment the button appears, you will have 2 seconds to decide whether or not to push the button until the button disappears. If you press the spacebar after the button disappears, the attempt will be computed as a non-action. So in this experiment there are only 2 action possibilities you can take in each attempt:

a) press the button (by typing the spacebar on the keyboard) during the 2 seconds interval,

b) do nothing and just watch what happens.

You will notice if the lamp bulb has lit or not lit immediately after the button disappears. If the lamp turns ON, you [EARN/LOSE] 1 point - otherwise, if the lamp REMAINS OFF, you [LOSE/EARN] 1 point. Pay attention and take this into account because your goal is to earn as many points as you can.

If the lamp bulb turns on, it will stay that way for 2 seconds, then it will go out by itself and new attempts will come. The button will reappear after a few moments, so you can press it or not. That is, during the experiment you will have many opportunities to push the button and see what happens to the lamp bulb.

You may find that the lamp bulb will light up in a certain percentage of the attempts at which you push the button. You may also find that the lamp lights up for a certain percentage of the attempts when you do not press the button. On the other hand, you may find that the lamp does not light for a certain percentage of the attempts at which you press the button, and you may find that the lamp bulb does not light for a certain percentage of the attempts at which you do not press the button.

So there are 4 possibilities in relation to what can happen in each attempt:

a) you press the button and the light bulb turns on,

b) you press the button and the light bulb does not turn on,

c) you do not press the button and the light bulb turns on,

d) you do not press the button and the light bulb does not turn on.

Because it's your role to earn points by learning how to turn the lamp bulb on, you can take advantage by pressing in some of the attempts and not in others, so that you know when you do not press, as well as when you press the button. That is, try to avoid pressing the button EVERY TIME it appears, and also avoid NOT PRESSING IT EVERYTIME.

Remember that you should try to earn as many points as you can by keeping the lamp bulb [ON/OFF] as much as possible through your actions and omissions. When you're ready, press the spacebar to begin. Good luck!

(Illustrative Screen Sequence)

If you have any question about the assignment, ask the researcher now. If you want to read the instructions again, press the "R" key. If you have read and understood the instructions, press the "B" key to begin the experiment.

(Self-assessment after the sequence of trials)

Now answer: How far did you control the light bulb switching?

Answer by CLICKING THE MOUSE on the scale, where:

-100 means: Pressing the button ALWAYS prevented the lamp from turning on.

0 means: Pressing the button had NO EFFECT to light on the lamp.

+100 means: Pressing the button ALWAYS causes the lamp to turn on.

Intermediate points mean INTERMEDIATE LEVELS OF CONTROL, or to prevent the lamp from turning on (negative values), or to cause it to turn on (positive values).

No início deste experimento, vai aparecer uma lâmpada nesta tela. A sua tarefa é aprender uma maneira de fazer que a lâmpada permaneça [ACESA/APAGADA] (sua pontuação final vai depender de quantas vezes a lâmpada acendeu).

À medida que o tempo passar, vai aparecer na tela um botão, abaixo da lâmpada. Este botão indica para você o início de uma nova tentativa, ou seja, o momento para tomar alguma ação. Enquanto o botão estiver aparecendo na tela, você terá a opção de apertar o botão ou de não apertar o botão. Se você decidir apertar o botão, pressione a barra de ESPAÇO uma ÚNICA VEZ. Se você decidir não pressionar o botão, não pressione nenhuma tecla do computador.

A partir do momento em que o botão aparece, você terá 2 segundos para decidir se vai ou não vai apertar o botão, até que o botão desapareça. Se você teclar a barra de espaços após o desaparecimento do botão, a tentativa vai ser computada como um não-acionamento. Portanto, neste experimento há apenas 2 possibilidades de ação que você pode tomar em cada tentativa:

a) apertar o botão (teclando-se a barra de espaços no teclado) no decorrer dos 2 segundos,

b) não fazer nada e apenas observar o que acontece.

Você perceberá se a lâmpada acendeu ou não acendeu imediatamente após o desaparecimento do botão. Se a lâmpada ACENDER, você [GANHA/PERDE] 1 ponto – caso contrário, se a lâmpada PERMANECER APAGADA, você [PERDE/GANHA] 1 ponto. Preste atenção e leve isto em conta, pois seu objetivo é ganhar tantos pontos quanto conseguir.

Se a lâmpada acender, ela vai ficar assim durante 2 segundos, então se apagará sozinha e novas tentativas virão. O botão vai reaparecer após alguns instantes, para que você possa apertá-lo ou não. Ou seja, durante o experimento você terá muitas oportunidades de apertar o botão e de ver o que acontece com a lâmpada.

Você pode achar que a lâmpada vai acender em certa porcentagem das tentativas nas quais você aperta o botão. Você também pode achar que a lâmpada acende durante certa porcentagem das tentativas quando você não aperta o botão. Por outro lado, você pode achar que a lâmpada não acende durante certa porcentagem das tentativas nas quais você aperta o botão, e pode achar que a lâmpada não acende durante certa porcentagem das tentativas nas quais você não aperta o botão.

Assim, há 4 possibilidades em relação ao que pode acontecer em cada tentativa:

a) você aperta o botão e a luz acende,

b) você aperta o botão e a luz não acende,

c) você não aperta o botão e a luz acende,

d) você não aperta o botão e a luz não acende.

Como é seu papel ganhar pontos ao aprender como fazer para [ACENDER/MANTER APAGADA] a lâmpada, você pode levar vantagem se apertar em algumas das tentativas e não em outras, de modo que você fica sabendo quando você não aperta, bem como quando você aperta o botão. Ou seja, tente evitar apertar o botão TODAS AS VEZES em que ele aparece, e evite também NÃO APERTÁ-LO EM NENHUMA DAS VEZES.

Lembre-se de que você deve tentar ganhar tantos pontos quanto puder ao manter a lâmpada [ACESA/APAGADA] a maior parte do tempo possível, por meio de suas ações e suas omissões. Quando estiver pronto, aperte a barra de espaços para começar. Boa sorte!

(Sequência de telas ilustrativas)

Se você tem alguma dúvida sobre a tarefa, pergunte ao pesquisador agora. Se você quiser Ler as intruções novamente, pressione a tecla "L". Se você leu e entendeu as instruções, pressione a tecla "C" para Começar o experimento.

(Auto-avaliação após a sequência de 50 tentativas]Self-assessment after the sequence of trials)

Agora responda: Até que ponto você controlou o acender da lâmpada?

Responda CLICANDO NO MOUSE na escala, onde:

-100 quer dizer: Pressionar o botão SEMPRE EVITOU que a lâmpada acendesse.

0 quer dizer: Pressionar o botão NÃO TEVE EFEITO ALGUM em acender a lâmpada.

+100 quer dizer: Pressionar o botão SEMPRE FEZ que a lâmpada acendesse.

Pontos intermediários querem dizer NÍVEIS INTERMEDIÁRIOS DE CONTROLE, ou de se evitar que a lâmpada acendesse (valores negativos), ou fazer com com ela acendesse (valores positivos).

APPENDIX B – SUPPLEMENTARY FIGURES AND TABLES (STUDY 2)

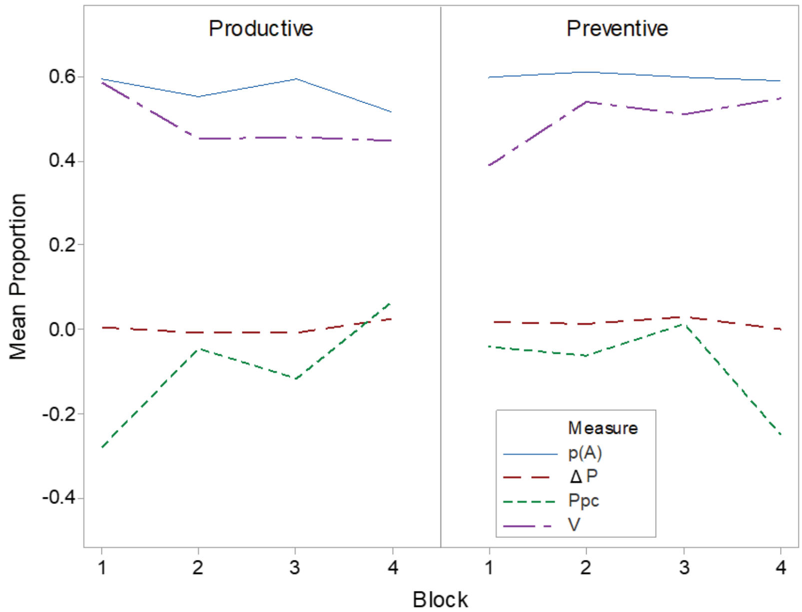

Figure B1. Line plots representing sequences of the mean values of proportion of the action (p(A)), contingency index (Δp), power PC index (P_{PC}), and expected reward (V), for both groups by block. There was no significant group nor block effect.

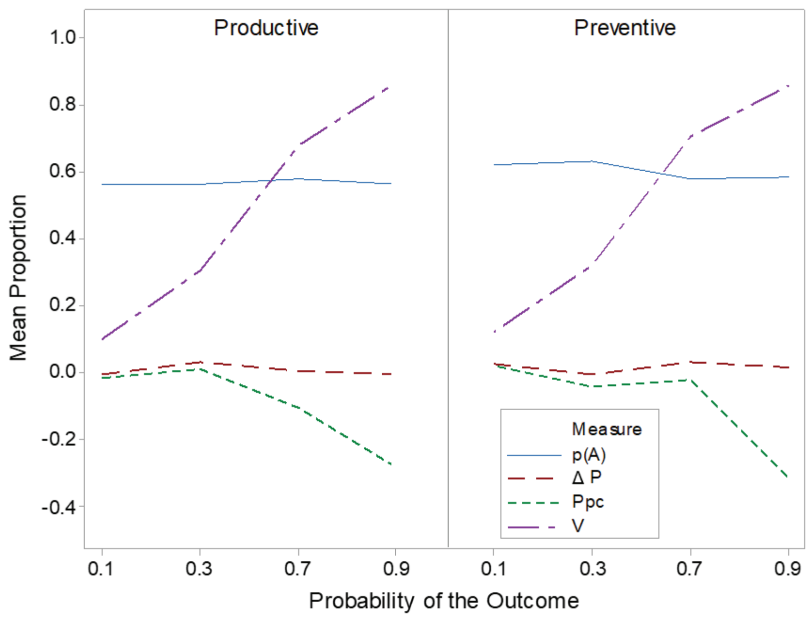

Figure B2. Line plots representing sequences of the mean values of proportion of the action (p(A)), contingency index (Δp), power PC index (P_{PC}), and expected reward (V), for both groups by probabilities of the outcome (p(O)). There was a significant large effect of p(O) on V.

Table B1

Final judgment of control (FJ), partial judgment of control (pJ) and probabilities of the action (p(A)) for each valence (group), block, and probability of the outcome (p(O))

		FJ				
Valence		*n*	*M*	*SD*	*SEM*	95% CI
Productive		40	19.77	29.24	4.62	[10.71, 28.33]
Preventive		41	3.34	30.19	4.72	[-5.91, 12.59]

		pJ					*p*(A)				
Valence		*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI
Productive		39	10.37	22.82	3.65	[3.20, 17.53]	39	0.57	0.15	0.02	[0.52, 0.61]
Preventive		41	1.88	21.52	3.36	[-4.71, 8.46]	41	0.60	0.13	0.02	[0.56, 0.64]

		pJ					*p*(A)				
Valence	Block	*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI
Productive	1	39	15.95	55.59	8.90	[-1.50, 33.39]	39	0.59	0.16	0.03	[0.54, 0.64]
Productive	2	39	12.28	56.72	9.08	[-5.52, 30.09]	39	0.56	0.17	0.03	[0.50, 0.61]
Productive	3	39	9.33	55.79	8.93	[-8.18, 26.84]	39	0.60	0.19	0.03	[0.54, 0.66]
Productive	4	39	3.90	49.73	7.96	[-11.71, 19.51]	39	0.52	0.21	0.03	[0.45, 0.58]
Preventive	1	41	4.02	46.40	7.25	[-10.18, 18.23]	41	0.60	0.12	0.02	[0.56, 0.64]
Preventive	2	41	6.78	55.16	8.61	[-10.10, 23.66]	41	0.61	0.19	0.03	[0.55, 0.67]
Preventive	3	41	-4.27	49.08	7.67	[-19.29, 10.76]	41	0.60	0.20	0.03	[0.54, 0.66]
Preventive	4	41	0.98	49.99	7.81	[-14.33, 16.28]	41	0.59	0.18	0.03	[0.54, 0.65]

		pJ					*p*(A)				
	p(O)	*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI
Productive	0.10	39	-26.23	48.42	7.75	[-41.43, -11.03]	39	0.56	0.17	0.03	[0.51, 0.61]
Productive	0.30	39	-9.56	47.26	7.57	[-24.40, 5.27]	39	0.56	0.16	0.03	[0.51, 0.61]
Productive	0.70	39	37.62	44.23	7.08	[23.73, 51.50]	39	0.58	0.19	0.03	[0.52, 0.64]
Productive	0.90	39	39.64	44.89	7.19	[25.55, 53.73]	39	0.56	0.22	0.03	[0.50, 0.63]
Preventive	0.10	41	-21.63	56.22	8.78	[-38.84, -4.43]	41	0.62	0.11	0.02	[0.58, 0.65]
Preventive	0.30	41	-23.95	38.23	5.97	[-35.65, -12.25]	41	0.63	0.15	0.02	[0.59, 0.68]
Preventive	0.70	41	30.66	35.18	5.49	[19.89, 41.43]	41	0.58	0.16	0.03	[0.53, 0.63]
Preventive	0.90	41	22.44	42.19	6.59	[9.52, 35.35]	41	0.58	0.24	0.04	[0.51, 0.66]

Table B2

Actual contingency as computed by Δp index, Cheng's power probabilistic contrast (P_{PC}), and Rescorla-Wagner's strength of the action (V) for each valence (group), block, and probability of the outcome (p(O))

		Δp					P_{PC}					V				
Valence		*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI
Productive		39	0.01	0.05	0.01	[-0.01, 0.02]	39	-0.09	0.30	0.05	[-0.18, 0.01]	40	0.49	0.08	0.01	[0.46, 0.51]
Preventive		41	0.01	0.09	0.01	[-0.02, 0.04]	41	-0.09	0.37	0.06	[-0.20, 0.03]	41	0.50	0.06	0.01	[0.48, 0.52]
		Δp					P_{PC}					V				
	Block	*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI
Productive	1	39	0.01	0.13	0.02	[-0.03, 0.05]	37	-0.28	1.01	0.17	[-0.60, 0.04]	40	0.59	0.35	0.06	[0.48, 0.69]
Productive	2	39	-0.01	0.11	0.02	[-0.04, 0.02]	38	-0.04	0.38	0.06	[-0.17, 0.08]	40	0.45	0.35	0.05	[0.35, 0.56]
Productive	3	37	-0.01	0.13	0.02	[-0.05, 0.04]	36	-0.11	0.56	0.09	[-0.30, 0.07]	40	0.46	0.35	0.06	[0.35, 0.57]
Productive	4	39	0.03	0.14	0.02	[-0.02, 0.07]	38	0.07	0.40	0.06	[-0.06, 0.19]	40	0.45	0.32	0.05	[0.35, 0.55]
Preventive	1	41	0.02	0.14	0.02	[-0.02, 0.06]	41	-0.04	0.45	0.07	[-0.18, 0.10]	41	0.39	0.33	0.05	[0.29, 0.49]
Preventive	2	39	0.01	0.14	0.02	[-0.03, 0.06]	39	-0.06	0.76	0.12	[-0.30, 0.18]	41	0.54	0.35	0.05	[0.44, 0.65]
Preventive	3	39	0.03	0.13	0.02	[-0.01, 0.07]	38	0.02	0.71	0.11	[-0.21, 0.24]	41	0.51	0.33	0.05	[0.41, 0.61]
Preventive	4	39	0.00	0.13	0.02	[-0.04, 0.04]	37	-0.25	0.99	0.16	[-0.57, 0.07]	41	0.55	0.36	0.06	[0.44, 0.66]
		Δp					P_{PC}					V				
	p(O)	*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI	*n*	*M*	*SD*	*SEM*	95% CI
Productive	0.10	38	-0.01	0.08	0.01	[-0.03, 0.02]	38	-0.01	0.09	0.01	[-0.04, 0.02]	40	0.10	0.11	0.02	[0.07, 0.13]
Productive	0.30	39	0.03	0.16	0.03	[-0.02, 0.08]	39	0.01	0.28	0.04	[-0.08, 0.10]	40	0.30	0.17	0.03	[0.25, 0.36]
Productive	0.70	39	0.00	0.14	0.02	[-0.04, 0.05]	39	-0.11	0.54	0.09	[-0.28, 0.06]	40	0.68	0.20	0.03	[0.62, 0.74]
Productive	0.90	38	0.00	0.11	0.02	[-0.04, 0.03]	33	-0.28	1.18	0.21	[-0.69, 0.12]	40	0.87	0.15	0.02	[0.82, 0.91]
Preventive	0.10	41	0.02	0.11	0.02	[-0.01, 0.06]	41	0.02	0.14	0.02	[-0.02, 0.07]	41	0.12	0.13	0.02	[0.08, 0.16]
Preventive	0.30	40	0.00	0.16	0.02	[-0.05, 0.04]	40	-0.04	0.30	0.05	[-0.13, 0.05]	41	0.32	0.21	0.03	[0.25, 0.38]
Preventive	0.70	39	0.03	0.16	0.02	[-0.02, 0.08]	39	-0.02	0.57	0.09	[-0.20, 0.16]	41	0.71	0.18	0.03	[0.65, 0.76]
Preventive	0.90	38	0.01	0.12	0.02	[-0.02, 0.05]	35	-0.32	1.40	0.24	[-0.78, 0.15]	41	0.85	0.19	0.03	[0.80, 0.91]

APPENDIX C – FORM FOR THE ASSESSMENT OF THE SAFETY RISK MANAGEMENT IN THE ORGANIZATION

UESTÕES	Unit 1	Unit 2
1. Os objetivos de SST da organização estão definidos.		
2. A direção foi treinada para compreender os riscos de SST e sua responsabilidade por eles.		
3. Foi definido um sistema de pontuação para avaliar os riscos de SST.		
4. O apetite por riscos (escala e critério de tolerância) da organização foi definido em termos de um sistema de pontuação.		
5. Foram definidos processos para determinar riscos. Esses processos são seguidos.		
6. Todos os riscos de SST foram compilados em uma lista. Os riscos foram alocados a cargos específicos.		
7. Todos os riscos foram avaliados de acordo com o sistema de pontuação definido.		
8. As respostas aos riscos (por ex.: controles) foram selecionadas e implementadas.		
9. A direção estabeleceu controles para monitorar a operação adequada dos controles-chave.		
10. Os riscos são analisados criticamente pela organização de forma regular, periodicamente.		
11. A administração/liderança relata os riscos para os diretores quando as respostas aos riscos não reduzem tais riscos a um nível aceitável.		
12. Todos os novos projetos significativos são avaliados rotineiramente quanto a riscos de SST.		
13. A responsabilidade pela determinação, avaliação e gestão dos riscos de SST está incluída nas descrições de cargos.		
14. Os gestores dão garantia da eficácia de sua gestão de riscos de SST.		
15. Os gestores são avaliados quanto ao seu desempenho no gerenciamento dos riscos de SST.		

Atribua pontos de 1 a 5. Utilize o critério: 1 = nada implementado; 2 = em início de implementação, em poucas áreas; 3 = em estado intermediário de implementação, em boa parte das áreas; 4 = alto grau de implementação, na maioria das áreas; 5 = totalmente implementado na unidade

APPENDIX D – PANAS SCALE

Escala de afetos positivos e negativos – PANAS

Esta escala consiste de um número de palavras que descrevem diferentes sentimentos e emoções. Leia cada item e depois marque a resposta adequada no espaço ao lado da palavra. Indique até que ponto você se sente desta forma neste momento.

1	2	3	4	5
Nem um pouco	um pouco	moderadamente	bastante	extremamente

___aflito
___amável
___amedrontado
___angustiado
___animado
___apaixonado
___apreensivo
___arrojado
___assustado
___chateado
___cuidadoso
___culpado
___decidido
___delicado
___determinado
___dinâmico
___envergonhado
___entusiasmado
___estimulado
___excitado
___forte
___hostil
___humilhado
___impaciente
___incomodado
___inquieto
___inspirado
___interessado
___irritado
___medroso
___nervoso
___orgulhoso
___perturbado
___poderoso
___preocupado
___produtivo
___rancoroso
___tímido
___vigoroso
___zeloso

APPENDIX E – BIS/BAS SCALE

O questionário a seguir avalia aspectos da personalidade das pessoas. Use a legenda abaixo para assinalar o quanto cada afirmação descreve você. Quanto maior o número assinalado, mais você concorda com o que está sendo dito, e vice versa.

1	2	3	4
Totalmente falso			**Totalmente verdadeiro**

1 Quando consigo algo que quero, fico animado e estimulado.	1	2	3	4
2 Cometer erros me preocupa.	1	2	3	4
3 Quando vejo uma oportunidade para algo de que gosto, fico imediatamente motivado.	1	2	3	4
4 Quando persigo um objetivo, uso uma estratégia de "vale-tudo".	1	2	3	4
5 Críticas ou recriminações me magoam bastante.	1	2	3	4
6 Quando estou indo bem em uma atividade, tenho prazer em continuar.	1	2	3	4
7 Sempre estou disposto a fazer coisas novas, se acho que será divertido.	1	2	3	4
8 Fico muito preocupado ou chateado quando penso ou sei que alguém está bravo comigo.	1	2	3	4
9 Fico preocupo quando penso que me saí mal em algo que fiz.	1	2	3	4
10 Quando coisas boas acontecem, isso mexe comigo fortemente.	1	2	3	4
11 Quando eu quero algo, vou com tudo para consegui-lo.	1	2	3	4
12 Frequentemente, faço coisas só pela diversão.	1	2	3	4
13 Mesmo se algo ruim está prestes a acontecer comigo, eu dificilmente sinto medo ou nervosismo.	1	2	3	4
14 Vencer uma competição me empolgaria.	1	2	3	4
15 Eu passo por tudo para conseguir o que quero.	1	2	3	4
16 Tenho fissura por emoção e novas sensações.	1	2	3	4
17 Eu tenho poucos medos quando comparado aos meus amigos.	1	2	3	4
18 Se eu vejo uma chance de conseguir o que quero, corro atrás imediatamente.	1	2	3	4
19 Frequentemente, faço coisas sem planejar.	1	2	3	4
20 Se eu penso que algo desagradável vai acontecer, fico bastante alerta.	1	2	3	4

APPENDIX F – PROCEDURE OF EXPERIMENT 1

Objetivo: Realizar o Experimento 1
Google Drive: /Doutorado/Experimento1/Protocolo do Experimento 1 rev0.docx

Etapa	O quê	Como	Conteúdos
1	Agendamento das sessões de coleta de dados	Equipe recebe mensagens por email, WhatsApp, Facebook ou telefone e registra na Google Agenda (experimentopsi@gmail.com)	[Produtos: agendas preenchidas e impressas]
2	Início de uma sessão e preparação do *setting*	1. Trinta minutos antes do horário agendado, pesquisadora autorizada reune os materiais e retira a chave da sala 300 na Secretaria do..., abre a sala, posiciona cuidadosamente as 4 mesas, 3 cadeiras, computador, 2 monitores e teclado na cabine acústica, posiciona o aparelho da fono. 2. Conectar o pendrive e ligar o computador. Abrir o programa E-Prime e rodar o início do cadastramento (No. do próximo participante conforme último registro do Formulário do Experimento) 3. Ao se ausentar do laboratório, trancá-lo sempre com a chave.	**Materiais:** **Pendrive verde (licença do E-Prime)** **TCLE** **Agenda** **Formulário do Experimento** **Pendrive preto (backup de dados)** **Lab-book** **Canetas** **Este protocolo**
3	Recepção dos participantes	1. Uma pesquisadora atende o participante que chega à sala no horário agendado, cumprimenta o participante, pergunta se veio para o Experimento de Controle, apresenta-se, confirma o nome completo. 2. Se no horário, acompanha o participante ao laboratório, ou solicita que aguarde nas cadeiras próximas à sala até o horário agendado.	[ânimo!] *Bom dia, veio para o experimento? Eu sou ..., você é ...? Me acompanhe, por favor. (ou Por favor, aguarde naquela cadeira até às ... horas, já irei buscá-lo).*

4	Preparação do participante antes de entrar na cae	1. Pesquisadora guia o participante para a sala e mostra a cabine e o computador, explica que a tarefa dura cerca de 20 minutos e que basicamente ele terá de teclar a barra de espaços para tentar controlar uma imagem de uma lâmpada que pode ou não acender. 2. Confirmando-se o interesse na participação, ele é guiado à mesa de preenchimento e solicita-se que leia e assine o TCLE. 3. A pesquisadora também preenche o formulário de registro dos participantes (não deixar o participante preencher, para evitar problemas de caligrafia e sigilo). Deixar uma cópia do TCLE com o participante.	[ânimo!] *Esta é uma cabine à prova de som. Aí dentro tem uma mesinha com monitor e teclado, onde vamos rodar um jogo no computador. Basicamente você terá de de teclar a barra de espaços para tentar controlar uma imagem de uma lâmpada que pode ou não acender. Você topa participar?* [Caso positivo, ainda fora da cabine:] *Sente-se nessa mesa e por favor leia e assine esse Termo de Consentimento. Vou precisar também preencher este formulário com teus dados, para se necessário depois entrarmos em contato contigo (até para te enviar informações sobre os resultados da pesquisa, mas isso vai demorar alguns meses, OK?)*

5	Preparação do participante dentro da cabine	1. O pesquisador conduz o participante para o interior da cabine, pede que se sente e, com a porta aberta, fala as instruções e verifica se ele se sente bem e concorda em continuar. 2. Termina de digitar a identificação do participante no programa e instrui para o início do experimento. Quando ele iniciar, fecha a porta da cabine.	[ânimo!] *Tudo bem contigo? Durante o experimento, vamos precisar fechar a porta da cabine, para evitar que sons te atrapalhem. Como está se sentindo?"* [Caso resposta positiva, prosseguir na instrução; caso negativa, interromper, perguntar o que ocorre e tentar solucionar o problema – caso perceber que o participante não se sente totalmente bem e à vontade, verificar se ele aceita realizar com a porta aberta e registrar o ocorrido no lab-book – em último caso, interromper o experimento, conduzi-lo até a entrada do laboratório e agradecer. A qualquer momento, caso necessário, pedir auxílio à Segurança nos telefones ...] *Com licença, vou precisar preparar o programa. Pronto! Basta você ler e seguir as instruções na tela. Se tiver algum problema e não se sentir legal, pode me chamar, batendo nesta janela. Eu vou estar aí fora te acompanhando todo o tempo. Alguma dúvida? (…) Vou fechar a porta, tá bem? Pode começar, então.*

6	Monitoramento do experimento	1. Acompanhar pela janela da cabine e pelo monitor externo se o participante aparenta estar conduzindo a tarefa sem dificuldades. Tentar não ficar muito à vista, mas também deixar claro que se está ali para o caso de qualquer dúvida ou problema. 2. Aproveitar para revisar as anotações do formulário, a assinatura do TCLE e preencher as ocorrências no lab-book. A pesquisadora pode em paralelo preparar o próximo participante fora da cabine.	**[Produtos: TCLE assinado, formulário e lab-book preenchidos.]**
7	Encerramento da tarefa	1. Quando o participante sinalizar que terminou a tarefa (avisando pela janela ou se levantando para sair da cabine), conduzi-lo para fora da cabine e pedir feedback. 2. Assegurar-se que tem a cópia do TCLE, agradecer e conduzi-lo para a saída do laboratório.	[ânimo!] *Foi tudo bem? Como se sentiu? Algum comentário ou alguma dúvida? Qualquer dúvida posterior busque informações nesses contatos que estão no Termo de Consentimento. Muito obrigada pela participação e até logo!* [Observação: não responder nada sobre a pesquisa: assunto, tema, objetivo, hipóteses, bibliografia, resultados esperados... nada! Caso pergunte algo:] *Pelo procedimento que temos de seguir, não podemos revelar nenhuma informação além do que está escrito no cartaz e nesse Termo de Consentimento, mas futuramente entraremos em contado para dizer de forma geral quais foram os resultados desta pesquisa.*
8	Encerramento do experimento	1. Salvar o arquivo de dados na pasta (...) do computador e no pendrive preto. Registrar todas as ocorrências e o desenrolar do experimento no lab-book.	**[Produtos: TCLEs assinados, formulário e lab-book preenchidos; pendrive preto com dados dos experimentos]**

9	Encerramento da sessão	Desfazer a Etapa 1.	

<u>Contatos importantes</u>:
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Pietra: XXXX-XXXX, ****@***.***
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Secretaria da CIPAS: XXXX-XXXX
Portaria: XXXX-XXXX
Emergência UFGRS: XXXX-XXXX
Segurança: XXXX-XXXX
SAMU: 192
Brigada Militar: 190
Bombeiros: 193

APPENDIX G – TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Estamos realizando uma pesquisa para investigar a aprendizagem de como uma pessoa controla uma tarefa. Para tanto, precisamos da sua colaboração. Você executará um jogo no computador em um ambiente confortável. Após ler as instruções na tela do computador, a sua tarefa será observar a figura de um semáforo que aparecerá repetidas vezes na tela e tentar encontrar um meio de evitar que o semáforo feche, através do acionamento, ou não, da barra de espaços do computador. O computador registrará o que você acionar no teclado, durante alguns períodos, e o que acontece na tela. Você responderá uma escala e fornecerá alguns dados pessoais. A duração total dessa atividade será de aproximadamente 30 minutos.

Os riscos são mínimos, os mesmos aos quais você está exposto quando frequenta instalações administrativas no trabalho e pratica um jogo não violento no computador, por curto espaço de tempo, destacando-se como principal prejuízo o tempo de permanência nesta sala. Caso você sinta qualquer incômodo (como um mal-estar) ou haja alguma situação adversa, o pesquisador está atento e preparado para lhe dar apoio e tomar os encaminhamentos necessários. Por outro lado, participar de um estudo experimental pode representar uma boa oportunidade de conhecer como se pesquisa, além de poder contribuir para ampliar o conhecimento sobre a cognição e o comportamento das pessoas em relação aos efeitos de suas ações e como elas controlam determinadas situações.

Sua participação é voluntária e você tem plena liberdade de poder interrompê-la a qualquer momento, inclusive no período de realização da tarefa experimental ou do preenchimento de algum instrumento; poderá também retirar seu consentimento em qualquer fase desta pesquisa, sem prejuízo algum para você. Sempre que desejar, poderá solicitar informações sobre os procedimentos. Além disso, todos os cuidados serão tomados pelos pesquisadores para garantir a sua segurança e a confidencialidade (sigilo) das informações, preservando-se a sua identidade e privacidade em todas as fases da pesquisa. Os resultados gerais (ou seja, dos dados em conjunto) e as conclusões do estudo poderão ser apresentadas em eventos ou publicações científicas ou especializadas, mas os dados individuais coletados no processo de pesquisa não serão informados a qualquer instituição envolvida. Todo o material desta pesquisa será mantido em sigilo e protegido no Instituto de Psicologia/UFRGS, sendo destruído após cinco anos.

Desde já, agradecemos sua contribuição para o desenvolvimento desta atividade de pesquisa e colocamo-nos à disposição para esclarecimentos. A pesquisadora orientadora e responsável é a Prof.ª Dra. Lisiane Bizarro Araújo, do Programa de Pós-Graduação em Psicologia do Instituto de Psicologia da Universidade Federal do Rio Grande do Sul (UFRGS), e o autor deste projeto é o doutorando Reinaldo Augusto Gomes Simões. Em caso de dúvidas, a equipe poderá ser contatada pelos telefones (51)3308-2117, ou pelo e-mail reinaldoags@gmail.com , ou contate o Comitê de Ética em Pesquisa do Instituto de Psicologia da UFRGS, localizado na Rua Ramiro Barcelos, 2600, Porto Alegre – RS, CEP: 90035-003, fone: (51)3308-5698, e-mail: ceppsico@ufrgs.br.

Este documento tem duas vias idênticas e você receberá uma delas.

Concordo em participar do presente estudo,

____

Assinatura do(a) participante

Nome completo do(a) participante: ____________________________________

Data de nascimento: ____/____/____

Unidade: ________________________

Documento: ____________________

Email: ________________________

Telefone: ______________________

Data de hoje: ____/____/____

____

Assinatura do(a) pesquisador(a)

_____ / Exp. 4

APPENDIX H – PARECER DO COMITÊ DE ÉTICA

INSTITUTO DE PSICOLOGIA - UFRGS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Ilusão de controle em cenários produtivos e preventivos e em contexto de riscos de segurança

Pesquisador: Lisiane Bizarro Araujo

Área Temática:

Versão: 2

CAAE: 52037115.0.0000.5334

Instituição Proponente: Instituto de Psicologia - UFRGS

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.446.952

Apresentação do Projeto:

O presente projeto de pesquisa corresponde aos estudos 2 e 3 da tese de doutorado do pesquisador auxiliar, orientado pela pesquisadora responsável pela pesquisa. Trata da questão da "ilusão de controle", a crença de que nosso comportamento produz um efeito que é na verdade independente do mesmo, em cenários produtivos e preventivos. De acordo com os pesquisadores, a importância dos estudos sobre ilusão de controle para o mundo real é que eles podem contribuir para se entender os mecanismos dos comportamentos de risco e tomada de decisão.

Os participantes (80 estudantes de graduação e 100 trabalhadores de indústrias mineradoras) realizarão uma tarefa computadorizada e programada que consiste em tentarem acender a luz verde ou vermelha de imagens de semáforos, conforme cenários de segurança desejáveis ou indesejáveis, e em diferentes probabilidades de resposta.

Objetivo da Pesquisa:

Avaliar os fatores moduladores e as magnitudes dos efeitos da ilusão de controle em cenários produtivos e preventivos, e em contexto de riscos de segurança.

Avaliação dos Riscos e Benefícios:

Riscos:

Os riscos foram avaliados pela equipe de pesquisa como mínimos, os mesmos aos quais o

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Bairro: Santa Cecília **CEP:** 90.035-003
UF: RS **Município:** PORTO ALEGRE
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participante fica exposto quando frequenta instalações na universidade e pratica um jogo não violento no computador, por curto espaço de tempo (30 minutos), destacando-se como principal prejuízo o tempo de permanência no laboratório. Caso o participante sinta qualquer incômodo (como um mal-estar) ou haja alguma situação adversa, os pesquisadores estarão atentos, acompanhando continuamente a realização da tarefa através de um segundo monitor de computador e pela visualização do participante, e preparados para dar apoio e tomar os encaminhamentos necessários.

Benefícios:
Os participantes do estudo experimental terão a boa oportunidade de conhecer um laboratório e um procedimento de pesquisa em psicologia experimental e comportamental, além de contribuir para ampliar o conhecimento sobre a cognição e o comportamento das pessoas em relação aos efeitos de suas ações e como elas controlam determinadas situações envolvendo segurança das pessoas e do trabalho.

Comentários e Considerações sobre a Pesquisa:
A pesquisa apresenta claramente a sua fundamentação teórica e os procedimentos que serão realizados, demonstrando preocupação com o bem estar dos participantes

Considerações sobre os Termos de apresentação obrigatória:
O TCLE é muito claro, apresentando o estudo ao participante e contendo todas as informações recomendadas pela CONEP.
Foi anexado termo de anuência (modelo) das instituições onde serão recrutados os participantes, contendo todas as informações necessárias para que os responsáveis possam avaliar a participação da instituição no estudo.

Recomendações:
Não há novas recomendações.

Conclusões ou Pendências e Lista de Inadequações:
A pesquisa encontra-se aprovada por este CEP.

Considerações Finais a critério do CEP:

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação

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Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_644516.pdf	04/02/2016 23:34:04		Aceito
Outros	termo_de_anuencia.pdf	04/02/2016 23:26:25	REINALDO AUGUSTO GOMES SIMÕES	Aceito
Folha de Rosto	folha_de_rosto.pdf	18/12/2015 23:17:53	REINALDO AUGUSTO GOMES SIMÕES	Aceito
Outros	ata_da_defesa_projeto.jpg	18/12/2015 22:59:44	REINALDO AUGUSTO GOMES SIMÕES	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	tcle20151213.pdf	13/12/2015 20:32:12	Lisiane Bizarro Araujo	Aceito
Projeto Detalhado / Brochura Investigador	projetodetese20151213.pdf	13/12/2015 20:31:16	Lisiane Bizarro Araujo	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PORTO ALEGRE, 11 de Março de 2016

Assinado por:
Clarissa Marceli Trentini
(Coordenador)