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To cite this version:

Hakim Djeriouat, Nadine Matton, Damien Mouratille. Does hostile intent cause physiological changes? An airport security check simulation experiment. International Journal of Psychophysiology, 2021, 165, pp.29-35. 10.1016/j.ijpsycho.2021.03.008 . hal-03992368

HAL Id: hal-03992368
https://hal.univ-lyon2.fr/hal-03992368

Submitted on 24 Apr 2023

Version of Record: https://www.sciencedirect.com/science/article/pii/S016787602100132X
Manuscript_646484ef6cc240cbc45aace2cf8a0b16

Does hostile intent cause physiological changes? An airport security check simulation experiment

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Word count: 8,180 with the references

Conflict of Interest: The authors declare that they have no conflict of interest.

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Abstract

The present research was aimed at investigating in a simulation experiment whether the initiation of a hostile project in an environment akin to airport security checkpoints would translate in variation of cardiac activity. Twenty-three participants (eight women) enrolled as mock passengers had to make several traverses of a security checkpoint while carrying luggage containing either a neutral or a falsely dangerous item. The traverses with the falsely dangerous item were associated with an elevation of heart rate and higher drops of heart rate variability than the traverses with the neutral item. These effects were more salient for the first traverses. Implication of results for security management and the role of arousal and mental workload in threat detection are discussed.

Keywords: Deception; Hostile intent; Heart Rate Variability; Cognitive load; mental stress; aviation security

1. Introduction

Air transport activities and airport settings have a long history of deadly terror attacks - The world’s deadliest airline disaster being the September 11 attacks. Although terrorism perpetrations at airports or in context of air transports are rare, many transport administrations have developed dispendious security programs designed to prevent as much as possible their occurrences. For example, in the aftermath of the transatlantic aircraft plot in 2006, the USA’s transport and security administration has deployed the screening passengers through observation technique (SPOT) program to all the United States (Weinberger, 2010). Behavioral deception sciences have largely influenced these programs (Weinberger, 2010) which mostly rest upon Darwin's hypothesis (1872) that the automatic components of emotional expressions cannot be voluntarily concealed when triggered (Ekman & Sullivan, 2006). If it could be acknowledged that leakage of some observable behaviors is barely unavoidable, their use for detecting deception is problematic because, in realistic settings, both guilty and innocent suspects may exhibit similar cues (e.g., stress, fear of being detected). As a result, it is not striking that behavior detection programs have spawned often-heated debates about its scientific validity (Ormerod & Dando, 2015; Weinberger, 2010), despite the advocacy that results from independent scientific scrutiny could hardly be made public.

What lies at the core of behavior detection programs at airport is the prevention of terrorism or unlawful actions through identification of markers of imminent pre-attack or pre-assault cues (National Commission on Terrorist Attacks Upon the United States, 2004). Pre-assault cues highlight the centrality of the notion of intention. Intention is a goal-directed mechanism that works towards an end-state (Malle & Knobe, 1997, Gollwitzer, 1999). Intention of perpetrating criminal or terrorist actions might have some physiological consequences because of the attentional resources devoted to the goal pursuit and to the concealment of believed suspicious behaviors (Mann, Vrij, and Bull, 2002; Sporer & Schwandt, 2007; Vrij, 2011). In this respect, previous findings have linked up hostile intent to changes in various physiological markers. For instance, it was evidenced that instructing people to transport mock explosives lead to higher subjective experience of hostile intent, higher levels of anxiety and inhibitory control than people from the non-hostile group (Wijn et al., 2017). Similarly, hostile intent in public crowded spaces were found to translate in various forms of bodily responses, including higher frequency of respiration, an overall significant change in salivary cortisol level, an increased heart rate, and a slight elevation of body temperature relative to control conditions (Eachus et al., 2013). Note that in this study, hostile intent was induced by having participants take photos without being detected. The magnitude of hostile intent was manipulated by instructing participants to cross a shopping mall faster than previous sessions and by warning them of the presence of closed-circuit television and plain-clothes security agents and of the fact that some individuals were allegedly caught in the same previous conditions. Additional research used eyeblink measurements as a proxy of arousal and cognitive load and revealed a lower frequency and duration of eyeblinks under the hostile intent condition in an interview, suggesting that nurturing hostile intent is more cognitively demanding (Marchak, 2013). Strikingly, diminutions in eyeblink rates were stronger when it came to lying about terrorist intent (i.e., explosive transportation) rather than about less serious unlawful actions (i.e., drug transportation), underscoring that the physiological effects of false intent are more elevated in high-stake cases. In a more recent work, it was observed that higher electrodermal activities were found to coincide with deceptive intents, indicating that the mere intent to deceive is sufficient to significantly modulate the sympathetic nervous system (Ströfer et al., 2015).

1.2 Psychophysiology of Hostile Intent

Should individuals be about to execute a hostile project within a scrutinized place, they will need to feign inconspicuous behaviors (DePaulo et al., 2003) and vigilantly monitor their surrounding environment (Koller et al., 2015). Not only are these actions stressful to most individuals (Eachus et al., 2013), but they also engage higher attentional resources and executive control (Wijn et al., 2017). These actions have consequences on both the sympathetic and parasympathetic branches of the autonomic nervous system. An increase in HR is expected due to the sympathoexcitatory effects of the stressful situation. According to the neurovisceral integration model (Thayer and Lane, 2000), parasympathetically mediated HRV is able to provide insights into the complex relationship between the autonomic nervous system, the subcortical and the cortical regions. To allow an organism to generate emotional and cognitive functioning tailored to fulfill adaptive behaviors, the prefrontal cortex exerts an inhibitory control over the subcortical parts of the brain. This prefrontal-subcortical inhibitory circuit is linked to the cardiac vagal tone (Thayer et al., 2009). “Inhibition involves the suppression of prepotent, irrelevant, or interfering stimuli or impulses associated with concomitant excitatory processes” (Thayer et al., 2009, p. 145). If higher order cortical functions are linked to parasympathetic activations in the nervous system, then individual differences in vagally-mediated HRV at rest should selectively align with performances in executive tasks. In this matter, Hansen et al. (2003) have shown that high HRV people showed significantly better performances in an executive task than low HRV people. However, individual differences in HRV did not yield distinct performances in a non-executive task, suggesting that HRV is closely related to higher levels of cognitive functions. In other words, tonic (resting) cardiac vagal activity is associated with cognitive and emotional self-regulatory capacity. Alternatively, experiencing stressful and cognitively demanding situations are more likely to translate into a decrease of parasympathetically mediated HRV to respond to immediate demands. This represents a reduction of phasic (reactivity) cardiac vagal activity or withdrawal of cardiac vagal control, which reflects defensive responses in a challenging environment (Thayer et al., 1996). There is evidence that parasympathetically mediated HRV is reduced whenever individuals drive attentional focus toward threatening stimuli (Thayer et al., 1996), or else during a stressful speech task (Hughes and Stoney, 1996). In addition, some simulation studies incorporating tasks requiring situation awareness (e.g., Police shooting) have revealed that a decrease of HRV in the preparatory and execution phases of the task, as compared to the baseline and post recovery phases, was observed in untrained (but not in trained) police agents, suggesting that they experienced higher difficulty handling a rapidly changing dynamic events (Saus et al., 2006). Conversely, in the absence of cognitive load, augmentation of phasic cardiac vagal activity has been evidenced to reflect self-regulatory efforts (see Segerstrom and Nes, 2007). When the mental resources are strained, no enhancement of phasic HRV is observed, even for people with higher tonic HRV (Park et al., 2014). Diminution of sympathetically mediated HRV as reflecting cognitive workload has also been evidenced in various domains like educational cognitive performance (e.g., Croizet et al., 2004), mental tracking and arithmetic tasks (Ryu and Myung, 2005), or realistic flying simulations (Hidalgo-Muñoz et al., 2018). Interestingly, in a complex cognitive task implying additional auditory threat before and during the experiment, Mandrick et al. (2016) showed that increase in HR was impacted by both threat and task difficulty while decrease in HRV was uniquely impacted by the level of task difficulty. The authors suggested that the absence of detrimental effects of stress on cognitive performance was handled by cognitive strategies and compensatory efforts. In this respect, concomitant inclusion of both HR and HRV are needed, especially when a situation entails both an emotional (stress) and a cognitive component (mental effort) (see Mandrick et al., 2016; Riese, 1999). In addition, according to Thyer et al. (2009), cognitive, affective, and physiological regulation are linked to vagally mediated cardiac function as indexed by both

HR and HRV. Heart rate variability decreases during episodes of mental stress (Madden and Savard, 1995). Also, changes in mere heart rate HR and HRV are produced in conditions requiring cognitive load (Porges & Byrne, 1992; Roscoe, 1992). Nonetheless, HRV is documented as more accurately reflecting variations in cognitive workload than HR, irrespective of the complexity of the task (see Wilson, 1992).

As hostile intent in a scrutinized environment requires transient attentional control, situation alertness, and mental efforts to appear inconspicuous, it would momentarily trigger cardiac vagal control withdrawal and elevation of sympathetic activity to respond to demands. Just like the Saus et al. (2006) study, having hostile intent in an exceptional context would create higher difficulty handling environmentally challenging events, especially regarding the fact that individuals are untrained. As such, a peripheral index such as parasympathetically mediated HRV should provide insightful information beyond that of HR because it would indicate a defensive action to cope with a stressful situation.

1.2 Overview of experiment

The present experiment adds to the previous works on hostile intent by connecting direct behaviors with more acute measurements of cardiac activities. In order to emphasize more thoroughly the physiological effects of hostile intent that might potentially occur at airport settings, we designed a laboratory experiment mirroring the condition of airport security checkpoint. Physiological effects of hostile intents are here appraised using electrocardiographic measurement. HR and HRV analyses carried out in this study coincided precisely with the moment of hostile phases (vs. non-hostile phases). Applying HR would indicate potential change of the level of sympathetic excitation in case of increase while HRV would afford important insights into the role of inhibition of parasympathetic activity in the development of hostile intent. **HR is influenced by both the sympathetic and the parasympathetic nervous systems. Sympathetic and parasympathetic nerves have**

antagonistic influences on heart rate. An increase in HR is indicative of a sympathetic stimulation through the release of norepinephrine at the SA node (see Klabunde, 2011). At rest, vagal influences on HR dominate. However, during episodes of stress, like trying to pass a security system with a prohibited item, an increasing sympathetic activity is expected. In other words, elevation of heart rate during the transportation of a prohibited item would mean that sympathetic stimulation outperforms the parasympathetic one.

A within-design approach was favored to limit the imputation of eventual differential responses to individual differences among participants. The positive side of experimental method, which is related to the establishment of ground truth, is tempered by the problem of reproducing the stake reflecting real criminal situations (Vrij, 2011). Herein, the stake was established by creating an environment of security surveillance in which the passengers are scrutinized by an agent and threatened to hear an aversive sound if suspected to carry prohibited items. In this experiment, the nonverbal interactions uniquely involved the agent and the passenger. Deceivers would have a greater level of stress and higher levels of circumspection or awareness, which could be attested by some variations in physiological responses (see Segerstrom & Nes, 2007). Therefore, it was posited that attempting to pass a security checkpoint undetected while carrying a prohibited item would be related to concomitant higher heart rate and a lower heart rate variability than attempting to pass with a non-prohibited item.

2. Method

2.1 Participants

All potential participants were contacted via email sent to the entire university campus with the description of the project attached. By the end, twenty-three participants (eight women, M_{age} = 36.26, SD_{age} = 12.32) volunteered for the experiment and signed a consent form. **A selection of the 46 studies measuring HR or HRV from a recent meta-analysis of the use of cardiac measures of cognitive workload (Hughes et al., 2019, information extracted from supplementary material) revealed that the median sample size was 21,5 (*M* = 27,3, *SD* = 23.1). Thus, our sample size was in line with other neuroergonomics studies measuring HR and HRV.**

A sensitivity analysis has been computed using MorePower 6.0 (Campbell and Thompson, 2012) with a power of .80, an alpha of .05, and a sample size of 23. The results yielded a partial η² of 0.28, which falls within the medium effect size range according to some recent guidelines (See Morris and Fritz, 2013).

The participants were all healthy and none of them had reported antecedents of heart disease or any other diseases affecting the nervous system. The screening was made with straightforward questions asked as inclusion/exclusion criteria prior to conducting the study and no medical professionals were involved in this scrutiny. These questions were as follows : Do you live with a condition that affects your cardiac activity or your nervous system? Are you under a medical prescription that could affect your daily cardiac activity? A research ethics committee has oversighted the experimental program prior to the recruitment stage. All participants received a laser pointer or an indoor fragrance for their participation.

2.2 Design

Each subject had to make seven traverses: An initial “familiarization traverse” referred to as the baseline passage were made without scrutiny and was also designed to make participants more familiar with the itinerary and the environment ; three traverses with the neutral item and three with the apparently dangerous item. The study used a within-subject design 2 (Neutral item vs. falsely dangerous item) × 3 traverses. Although all the participants had to make three hostile traverses and three non-hostile traverses, **the passing number** of all the six traverses was randomly arranged across participants. As a result, after the familiarization phase, some participants initiated the first traverse with the prohibited item while some others with the neutral item and the type of successive traverses also randomly appeared for the participants.

2.3 Materials

2.3.1 Setting. An improvised security checkpoint akin to a typical airport security checkpoint was constructed for the purpose of the experiment. In a 142 m² room (length= 13.88 m², width = 10.26 m²), we marked out a path by using retractable rope barriers forming a corridor until a transportable security gate. Two meters behind the security gate, a HD Pro video camera was front-positioned to take semi-close shots while participants went through the gate. At the left of the security gate, a fake security agent wearing an authentic security agent uniform was posted to observe each passenger and manually check the luggage when necessary. The mock agent did not appear in the camera field of view.

2.3.2 Audio. A wireless in-ear headphone was used to broadcast two different sounds to participants according to experimental conditions. The first sound was a Fingernails-on-blackboard sound effect used as a painful signal broadcasted at the end of the traverse depending on the situation. The second was a Harp sound effect used as a pleasant signal also broadcasted at the end of the traverse depending on the situation.

2.3.3 Transported items. We prepared a rolling suitcase packed with travel essentials. Within the suitcase, the participants had to transport as a function of the experimental process two types of items; either a neutral item (i.e., a diary) or an apparently dangerous prohibited item (false improvised explosive device, I.E.D).

2.3.4 State anxiety measure. A 6-item version of the state anxiety scale of the Spielberger State—Trait Anxiety Inventory (STAI, Marteau & Bekker, 1992) was administered to participants immediately after each passage. This instrument taps anxious states felt at the moment and is known to be particularly sensitive to short-term stressors (see Marteau & Bekker, 1992). An example is *" I feel tense"*. They indicated their levels of agreement in a four-point scale (1 = "Not at all", 4 = "very much"; **Total Cronbach's alpha = 0.75, mean inter-item correlation = 0.36).**

2.3.5 Physiological recording and data reduction. Throughout the experiment, the participants were equipped with a professional wireless ambulatory Holter ECG monitor (Faros 360 ®). To reduce invasiveness as much as possible, we had participants place the monitor using a chest strap with an easy step-by-step illustrated guide. ECG was acquired at a sampling frequency of 250 Hz. ECG data, timestamps and events were stored within the monitor during the experimental session and extracted with Matlab 2017a (© The Mathworks, Inc., MA, USA). Participants kept the monitor during all the experimental sessions and episodes were created from the moment the participants entered the room until they crossed the gate ($M_{Traversetime}$ = 18.19 seconds, $SD_{Traversetime}$ = 7.27 seconds). A 1st order zero-phase low-pass Butterworth filter was applied on signals with 15 Hz cut-off frequency in order to reject high-frequency noise and baseline wander artefacts. Pan-Tompkins algorithm (Pan & Tompkins, 1985) was used to detect QRS complex in the ECG signal. All filtered signals were visually checked. Occasional artifact noises were automatically replaced with the interpolated adjacent RR interval values, three participants were excluded due to several interpolated RR intervals greater than 5% (Peltola, 2012), leaving a final sample of 20 participants.

As the durations of episodes were ultra-short, we circumscribed the analysis to the time domain only (see Nussinovitch et al., 2011). Heart rate (HR) corresponds to the ratio between 1 second and the average duration of RR interval, multiplied by 60. Heart rate variability was measured as the root mean squared of the successive RR interval differences (RMSSD: Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). RMSSD is thought of as a commonly used measurement of the vagally-mediated changes predominantly featuring parasympathetic modulations (Nussinovitch et al., 2011). According to Nussinovitch et al. (2011) and confirmed by Munoz et al. (2015), RMSSD is the most reliable time domain indicator of HRV when dealing with ultrashort slices (10 s to 1 minute). In addition, respiratory frequency differences can be affected by the experimental conditions and can have some consequences on heart rate. Since RMSSD has been evidenced to be much less affected by respiratory frequency (Penttilä et al., 2001), its inclusion will help alleviate as much as possible this confounding variable.

2.4 Procedure

2.4.1 Initial phase. Upon arrival at the preparatory room located near the experimental setting, the participants signed the consent form and were screened for medicine use and medical issues. They were explained that they would participate in a behavioral screening passenger study. All the instructions were made orally. Once the Holter ECG monitor was placed, they made a first traverse meant to familiarize themselves with the exercise; they did not put something inside the rolling suitcase. The participants were explicitly said that the first traverse was meant to make them familiar with the environment and the route. They were warned that an agent would be in place, but we made them sure that their behavior would not be scrutinized for this familiarization phase. At the end of each traverse, they filled out the short STAI questionnaire.

2.4.2 Stake manipulation. After the first traverse, and once the participants indicated they understood the principle, they had to make three additional traverses with the neutral items and three others with the apparently dangerous item. The I.E.D was said to be nonfunctional and incomplete and it was clearly reminded that transporting such an object is highly prohibited and is legally punishable in real circumstances.

To elicit more evaluative pressure, the participants were tricked into thinking that the agent was a handpicked talented behavior detector enrolled to keep watching over them during the traverses while they were carrying the rolling suitcase. They were informed that if the agent estimated that they were carrying the apparently dangerous object, the agent would broadcast via their in-ear headphone a painful sound after having crossed the gate. Conversely, if the agent thought that they were carrying the neutral item, a pleasant sound would be broadcasted. The participants did not get acquainted with pleasant and the aversive sounds prior to starting the traverses.

The participants were said that their objective was to successfully pass the security gate undetected by this agent. Each time the unpleasant sound was broadcasted, the agent manually checked the suitcase. To make the agent skills credible, the experimenter surreptitiously sent a vibratory signal to the agent during the experimental process to indicate that the passenger is carrying the falsely dangerous device. Everything was organized such that the agent made only one false positive decision (i.e., signaling to the agent while the participant was transporting the neutral item) and only one false negative decision (i.e., not signaling the presence of I.E.D). The passing number of the traverses was counterbalanced across participants. The false positives and misses appeared randomly.

A suspicion check questionnaire was administered at the end of experiment and no suspicion of trickery was reported.

3. Results

3.1 Data Analysis

Statistical analyses were computed in R (R Core Team, 2017) using the *ez* ANOVA package (Lawrence, 2011). Post hoc analyses were carried out with the AFEX and the Lsmeans packages (R Core Team, 2020). Statistical significance for multiple comparisons and contrasts was adjusted with the Bonferroni method and the Kenward-Roger’s method was used for adjustment of degrees of freedom. We reported an effect size calculation that is more suitable to within-subject designs, the generalized eta squared (η^2_G) (Bakeman, 2005) **and also provide partial eta squared in parentheses**. The data and R scripts (and an SPSS file version) are publicly available on the open science framework platform (https://osf.io/yf4cx/).

The descriptive statistics of the studied variable are presented in Table 1.

Table 1. Descriptive statistics of state anxiety and cardiac features

Variable	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
STAI	6	18	10.8	3.20
Anxiety change scores	-8	13	1.85	3.55
HR (bpm)	**67.57**	**156.35**	**101.29**	**20.27**
RMSSD (ms)	**4.64**	**95.66**	**19.48**	**15.11**
HR change scores (bpm)	-32.55	55.44	8.77	13.06
RMSSD change score (ms)	-34.43	57.58	-1.95	15.28

Note: HR = Heart rate in beat per minutes, RMSSD = Root Mean Square of successive RR interval differences expressed in milliseconds.

3.2 Manipulation check

We first tested the differences in self-reported state anxiety between each condition (i.e., neutral item vs. falsely dangerous item). Relative indexes were calculated by subtracting the baseline scores from those of the condition scores. Baseline scores reflected state anxiety measured after the familiarization phase.

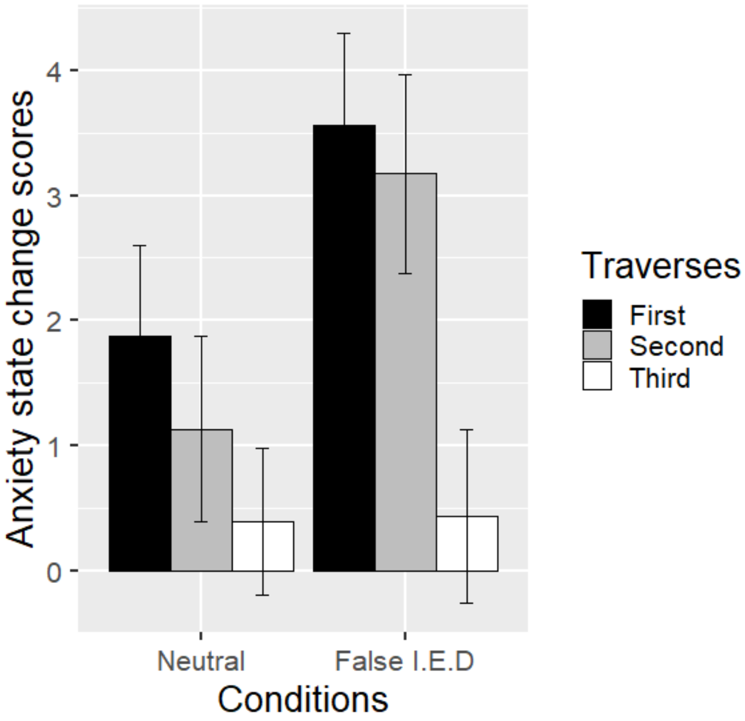

Figure 1. **Anxiety state change scores as a function of hostile intent condition**. Each bar depicts the average mean of state anxiety relative to the baseline. Scores higher (lower) than zero reflect higher (lower) levels of anxiety states than the baseline. Error bars represent standard errors of the mean.

The relative state anxiety scores were subjected to a 2 × 3 repeated measures ANOVA. The analysis detected a significant main effect of the condition, F (1, 22) = 5.72, p = 0.026, $\eta^2_G = 0.04$ ($\eta^2_p = 0.22$). The traverses with the false I.E.D were associated with higher levels of relative state anxiety (M = 2.55, SE = 3.73) than the traverses with the neutral item (M = 1.14, SE = 3.25). The analysis also detected a **passing number** effect, F (2, 44) = 8.56, p = 0.026, $\eta^2_G = 0.06$ ($\eta^2_p = 0.35$). Linear contrasts have shown that the first and the second traverses (M = 2.7, SE = 3.58) were associated with higher levels of anxiety states than the third traverses (M = 0.71, SE = 3.03), t(44) = 4.67, SE = 0.49, adjusted $p < 0.001$, Cohens' d = .70, 95 % CI [0.37 : 1.03], and with higher levels than the second traverses (2.14, SE = 3.79), t(44) = 3.53, SE = 0.49, adjusted $p < 0.003$, Cohens' d = .53, 95 % CI [0.21 : 0.84]**.** No statistically significant differences were observed between the first and the second traverses. The interaction effect between the condition and the **passing number of the traverses** was not significant, *F* (2, 44) = 2.63, $p = 0.08$, $\eta^2_G = 0.01$($\eta^2_p = 0.10$).

3.3 HR analyses

To test the hypothesis of the differential levels of HR between the conditions, we have calculated HR change scores by subtracting HR scores of the conditions from that of the baseline condition corresponding to the familiarization phase. We computed a 2 × 3 repeated measure ANOVA with the **passing number** of the traverses and the condition as factors and HR as dependent variable.

The analysis detected a significant main effect of the condition, *F* (1, 19) = 8.01, $p = 0.011$, $\eta^2_G = 0.02$, ($\eta^2_p = 0.30$), showing that the level of HR in the neutral condition was lower (*M* = 8.08, *SE* = 2.52) than that of the false I.E.D condition (*M* = 12.002, *SE* = 2.92). The analysis also detected a significant main effect of **passing number** , *F* (2, 38) = 5.11, $p = 0.012$, $\eta^2_G = 0.02$, ($\eta^2_p = 0.21$). Linear contrasts have shown that the first traverses were globally related to higher HR (*M* = 12.73, *SE* = 3.19) than the third traverses (*M* = 8.81, *SE* = 3.19), *t*(38)= 2.84, SE = 1.46, adjusted $p < 0.04$, Cohens' *d* = .46, 95 % CI [0.12 : 0.79]. Finally, a significant interaction effect was observed, *F* (2, 38) = 3.5, $p = 0.04$, $\eta^2_G = 0.013$, ($\eta^2_p = 0.16$). Simple effects analysis have shown that the interaction was qualified by the difference in HR between the neutral item (*M* = 8.75, *SE* = 2.75) and the false I.E.D of the first traverses (*M* = 16.70, *SE* = 4.05), *t*(55)= -3.7, SE = 2.15, adjusted $p < 0.008$, Cohens' *d* = .50, 95 % CI [0.22 : 0.77] and by the difference in HR between the first **passing** (*M* = 16.70, *SE* = 4.05) and the third **passing** in the false I.E.D condition (*M* = 9.06, *SE* = 2.65), *t*(76)= 3.76, SE = 2.03, adjusted $p < 0.005$, Cohens' *d* = .43, 95 % CI [.19; .67].

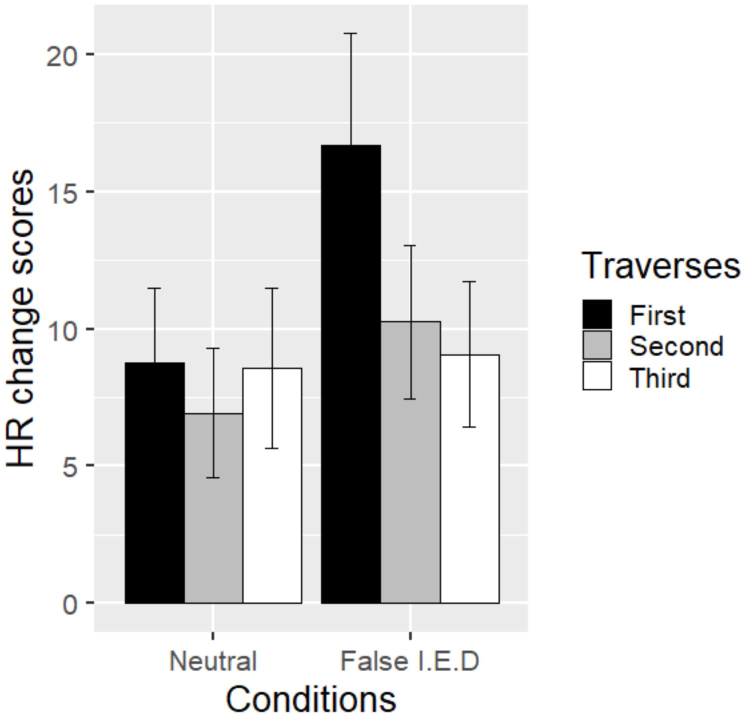

***Figure 2*. HR change scores as a function of the conditions and traverses**.

Each bar depicts the average drop in HR relative to the baseline. Error bars represent standard errors of the mean.

3.4 HRV analyses

The same procedure as detailed above concerning statistical analyses of HR was applied to HRV with RMSSD values. RMSSD values were subjected to a 2 × 3 repeated measures ANOVA. The analysis yielded, as predicted, a significant drop of HRV across the conditions, F (1, 19) = 6.22, p = 0.022, $\eta^2_G = 0.05$, ($\eta^2_p = 0.25$). Effect size is medium and consistent with sensitivity analysis. The traverses with the false I.E.D were associated, as predicted, with higher drops of HRV (M = -5.83, SE = 2.12) than the traverses with the neutral item (M = 0.65, SE = 2.65). No statistically significant **passing number** effect, F (2, 38) = 1.22, p = 0.30, $\eta^2_G = 0.02$, ($\eta^2_p = 0.06$), nor interaction effect were detected, F (2, 38) = 0.48, p = 0.61, $\eta^2_G = 0.003$, ($\eta^2_p = 0.02$).

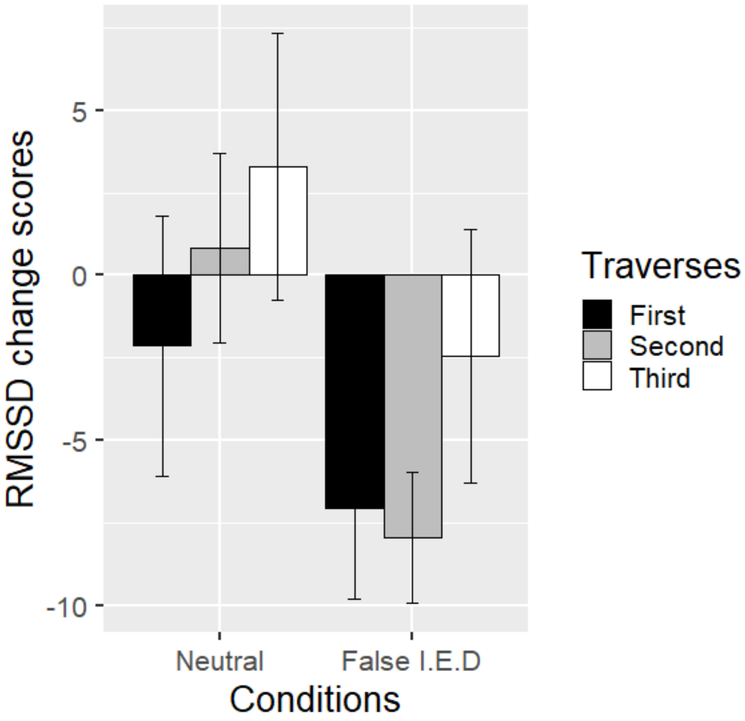

Figure 3. Drops in HRV as a function of the conditions and traverses.

Each bar depicts the average drop in HRV relative to the baseline. Error bars represent standard errors of the mean.

4. Discussion

The present research was aimed at testing the premise that hostile intent would predict differential physiological responses in the context of a controlled experiment. To our knowledge, there was no research examining heart rate variability of nonverbal hostile intent. Our data support the hypothesis that the nature of the object to be transported triggered higher levels of both state anxiety and physiological responses in passengers. The results provide a novel insight into the previous work by showing that hostile intent relates to transient physiological change in a controlled experiment. More specifically, using HRV measures indicated that attempting to get around a security checkpoint undetected prompted significantly more physiological stress in participants. These results provide a new groundwork for the idea that intent to deceive predicts different neurophysiological responses usually due to attempted behavioral control to convey good impression (Vrij, 2011). From a psychophysiological point of view, it is suggested that a hostile maneuver in a context of surveillance imposes a threat, which triggers a defensive response akin to a ‘fight-or-flight’ response (Jansen et al., 1995). This response is indicated by the withdrawal of cardiac vagal control under pressure (Thyer et al., 1996; Park et al., 2014). In this kind of situation, the prefrontal inhibitory regulation is attenuated and the sympathoexcitatory subcortical pathway is exacerbated. The attribution of the reduction of phasic HRV in terms of increased cognitive load is a possibility that could not be guaranteed since the situation possibly conflates stress and cognitive demand, and phasic HRV does not constitute in itself and by itself a selective measure of cognitive load.

Interestingly, building upon HR results, the effects seemed to vanish as the passengers performed more traverses. This effect was accompanied by a decrement in the degree of self-reported anxiety. One explanation is that the participants became progressively accustomed to the experimental design and that the stake and the object to be transported would no longer have an impact on them. A psychophysiological interpretation would afford the idea that participants lately managed to exert emotional self-regulation, which would be a favorable condition to self-presentational strategies in deceptive situations (DePaulo et al., 2003). There is evidence that an increase (Thayer et al., 1996) or even a smaller decrease in cardiac vagal control reflects a better executive control under pressure as compared to a larger cardiac vagal control withdrawal (e.g., Laborde and Raab, 2013; Laborde et al., 2014). If this observation is not only related to the features of experimental conditions, an important inference can be drawn on the alleviating effects of training and mental preparation. Cognizant that passengers’ behaviors would be scrutinized for, it is possible that individuals with malicious intent who are planning an attack at the airport undergo an intensive phase of mental preparation enabling them to better cope with this stressful situation and enhance the inhibitory activity of the prefrontal cortex (elevated tonic HRV) to engage more cognitive and emotional adaptivity (Thayer et al., 2009). As such, the occurrence of expected changes could be less noticeable, and the process of detection could therefore be hampered.

Our finding is consistent with the Eachus et al. (2013) study in which distinct physiological responses─reflected by measurements of cortisol, stress pheromones, heart rate, respiration, and body temperature─ emerged by merely having participants perform hostile reconnaissance (inconspicuously taking photos in a shopping mall). Importantly, in the Eachus et al. (2013) study the examination of participants' behaviors recorded on CCTV did not confirm a difference between low intent and high intent. As such, physiological differences in the context of hostile intent do not guarantee that physiological signs of stress might stand out behaviorally. Behavioral screening programs are underpinned by the rationale that criminal engagement entails identifiable observable behaviors that would not be present in the absence of intention. Evaluating the core effectiveness of such programs implies the examination of this conjecture. If there is no scientific evidence that hostile intention is noticeable, then the implementation of behavioral programs could be unproductive. In malevolent individuals, hostile intent is likely deemed negative because of the awareness that the project constitutes an outright violation of basic norms of morality. The stakes associated with the criminal project modulate the intensity of the hostile intention, which could modulate physiological responses. For instance, discreetly taking photos might not be like trying to dissimulate explosives, even in a mock paradigm.

Although this project falls into the domain of hostile intent in nonverbal communication context, the results should be discussed in the perspective of psychophysiological measures of deception detection to shed the light on potential issues with research on hostile intent. Like much deception works relying on measures of the activity of autonomic nervous system (ECG, GSR, BP) and central nervous system (EEG, and fMRI), differential responses in deceptive behaviors were reported (e.g., Furedy et al., 1988; Gödert et al.,2001; Meijer et al., 2014). These elements are sometimes the only indicators upon which deception is inferred. Such a process can suffer from a drawback that neuroscientists are familiar with when it comes to interpret physiological data: the reverse inference fallacy (Poldrack, 2006). Bluntly put, it refers to the proclivity to reason backwards from physiological or neuroimaging data to infer a specific state or cognitive activity without direct measurement of them. If deceptive conducts triggered differential physiological responses, relying on such responses could not be retained as necessary nor sufficient condition for inferring deceptive conducts in the future (Meijer et al., 2016). The reasonable empirical evidence for the validity of the premise should not translate into an affirmation of the consequent leading to impart empirical credential to behavior detection. A single physiological response might originate from many types of intentions as well as a single intention might be related to many different types of physiological states (see Burgoon et al., 2005, 2009). From a more practical standpoint, only trusting machine-based pre-crime detector showing physiological manifestations and brain activity of passengers - e.g., the future attribute screening technology, FAST (see Weinberger, 2011) - could be insufficient and counterproductive. Note that while methods designed to make high probabilistic inference about deception (e.g., the Control Question Test) differ in many important features from methods designed to detect concealed memories (e.g., the Concealed Information Test) (Ben-Shakhar, 2012), **physiological responses (e.g., skin conductance, electrocardiogram, and respiratory activity)** remain the only indicators of these procedures and could therefore be affected by this fallacy.

This research project emphasizes the necessity of performing crime simulation protocols with physiological measurements without discarding the utilization of self-report measures. The main advantage of resorting to physiological measurements beyond self-report is linked to the possibility to capture the richness of mental processes at work within a specific context of simulated crime attempts. This line of reasoning is consistent with a recent evidence in an experimental study of fear of crime which suggests a discrepancy between physiological and self-report results (see Castro-Toledo et al., 2017).

Some limitations need to be addressed. Even though results yielded as hypothesized, using HRV is not sufficient in itself and by itself to disentangle the implication of cognitive load and arousals. We may simply concur that mental workload might have been operant while being cautious about its relative impact during a mock criminal intent. Secondly, in the design, the choice that has been made to elevate the experienced stake can be a limitation. The signaling sent to the agent about the exact moment when the luggage inspection needed to be made may have impacted the way the agent treated the participant, making it less clear about whether the observed effects were only due to the hostile intent.

4.1 Concluding remark

The simulation experiment had demonstrated that transporting a prohibited item generated a phasic cardiac vagal withdrawal. The observed effects appeared to be stronger during the first and second traverses, which raises the question of training and familiarity. It is unclear at this stage how transporting the prohibited item was conducive to these physiological effects. The stress might stem from the action of feigning normal appearance while concealing the item or from the simple action of transporting an evocative and symbolically dangerous item, or both. Future studies are needed to disentangle the effect of stress management and the effect related to mere transport of a prohibited item using a broader variety of physiological measurements.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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