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RESEARCH ARTICLE

Further Evidence of the Possibility of Exploiting Anticipatory Physiological Signals To Assist Implicit Intuition of Random Events

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Abstract—With this study, we aimed to replicate and extend the findings obtained by Tressoldi, Martinelli, Zaccaria, and Massaccesi (2009) who showed that in participants with high scores on the Tellegen Absorption Scale (score > 20), anticipatory heart rate responses in an implicit pre-alerting paradigm could be used to improve their intuitive decisions on random events. In this study, two pools of pleasant and alerting sounds were used to test the generality of previous findings. By using fifty participants, it was also possible to study whether gender could be a further moderator of the observed effect. Results confirm the findings of Tressoldi, Martinelli, Zaccaria, and Massaccesi (2009), clarifying that the effect was present only in females. Females with a high level of absorption predict more hits than females with a low level. Further statistical analysis suggests that absorption acts as an implicit cognitive "filter" only for pleasant sounds.

Keywords: anticipatory responses—heart rate—intuition—random events—absorption—gender differences

Introduction

Since the pioneering findings of Radin (1997) and Bierman and Radin (1997), the pre-sentiment effect has received further support (Bierman & Scholte, 2002, Bierman, 2004, McCraty, Atkinson, & Bradley, 2004a, 2004b, Radin, 2004, Radin & Borges, 2009). Furthermore, this effect has been observed using conceptually similar paradigms to alerting (Spottiswoode & May, 2003, May, Paulinyi, & Vassy, 2005) and guessing tasks (Sartori, Massaccesi, Martinelli, & Tressoldi, 2004, Tressoldi, Martinelli, Massaccesi, & Sartori, 2005). All this evidence suggests that it is possible to measure differential anticipatory psychophysiological signals (galvanic skin responses, heart rate, fMRI, slow cortical potentials, pupillary dilation) related to two categories of stimuli, that is emotional versus neutral images, target versus non-target pictures, alerting versus neutral or pleasant sounds.

Apart from the interest in studying this phenomenon in more detail to comprehend whether it represents a true violation of a unidirectional arrow of time or a simple anticipatory response to conscious awareness (see, for example, Bierman's "Consciousness Induced Restoration of Time-Symmetry" theoretical perspective, in Bierman 2008), there is also an interest in exploring whether this effect can be used to predict the category of future information.

Tressoldi, Martinelli, Zaccaria, and Massaccesi (2009) in one exploratory and one confirmative experiment employing a pre-alerting paradigm, observed that participants with a high level of absorption[1] (score > 20 on the Tellegen Absorption Scale) were able to predict pleasant and unpleasant sounds in an implicit intuitive task (without overt responses), using a special apparatus to analyse anticipatory heart rate frequency. In these experiments, the number of male and female participants was insufficient to be analysed separately in order to control for the presence of a gender effect.

Purpose of the Study

The rationale behind the hypothesized relationship between absorption and correct guesses of random events is based on the premise that this particular personality trait may favor the use of intuition, by exploiting the capacity to adopt a mental set free from any cognitive activity that could interfere with a pure guessing approach. This approach is the only one possible if the task requires the prediction of random events, because any other conscious or implicit strategies are fruitless.

By recruiting a larger sample, we will test whether gender can be a further moderator of the pre-alerting effect. Furthermore, using a second pool of sounds, we will test whether this effect is independent from the pool of sounds used previously.

To summarize, we aimed to test the following main hypotheses:

H1. If our procedure permits the use of anticipatory heart rate signals to predict the category of incoming sounds beyond Mean Chance Expectation (MCE) = 50%

H2. If only participants with a high Absorption level will obtain this result

H3. If gender has as a mediating effect on the above expected results, that is if males or females with high or low Absorption level will obtain different results. This hypothesis is clearly exploratory because, at the moment, there is no clear evidence suggesting which one of the four combinations among gender and level of Absorption is more advantaged to exploit the anticipatory heart rate signals.

Methods

Participants

Fifty participants, 34 females and 16 males, were recruited by email and personal contacts by the third author (LS) and asked to complete the Tellegen Absorption scale (Tellegen & Atkinson, 1974). Their chronological age was M = 32, SD = 11.9, range 23–60; scores on the Absorption scale, M = 21.4, SD = 3.7, range 17–32.

Stimuli and Apparatus

The first pool of 20 sounds, 10 judged to be neutral or pleasant and 10 judged to be unpleasant or alerting, was the same used by Tressoldi, Martinelli, Zaccaria, and Massaccesi (2009) using the procedure suggested by Bradley and Lang (2000). The two sound categories were judged to be significantly different for the parameters of pleasure and arousal.

Pleasure: pleasant sounds, M = 5.47, SD = 1.28; alerting sounds, M = 2.20, SD = .59
Arousal: pleasant sounds, M = 3.29, SD = .63; alerting sounds, M = 6.58, SD = .71

The second pool was extracted from the International Affective Digitized Sounds (IADS) collection (Bradley & Lang, 1999, 2000), selecting 10 among those with higher scores and another 10 among those with lower scores on pleasantness from within the lists of males and females.

Means and standard deviations of pleasantness and arousal of the two sound categories are presented in Table 1.

Statistical comparisons of both Pleasantness and Arousal were similar (*ns*) for males and females, whereas the differences between the categories were statistically significant with Cohen's ES (*d*) = 8.3 for Pleasantness and 2.1 for Arousal.

TABLE 1
Means and SDs of Pleasantness and Arousal Scores of the Two Sound Categories for Males and Females

	MALES		FEMALES		MALES		FEMALES	
	PLEASANTNESS				AROUSAL			
Sounds Category	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pleasant	7.0	.2	7.6	.3	5.0	.2	5.0	.2
Alerting	3.4	.2	2.6	.3	6.7	.2	6.9	.3

SD, standard deviation.

Heart Rate Sampling

The software for heart rate data acquisition was original and devised for experiments like the present one (Massaccesi, 2001). Briefly, the apparatus for heart rate acquisition consisted of an optoelectronic sensor for a photoplethysmographic measurement by infrared light applied to the index finger of the left hand. The signal was subsequently conveyed to a Pulse Monitor 701 and to a SCB-68 National Instrument card converting the analogical signal to digital and fed to a PC for online data acquisition.

Heart rate per minute was automatically estimated using the formula *P* (pulse) = 60,000 ms/IBI (inter beat interval).

Sounds Presentation. Sounds were stored on a PC and conveyed by headphones (model Inno Hit SH-154) using software utilizing a randomized algorithm (it returns a random number from 1 to 20 after initialization with a random value obtained from the system clock), written in C++ for these experiments by the fourth author (SM). Randomness was controlled for by a simulation of 5,000 trials. As expected, numbers frequency was represented as a discrete uniform distribution.

Procedure

Participants were asked to take part in an experiment on intuition conducted in two sessions, one right after the other.

Session One. In this session, participants were asked to listen to 20 sounds, 10 pleasant and 10 unpleasant, delivered randomly through headphones while their heart rate was being monitored. Moreover, they were asked to remain as calm as possible to prevent the occurrence of anomalies. Figure 1 illustrates the sequence of events in Session One.

After this session of the experiment, special software[2] averaged offline the heart rate data collected in the "pre-stimulus period" (5 seconds), extracting two vectors of data, one for each sound category, for each participant.

Session Two. In this session, as before, participants were asked to listen to 20 sounds, 10 pleasant and 10 unpleasant, delivered randomly through headphones while their heart rate was being monitored. The only difference with this session was that participants were asked to try and block out the unpleasant sounds and listen only to the pleasant ones by using their implicit intuition and simply "wishing" it. The computer would automatically "detect" their intuition and skip the unpleasant sounds. Figure 2 shows a schematic presentation of the sequence of events in Session Two.

In this second part of the experiment, for each of the 20 trials corresponding to the delivering of the 20 sounds, the heart rate data in the pre-stimulus period (5 seconds) were first normalized to z scores, as in Session One, and then

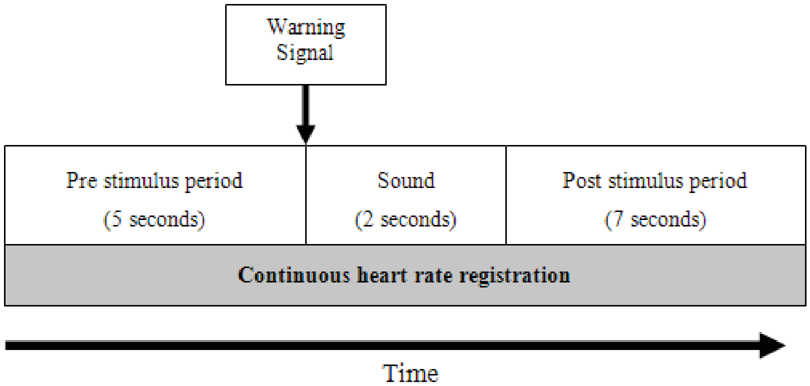

Figure 1. Sequence of events in Session One.

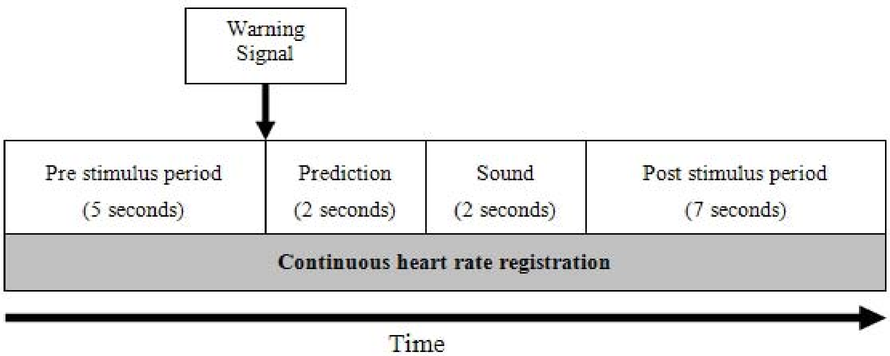

Figure 2. Sequence of events in Session Two.

correlated online, using Pearson's statistics, during the "prediction period" (2 seconds) before the sound presentation (see Figure 2), with the two vectors of data (relating to pleasant and unpleasant sounds) extracted in the first session, to predict the category of the incoming sound. For example, if the vector of data related to unpleasant sounds, extracted in Session One, correlated more with the data collected in the pre-stimulus period, an unpleasant sound was predicted and automatically skipped. In contrast, if a higher positive correlation was obtained with the vector of data related to pleasant sounds, a pleasant sound was predicted and delivered to the participant.

After each trial, participants did not receive any feedback so as not to alter their emotional state according to the success or failure of their predictions. At the end of the task, they were informed about the number of correct hits they had achieved.

If, during the experiment, any anomalies (e.g., anomalous heart rate recording due to the photoplethysmograph malfunctioning) were noticed by the research assistant, usually an undergraduate trained in carrying out psychophysiological experiments, the session was interrupted and restarted. The research assistant could not hear the sounds delivered to the participants, so was blinded to the predictions made by the computer. This meant there was no possibility of them altering the results according to their expectations.

All data were stored automatically on the PC's hard drive, and, once they were registered, there was no possibility of discarding or manipulating them online.

Sound Pools Comparison

To control if the two pools of sounds yielded different effects, we compared the means of percentages of correct hits identification (total number of pleasant sounds delivered + alerting sounds blocked/20). See Table 2.

TABLE 2

Means and SDs of Percentages of Hits Identification Obtained with the Two Sound Pools

Sounds Pool	Percentage of Hits Identification		
	Mean	SD	Number of Participants
Tressoldi, Martinelli, Zaccaria, & Massaccesi (2009)	.52	.09	24
International Affective Digitized Sounds	.52	.13	26

SD, standard deviation

The means of percentages of correct hits were almost identical between the two pools of sounds. As a consequence, all successive analyses were done collapsing the two pools.

To replicate the findings of Tressoldi, Martinelli, Zaccaria, and Massaccesi (2009), we divided participants according to their levels of Absorption using the cutoff of 20. Unlike the previous study, we separated males from females in the analysis of the data. Figure 3A and 3B show mean and 95% CI of blocked pleasant and alerting sounds in the different groups. We point out that an optimal performance should show zero blocked pleasant sounds and ten blocked alerting sounds.

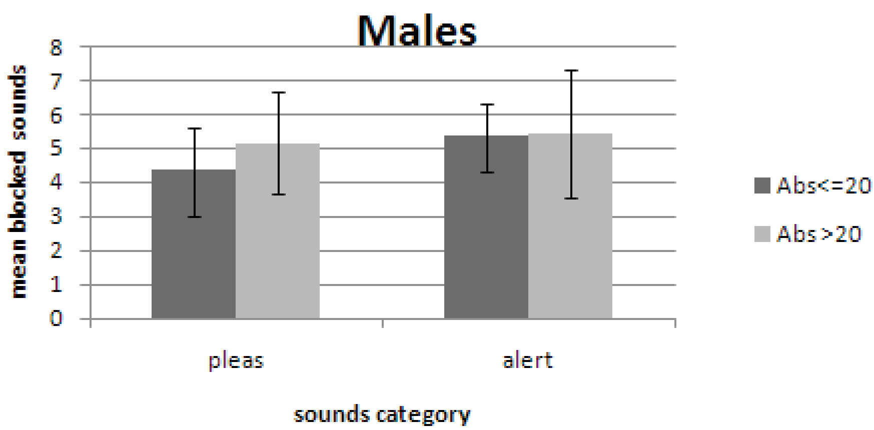

Figure 3A. Means and 95% Confidence Intervals of blocked pleasant and alerting sounds by males with different levels of Absorption.

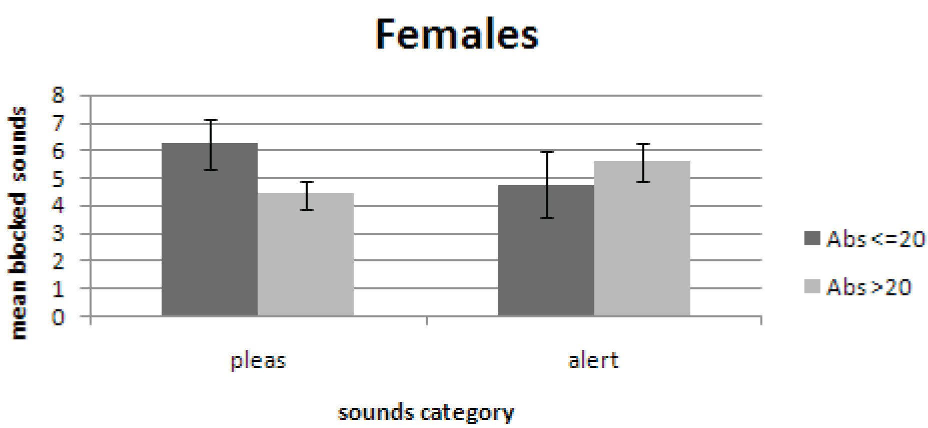

Figure 3B. Means and 95% Confidence Intervals of blocked pleasant and alerting sounds by females with different levels of Absorption.

In order to overcome the limitations of Null Hypothesis Significance Testing (Cohen, 1994, Hunter, 1997), and of the unbalanced number of participants in the different groups, and to extend the generalizability of the results, effect sizes and their corresponding confidence intervals were computed using the bootstrap procedure suggested by Algina, Keselman, and Penfield (2005, 2006)[3]. In Table 3, we report these results.

TABLE 3
Robust Effect Size *d* and 95% CI of the Difference between Blocked Pleasant and Alerting Sounds

Gender	Absorption Level		Pleasant	Alerting	*d*(95%CI)
Males	≤ 20 N = 9	Mean	4.3	5.3	.37 (−.59—1.8)
		SD	1.7	1.3	
	> 20 N = 7	Mean	5.1	5.4	
		SD	1.7	2.1	
Females	≤ 20 N = 12	Mean	6.3	4.8	*.78 (.19—2.1)
		SD	1.4	1.9	
	> 20 N = 22	Mean	4.4	5.6	*.91 (.34—1.8)
		SD	1.2	1.6	

*, differences statistically significant using Student $t(t(11) = 2.46, p = .032; t(21) = 3.69, p = 001$. Similar results were obtained using non parametric statistics (Wilcoxon test). CI, confidence interval. SD, standard deviation.

The data presented in Figure 3A and 3B and in Table 3 clearly show that only females show statistical and large effect size differences between blocked pleasant and alerting sounds. Females with a low level of Absorption blocked more pleasant than alerting sounds, whereas females with a high level of Absorption obtained statistically similar but opposite results.

Hits Results

Figure 4 presents the means and relative 95% Confidence Intervals of percentages of hits identification of males and females with different levels of Absorption.

Similar to the comparison between blocked pleasant and alerting sounds, only females with different levels of Absorption show a statistical and very large *effect size* difference in the percentage of hits identification, $d = 1.5$ (95% CI = .67–3.3).

Comparisons with Previous Experiments

If we compare the results obtained by Tressoldi, Martinelli, Maccaria, and Massaccesi (2009) in Experiments 2 and 3, with those obtained in the present study (see Table 4), we observe quite similar findings that once accumulated give further support to the main hypothesis of this research project.

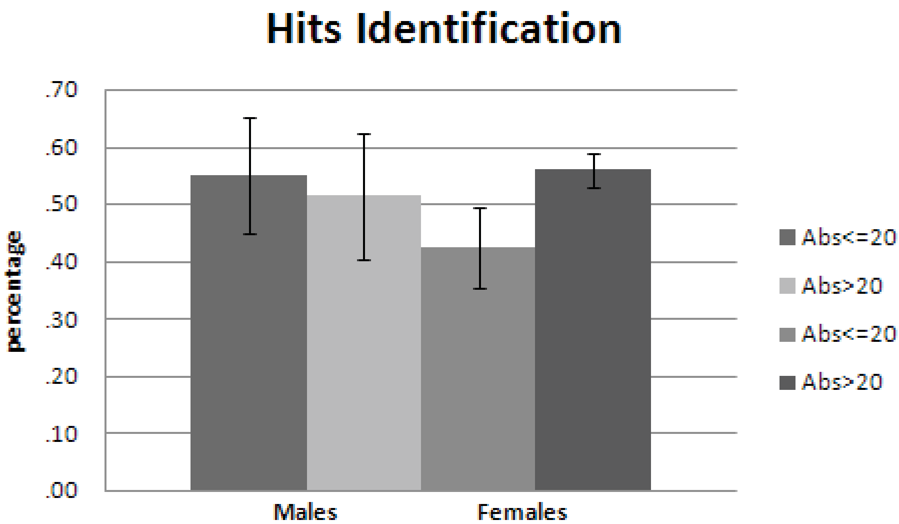

Figure 4. Means and 95% Confidence Intervals of percentages of correct hits identification by males and females with different levels of Absorption.

Correlations between Personality Scores, Number of Blocked Pleasant and Alerting Sounds, and Percentage of Hits Identification

Table 5 reports the Pearson (*r*) correlation obtained with the bootstrap procedure implemented with SimStat (Péladeau & Lacoutre, 1993) between scores on the Absorption scale and the number of pleasant and alerting blocked sounds and percentages of hits identification.

TABLE 4
Results Obtained in Experiments 2 and 3 by Tressoldi, Martinelli, Zaccaria, & Massaccesi (2009), and in the Present Study

	Pleasant vs. Alerting Number of Blocked Sounds (Only High Absorption Level)*	Percentage of Hits Identification (Low vs. High Absorption Level)*	Hits of Groups with High Absorption Level MCE .50	z and *ES* z/√N
Experiment 2	.90 (.16–2.9)	1.08 (.19–2.8)	.55 (111/200)	1.48 (.10)
Experiment 3	.66 (.17–1.5)	2.1 (.0–3.8)	.57 (103/180)	1.86 (.13)
This study	.91 (.34–1.8)	1.5 (.67–3.3)	.56 (246/440)	2.43 (.11)
Overall	.75 (.40–1.2)	1.4 (.70–2.6)	.56 (460/820)	3.46 (.12)

*, robust effect size *d* with corresponding 95% CI. CI, confidence interval. MCE, mean chance expectation.

TABLE 5
Simple Correlations and 95% CI, between Absorption Scores Number of Pleasant and Alerting Blocked Sounds and Percentages of Hits Identification

	Pleasant Sounds (Number Blocked)	Alerting Sounds (Number Blocked)	Percentage Hits Identification
Males n. 16	.13	.02	−.08
Females n. 34	−.53* (−.79, −.16)	.17	.52* (.24 − .73)

*, p < .01. CI, confidence interval.

It is evident that only females demonstrate a significant and large correlation between Absorption scores and percentage of hits identification. The specific role of absorption in this implicit intuition task is revealed by the significant and robust correlation between absorption and the number of blocked pleasant sounds and by the low and nonsignificant correlation with the number of blocked alerting sounds.

Discussion

The hypothesis that pre-alerting psychophysiological signals may be exploited to assist implicit intuition of random events suggested by the preliminary findings of Tressoldi, Martinelli, Zaccaria, and Massaccesi (2009) seems to be supported by the large effect size difference between blocked pleasant and alerting sounds of females with a high level of Absorption (d = .90), the large difference in the percentages of hits identification between high versus low absorption groups of females (d = 1.5), and the robust negative correlation (r = −.52) between Absorption scores and blocked pleasant sounds. In all these results, the level of Absorption emerges as a fundamental mediator, acting like a sort of implicit cognitive "filter" for pleasant sounds[4].

The cumulative evidence obtained comparing the result obtained in the present study with the previous one gives further support to this interpretation.

What this study adds to the previous findings is that the role of absorption manifests its effect only in females, suggesting that gender acts as a second important mediating effect in supporting implicit intuition. If we consider that in Experiments 2 and 3 by Tressoldi, Martinelli, Zaccaria, and Massaccesi (2009) where gender was not considered as a mediating factor—the percentages of females were 64% and 86%, respectively—their findings could be mainly due to the prevalence of female participants.

The role of gender in the pre-alerting studies also seems to be supported by the results obtained by Radin and Lobach (2007) using a random flash of light and a non-flash, by Radin and Borges (2009) using photographs with varying degrees of emotional affect, and by the experiment of May, Paulinyi, and Vassy (2005) who used 97 db acoustic stimuli alternated with silent controls, where the females' percentage was 66%.

It remains an open question why males seem not to have the benefit of this facility, because at present there are no studies related to the interaction between absorption and gender in intuition tasks.

From a theoretical point of view, the possibility of avoiding listening to unpleasant sounds and therefore listening only to pleasant ones may have implications for the intervention paradox, which highlights logical problems in using precognitive information to change the future event being precognized. However, the data reported in Table 3 shows that only the number of blocked pleasant sounds, the sounds that participants are actually listening to, are above or below chance. On the other hand, the number of blocked unpleasant sounds, those that will not be listened to in the future, are at chance level.

The procedure used in this study may be considered as another tool to investigate ESP, which, unlike ones that use forced and free choice variants, does not require explicit cognitive activity. With our procedure it is left to the "body" (heart rate) to do the task. However, as is often recommended in all ESP investigations (Braud, 2002), it is important to consider individual differences even when overt cognitive activity is not required. From our results, absorption and gender are revealed to be important moderators for implicit precognitive intuition, but other characteristics such as transliminality (Thalbourne, 2000), defined as a hypersensitivity to psychological material (imagery, ideation, affect, and perception) originating in (a) the unconscious and/or (b) the external environment, or other so-called "lability personality characteristics" such us those associated with mild dissociative experiences (Wolfradt, 1997), may contribute to similar effects.

Future replications are under way to test if these effects can be observed with other psychophysiological signals such as pupil dilation and blinking and, more importantly, if the percentage of hits identification can be improved.

Acknowledgments

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Notes

[1] The construct of *absorption* was originally identified in work on individual differences in hypnotizability (Hilgard, 1965, Tellegen & Atkinson, 1974). Iterative conceptual and psychometric work had led to the Tellegen Absorption Scale (TAS), a reliable self-report instrument. The concept of absorption was subsequently elaborated as involving ''imaginative and oblivious involvement . . . affective responsiveness to engaging stimuli . . . expansion of awareness . . . [and] responsiveness to highly 'inductive' stimuli,'' inter alia. More recently, Tellegen (1992) defined absorption as ''a disposition to enter into psychological states that are characterized by marked restructuring of the phenomenal self and world'' in which there is, in particular, an alteration in attention, whether it be expanded or narrowed.

[2] For each trial, the heart rate data registered during the 5 seconds in the pre-stimulus period (see Figure 1) were normalized to *z* scores to reduce differences in mean heart rate between participants (Ben-Shakhar, 1985), and associated with the category—pleasant or unpleasant—of the sound delivered. After the 20 trials, the values of the heart rates registered in the pre-stimulus periods were averaged to give two vectors of data, one related to the 10 pleasant sounds and one related to the 10 unpleasant sounds. All the software was developed in LabView by one of the authors (SM).

[3] Bootstrapping is a nonparametric approach to effect size estimation and hypothesis testing that makes no assumptions about the shape of the distributions of the variables or the sampling distribution of the statistic (see, e.g., Efron & Tibshirani, 1993, Mooney & Duval, 1993). This approach has been suggested by others as a way of circumventing the power problem introduced by asymmetries and other forms of non-normality in the sampling distribution. It also produces a test that is not based on large-sample theory, meaning it can be applied to small samples with more confidence.

[4] The probability of predicting unpleasant sounds more than by chance (MCE = 5), when the sound sequences end with a number from six to ten sounds of this category using conscious strategies to count the number of pleasant sounds, is $5/[20!/(10!*10!)] = 5/184756 = .000027$.

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