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To Do or not to Do: Inhibiting Attention and Action Depending on the Level of Extraversion

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Abstract

Research into inhibition processes has been very fertile in modern psychology, especially with the more common use of advanced methods such as functional brain imaging. Despite all the advances made many questions still remain concerning the nature of inhibition processes and the very existence of inhibition. The term inhibition is widely used in everyday life with many meanings which is reflected in the many definitions and methods used to investigate inhibition in psychology. The aim of this study was to determine the relationship between inhibition processes and extraversion. Participants (N=50) completed the Croatian version of the HEXACO-PI-R personality inventory (60 item version). Cognitive inhibition was measured with a location based inhibition of return task while behavioral inhibition was measured with a nonverbal Stroop-like interference task. Results show an interaction of extraversion and stimulus onset asynchrony (SOA) periods whereby extraverts show a greater inhibition effect at the shorter SOA periods (400, 600 ms) compared to introverts while the difference was nonsignificant at the longest SOA period (800 ms). The expected relationship between the two inhibition tasks was not observed. Implications for theories of extraversion and research concerning inibition processes are discussed.

Keywords: cognitive inhibition, inhibition of return, Stroop interference, personality, HEXACO, extraversion

Introduction

Concept of Inhibition in Psychology

The concept of inhibition has been a subject of research and discussion ever since the very beginning of psychology as a science. Early definitions of inhibition firmly establish it as a set of conscious processes. Ferrier (1886) defines it as the ability to inhibit behavior which emerges in the frontal areas of the brain. Wundt (1904) further observes that inhibition processes are not all or none, rather, they are context dependent and reactive, under the influence of many factors including

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individual differences. Since that time many psychologists have studied and identified various inhibition processes in areas such as: memory, visual search, visual attention, attention in general and many others (MacLeod, 2007). Technological advances have enabled functional brain imaging, with studies revealing involvement and the importance of specific brain areas for successful inhibition. It has been shown that frontal regions play an important role for inhibition of behavior while observing brain activity during completion of the Stroop task (Bernal & Altman, 2009; Chen, Wei, & Zhou, 2006). The anterior cingulate cortex has been shown to be important for both cognitive and behavioral inhibition, with a specific role in conflict detection and resolution. This was the case for a number of different tasks such as the Stroop task (Bernal & Altman, 2009; Carter & van Veen, 2007; Liu, Banich, Jacobson, & Tanabe, 2004), inhibition of return tasks (Mayer, Seidenberg, Dorflinger, & Rao, 2004), and complex reasoning tasks (De Neys & Glumicic, 2008). In their meta-analysis of 47 brain imaging studies, Nee, Wagner, and Jonides (2007) identify key areas of activation common to a number of inhibition tasks: anterior cingulate cortex, dorsolateral prefrontal cortex, posterior parietal cortex, inferior frontal gyrus, and the insula. Evidently the pattern of activation is quite diffuse and is accompanied by many other processes depending on the type of task and contextual factors.

The development of many tasks testing different types of inhibition has resulted in a state without a single, clear concept of inhibition. MacLeod (2007) proposes each researcher should clearly define the type of inhibition process he or she intends to study to reduce the possibility of confusion. For example, cognitive and behavioral inhibition are measured by administering different types of tasks and are presumed to activate different types of processes, and yet they are routinely clumped together under the umbrella concept of inhibition. For the purposes of this paper we have chosen clear definitions upon which to build, conduct and present our research. For a definition of behavioral inhibition we look to Miyake, Friedman, Emerson, Witzki, and Howerter (2000). They define inhibition as the volitional suspension of a dominant reaction, explicitly excluding automatic inhibitory processes from this definition. On the other hand, MacLeod (2007) defines inhibition as an intended or unconscious, partial or complete suspension or bypassing of a mental process. This is intended as a definition of cognitive inhibition (even though it can be generalised to behavior as well). The presented definitions represent the base from which we present and discuss our findings.

Inhibition of Return and the Stroop Task

The classic inhibition of return (IOR) task falls under the second of the two definitions given in the previous paragraph. It is an unconscious inhibition of attending to a previously searched area of the visual field. In the usual form of this task a participant is told to fixate his or her gaze at a central point and to react when a goal stimulus appears on either side in their peripheral vision. The goal is preceded by a cueing stimulus which can appear either on the same side or on the opposite side of the goal it preceeds (Cheal & Chastain, 1999; Tipper & Kingstone, 2005). The cue stimulus is sometimes called the orienting stimulus because it orients attention. The speed at which participants react to the following, goal stimulus depends on the length of the period between the cue and goal (stimulus onset asynchrony time – SOA). If the goal stimulus appears within 300 ms of the cue then participants react faster to a goal in the same location as the cue, a facilitation effect. The inhibition effect is present when the SOA time is above 300 ms. In that case participants react faster to a goal stimulus which appears on the opposite side of the cue (Hunt & Kingstone, 2003; Prime & Ward, 2004, 2006). Participants inhibit the process of focusing their attention to a previously attended location (provided a sufficiently long SOA interval) and this process is automatic. Automatic inhibition of attention has been proven to be a robust effect for many different tasks: discrimination tasks (Lupiánez, Milliken, Solano, Weaver, & Tipper, 2001), identification tasks (Cheal & Chastain, 1999), object recognition (Riggio, Patteri, & Umilta, 2004), and many others (Bao et al., 2011). The effect usually diminishes for SOA interval above 1400 ms (Riggio, Scaramuzza, & Umilta, 2000). The most common explanation states IOR is an adaptive process that saves time and effort while analyzing our surroundings (Berlucchi, 2006; Prime & Ward, 2006). Sapir, Soroker, Berger, and Henik (1999) advanced the discussion of the neural foundations of IOR in their hugely influential work. In their single participant study, a lesion to the right superior colloculus (SC) caused an absence of the usual IOR effect in the contralateral (left) visual hemifield with an intact effect in the right part of the field. The SC has been found to provide early analysis of visual stimuli and participates in attention reorientation (Rafal & Henik, 1994, as cited in Bari & Robbins, 2013; Redgrave et al., 1993, as cited in Winn, 2001). Since then the discussion has grown more complex with a number of researchers noting the SC is not necessary to induce the IOR effect but likely has a modulating effect (Dorris, Klein, Everling, & Munoz, 2002; Sumner, Nachev, Vora, Husain, & Kennard, 2004). Further research implicates other areas in the induction and modulation of IOR: the occipital cortex (Prime & Jolicoeur, 2009), the parietal cortex (Bourgeouis, Chica, Valero-Cabré, & Bartolomeo, 2013), associative visual areas (Dorris et al., 2002), and the anterior cingulate cortex (Mayer et al., 2004). Some have even questioned whether or not IOR is an inhibitory process at all (Pratt, Spalek, & Bradshaw, 1999) but for the purposes of this paper IOR is viewed as an automatic inhibition of attention reorientation to a previously attended location, an example of cognitive inhibition.

The classic Stroop task is a prime example of behavioral or intended inhibition. The participant has to name the color in which a word is written in congruent and incongruent, situations. The congruent situations pair the same meaning and color of the word, for example, the word *BLUE* in blue font. Incongruent trials pair different meanings and colors, for example the word *BLUE* in red font. Naming times are significantly longer for incongruent trials because of interference effects (Prime & Ward, 2006). It is necessary to effortfully inhibit a dominant response, reading the word, in order to correctly name the color of the font in conflict trials. There are nonverbal variations of the Stroop task as well. One of the most used nonverbal variations is the Pomerantz variant (1983; as cited in Prabhakaran, Kraemer, & Thompson-Schill, 2011) based on global and local movement. A larger frame moves in one direction, for example clockwise (global movement) while stimuli within it can move in the same or in the opposite direction (local movement). Participants need to respond by indicating the direction of local movement, inhibiting the dominant global movement. Enticott, Ogloff, Bradshaw, and Fitzgerald (2008) use a spatial variant of the Stroop task in which participants need to indicate where an arrow is pointing on the screen. The arrow can point towards the left or right while appearing on the left or right side of the screen. Conflict arises when the arrow is pointing in the opposite direction of where it appears on the screen. Compared to IOR the Stroop effect is more often associated with frontal brain activity, especially the dorsolateral prefrontal cortex (Carter & van Veen 2007). As in similar tasks, the other key area is the anterior cingulate cortex (Bernal & Altman, 2009; Carter & van Veen, 2007; Liu et al., 2004). Carter and van Veen (2007) hypothesize that the anterior cingulate detects conflict while frontal areas process and resolve it. For the purposes of this paper we developed a nonverbal Stroop-like task (see section on materials and methodology) which conforms to inhibition as defined by Miyake et al. (2000).

Personality and Inhibition

The history of personality as a concept is as old as human language, but true scientific research which resulted in modern models such as the *Big five* or the *HEXACO* model stems from the early 20th century. At the beginning of the 20th century Otto Gross describes two types of personality, the *broad/shallow* and *deep/narrow* types. The first experience stimuli, as the name itself describes, on a shallow level of intensity expending little *neural energy* as Gross called it. On the other hand, the second type is more easily aroused by stimuli and expends *neural energy* faster (as cited in Eysenck, 1987). Foundations laid down by Gross, Pavlov and others resulted in one of the most influential models of personality by Eysenck. According to Eysenck personality traits can be grouped into three main dimensions: extraversion, neuroticism, and psychoticism. The theory is also referred to as a biological theory of personality because Eysenck explains individual differences in terms of biological differences, specifically differences in levels of *arousal*. Extraversion is a result of activity in the reticulo-cortical loop. The reticular activation system stimulates cortical structures and dictates levels of arousal. According to this model extraverts have lower base levels of arousal than introverts which makes them seek more stimulating environments and activities. Introverts on the other hand need to keep arousal in check and prefer less stimulating surroundings (Eysenck, 1998; Matthews & Gilliland, 1999). Neuroticism is dictated by the levels of activity in the reticulo-limbic loop, under the influence of strong emotional reactions, while the neural foundation of psychoticism is not defined as clearly, but is hypothesized to be connected with the dopaminergic and serotonergic neurotransmitter systems (Eysenck, 1998). While results of testing the base arousal level hypothesis do not offer a consensus, studies have uncovered differences in *arousability* rather than *arousal* depending on extraversion levels. Psychophysiological research (EEG, evoked potentials, electrodermal activity) show larger spikes of activity during stimulation for introverts than for extraverts (Matthews & Gilliland, 1999; Zuckerman, 2005).

Cooper and Brebner (1987) introduce a *unified theory of extraversion* which proposes that stimulus analysis (S-analysis) processes arouse introverts and inhibit extraverts, while organizing reactions (R-organization) processes inhibit introverts, and arouse extroverts. Stimulus analysis within this theory describes orienting attention and extracting information about multiple stimuli, while organizing reactions refers to reaction choice and execution. This would predict fast reactions of introverts to the first of a series of stimuli due to high arousability but slower reorientation of attention for successive stimuli. Extraverts on the other hand seek to increase stimulation thus attending to successive stimuli faster. Using sound stimuli and measuring evoked potentials, Stelmack and Michaud-Achorn (1985; as cited in Stelmack, 1990) demonstrate that introverts react intensely to the first in a series of stimuli, while further stimulus analysis seems to be inhibited. While measuring the psychological refractory period (elongation of reaction times for the second of two successive stimuli) Brebner (1998) concludes that the first stimulus has a significantly smaller influence on extravert reaction times to the second stimulus compared to introvert reaction times.

Campbell, Davalos, McCabe, and Troup (2011) assessed the success rate on a variety of cognitive tasks including inhibition-based tasks depending on the levels of extraversion. Extraverts proved to be more successful with a significant interaction between extraversion and task difficulty; at lower levels of difficulty there was no difference between introverts and extraverts while at higher levels extraverts were more successful.

The aim of this study was to determine differences between introverts and extraverts for two different inhibition based tasks. We predicted higher levels of IOR and lower levels of Stroop interference for extraverts. On the IOR task extraverts should have an easier time reorienting attention from the cued location, resulting in a higher level of IOR effect. For the Stroop-like task extraverts should more easily attend to all stimuli and react accordingly which would result in lower interference and faster response times for incongruent trials. As was stated earlier, these two tasks measure different types of inhibition and while a correlation is to be expected, we predict it to be low to moderate rather than high.

Method

Participants

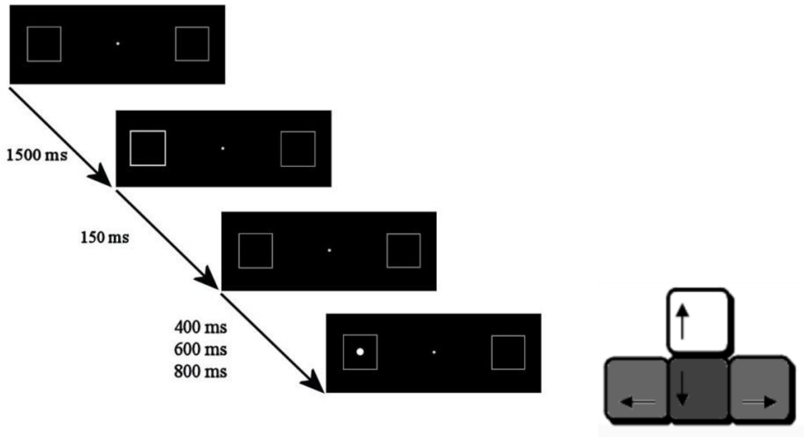
The sample (*N*=50) was recruited among undergraduate students of psychology at the University of Zadar. The group consisted of 45 female and 5 male students with a median age of 20 (a range of 18 – 26 years of age).

Materials, Design and Procedure

For the purposes of measuring extraversion and other personality traits the Croatian version of the HEXACO-PI-R personality inventory was used. The HEXACO model was developed by Ashton and Lee as an extension of the *Big five* model that has dominated research for the past few decades (Ashton et al., 2006). Alongside the standard five dimensions (E – emotionality, X – extraversion, A – agreeableness, C – conscientiousness, and O – openness to experience) it introduces the dimension of *honesty/humility*. While the model does define emotional stability (emotionality in the HEXACO taxonomy) and agreeableness somewhat differently than the classic big five approach, extraversion remains defined in the same way and high correlations between HEXACO and big five results have been observed (Ashton et al., 2006). This model was chosen because of its open source nature and the fact that a thorough validation for the Croatian version has been conducted (Babarović & Šverko, 2013). For this study we used the 60 item, short version of the HEXACO inventory.

To measure cognitive inhibition, as defined previously, an inhibition of return task was designed using OpenSesame v.0.27.4 open source experiment building software. Participants were seated in front of a 17" monitor (1280x1024 pixel resolution) at a distance of 50 cm. They were told to keep their gaze fixated at a central fixation dot. At either side of the dot two 192x192 pixel squares were presented (centers of the squares at a distance of 420px from the central fixation dot). A single trial started with a 1500 ms pause after which one of the squares became brighter for a duration of 150 ms. This was used as the *cue* (attention orienting) stimulus. The goal stimulus (a circle 40px in diameter) was presented 400, 600, or 800 ms (possible SOA intervals) after the cue stimulus. Congruent trials were the ones in which the goal stimulus appeared at the cued location, and conflict or incongruent trials were the ones in which the goals appeared on the opposite side. Participants were instructed to hold the index finger of their dominant hand above the *up* arrow on the keyboard and react as fast as possible with the appropriate arrow key on the keyboard: ← when the goal appeared in the left side of the fixation dot, and → when it appeared on the right. A single trial procedure example can be seen in Figure 1.

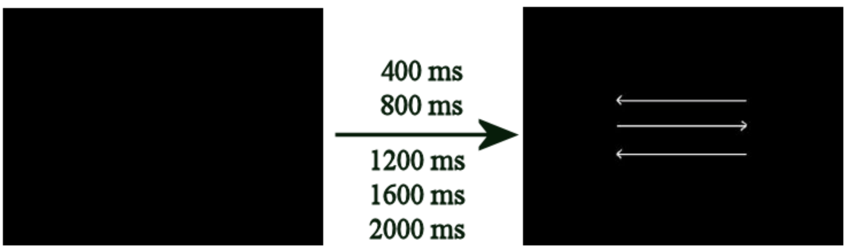
Figure 1. *IOR Task Procedure and Response Keys*



There were 96 trials in total: 48 congruent, 48 conflict, 32 trials per SOA interval, and 8 practice trials at the beginning. The order of trials was randomized for each participant. Responses, response times and accuracy were recorded in spreadsheet files by the software.

As a measure of behavioral, intentional inhibition, as defined earlier, a nonverbal Stroop-like task was designed in the same software package. In this simple task participants had to react to the direction of a middle of three horizontally oriented and vertically arranged arrows. A single trial procedure can be seen in Figure 2.

Figure 2. *Nonverbal Inhibition Task Procedure*



The arrows measured 192px in length, and could appear after a variable time delay. The varying time delay was introduced to avoid participant habituation to when the stimuli would appear. Congruent trials were those in which the middle arrow points toward in the same direction as the remaining two, while conflict trials (example depicted in Figure 2) were the ones in which the arrows pointed in different directions. There were 80 trials in total: 40 congruent and 40 conflict trials. For half of the conflict trials the goal arrow pointed towards the right side of the screen and for the other it pointed to the left. Trials were randomized for each participant. For a similar nonverbal inhibition task we recommend reading up on an example of the Flanker task in Pratt, Willoughby, and Swick (2011).

The study was conducted in the Laboratory for experimental psychology. Participants first completed the HEXACO inventory after which half of them completed the inhibition tasks in order IOR-Nonverbal Stroop, while the other half completed them in reverse order.

Results

For the inhibition measures all responses faster than 200 ms and slower than 1500 ms were not considered. Incorrect responses were also removed before average scores were calculated. For the IOR task 82% of participants did not make a single mistake while none of the participants had more than 3.2% percent total invalid responses (out of range or incorrect). The nonverbal Stroop was completed without mistakes by 44.9% of our sample. No single participant had more than 5% of invalid responses. One participant misunderstood instructions for the task and his results were removed from the sample.

The results show participants were faster for incongruent trials compared to congruent ones for the IOR task, while the opposite was true for the nonverbal Stroop task (Table 1).

Table 1. *Inhibition Tasks Mean Response Times and Standard Deviations*

Task	Congruent RT (ms)		Incongruent RT (ms)	
	M	*SD*	*M*	*SD*
IOR400	431.10	63.62	396.99	60.56
IOR600	397.00	57.83	378.26	64.35
IOR800	393.05	63.26	368.30	61.61
Nonverbal Stroop	466.96	67.88	511.27	72.08

A repeated measures 2 (congruence) x 3 (SOA interval) analysis of variance was calculated to determine whether a reliable IOR effect was induced. The analysis shows a main effect of SOA interval (F(1, 48)=52.28, p<.01) with post hoc tests (Tukey HSD) revealing significantly slower reactions for the 400 ms condition compared to the remaining two. A significant main effect of congruence was also observed (F(2, 96)=24.14, p<.01) which means participants were slower for congruent compared to incongruent situations. The two-way interaction was also significant ($F(2, 96)=4.32$, $p<.05$) because the effect was larger for the 400 and 800 ms condition even though it was still significant for the 600 ms condition. Stroop task interference significance was tested by calculating a t-test for dependent samples, the result shows that significant interference was induced ($t(46)=11.46$, $p<.01$).

For further analysis, a relative size of effect was calculated for each participant using the following equations.

$$IOR\ effect = \frac{congruent\ RT - incongruent\ RT}{congruent\ RT} \quad (1)$$

$$Stroop\ interference\ effect = \frac{incongruent\ RT - congruent\ RT}{congruent\ RT} \quad (2)$$

Equations (1) and (2) enable a calculation of pure effect size rather than the analysis of absolute differences. For example: if participant A reacts to a congruent IOR trial after 440 ms, and to an incongruent trial after 400 ms the absolute difference is 40 ms, the effect size is 9.1% (the reaction was that much faster). Observe that if participant B reacts to the same trials after 500 and 460 ms the absolute difference remains the same, but the effect size for participant B is smaller (8%). Calculating relative effect size better differentiates participant scores and allows for better comparison between different groups. Effect size data for the two tasks can be seen in Table 2.

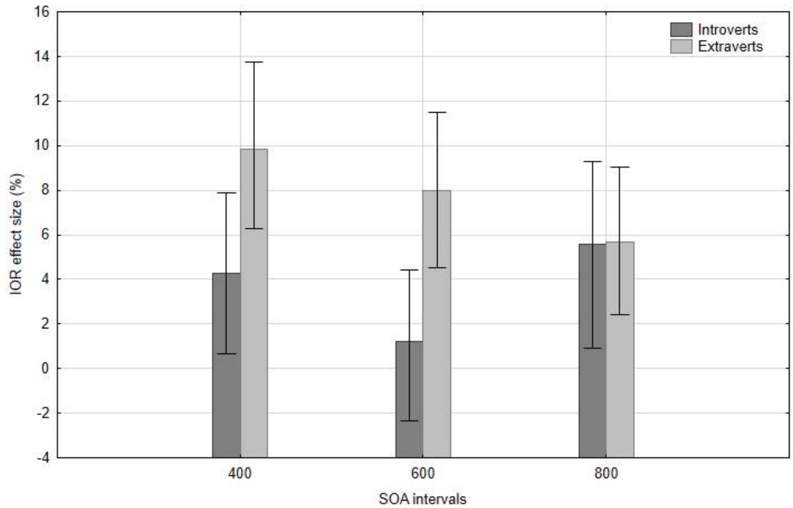
Table 2. *Effect Size Date for the Two Inhibition Tasks*

Task	*M*	*SD*
IOR400	7.38	10.26
IOR600	4.68	8.51
IOR800	5.81	10.25
Nonverbal Stroop	8.56	5.44

The results from the HEXACO inventory were used purely to define two groups based on median scores. For extraversion the median score was 3.4 ($M=3.42$, $SD=.55$). Participants were divided into higher and lower extravert groups (from now on introvert and extravert groups) based on median score. By doing this the extravert group numbered 24 participants, and the introvert group numbered 23. Participants with the exact median score were not assigned to either group.

In order to test size differences for the IOR effect depending on SOA intervals and extraversion a 2 (introvert/extravert) x 3 (SOA interval) mixed analysis of variance was calculated. The only significant effect was the two-way interaction ($F(2, 90)=3.61$, $p<.05$) which can be seen in Figure 3.

Figure 3. *IOR Effect Size as a Function of SOA Intervals and Extraversion*



Post hoc analysis shows significant differences between extraverts and introverts in IOR effect size for the shorter SOA intervals with no difference for the longest interval. There was no significant difference in Stroop interference size between the two groups ($t(45)=.10$, $p>.05$). Finally there were no significant correlations between the two inhibition tasks (all $r(47)<.20$, $p>.05$).

Discussion and Conclusion

This study aimed to determine whether or not extraverts and introverts experience different levels or timelines of inhibition processes. Results showed extraverts experienced a larger effect of IOR compared to introverts but only for short SOA intervals. These results are in line with previous research of the psychological refractory period (Brebner, 1998) as well as research by Stelmack and Michaud-Achorm (1985; as cited in Stelmack, 1990). Based on both studies, introverts are less attentive to the second of two stimuli, with the first occupying more of their attention. By increasing the time delay between the two stimuli introverts are enabled to reorient their attention. This is the exact pattern of results we encountered. Introverts were less effective (smaller IOR effect) at reorienting attention to the goal stimulus (inhibiting a previously cued location) but only when the intervals between the cue and goal stimulus were shorter. Extraverts seek more stimulation so they reorient attention faster and easier than introverts. It would seem the timeline of IOR effects is different for the two groups, which is indicated by a significant two-way interaction but not a main effect of extraversion on IOR size. Introverts require longer refractory periods (SOA intervals in the case of our IOR task) in order to effectively reorient their attention. It is interesting that there was no difference between the groups for the second inhibition task. This is probably due to the fact that one trial on the nonverbal Stroop task is made up of only one stimulus (the three arrows) while a single IOR trial consists of two (cue + goal). Introverts and extraverts seem to be under an equal influence of interference from the other two arrows since there was no difference in performance. We can speculate introverts and extraverts do not differ in speed of processing or the ability to inhibit contextual cues within a single stimulus. The effect we detected is rather subtle but does clearly indicate differences in processing. These differences are not qualitative but quantitative. The IOR process occurs for both introverts and extraverts but on a different *timetable* and with subtle differences in size. These findings are in line with a dimensional approach to extraversion as a personality trait, and support a psychophysical and psychophysiological approach to personality research. The results indicate a significant difference in *arousability* depending on extraversion levels. Introverts respond stronger on a psychophysiological level and this activity seems to inhibit attention reorientation, prolonging refractory periods thus decreasing IOR.

Additionally, it is interesting the two inhibition tasks were not correlated for our sample. This emphasizes the need for researchers to clearly indicate what type of inhibition processes are studied in their work. However, it is unexpected that the correlation was not even approaching significance since many researchers link activity of common brain areas to what are generally considered inhibition processes (Nee et al., 2007). It is important to note that the second inhibition task was designed specifically for the purposes of this study. Further research is required to determine factors and processes that influence performance for this type of task, as well as replicating the effect.

To conclude, the results of this study indicate size and timeline differences in expression of the IOR effect depending on the level of extraversion. Extraverts require a shorter refractory period to experience the effect, while introverts have a delayed onset of peak IOR due to higher arousability. Findings also emphasize the need for clear and detailed definitions of inhibition processes rather than lumping them under a single concept. Finally, some methodological refinements could be suggested as well as the introduction of other tasks/personality measures may expand our knowledge of both extraversion and inhibition processes.

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Hacer o no hacer: Atención y acción de inhibir dependientes del nivel de extraversión

Resumen

Investigaciones en el campo de procesos de inhibición han sido muy fértiles en la psicología moderna, especialmente con el uso más frecuente de métodos avanzados, como la imagen por resonancia magnética funcional. A pesar de todos los avances todavía quedan muchas dudas en cuanto a la índole del proceso de la inhibición y ya su propia existencia. Término inhibición se usa ampliamente en la vida cotidiana con varios significados que se reflejan luego en varias definiciones y métodos usados para investigarla en la psicología. El objetivo de este estudio fue determinar la relación entre los procesos de inhibición y la extraversión. Los participantes (N=50) completaron la versión croata del inventario de la personalidad HEXACO-PI-R (versión de 60 ítems). Inhibición cognitiva se midió con la tarea de inhibición de retorno basada en la locación, mientras que inhibición conductual se midió con la tarea de interferencia no verbal de tipo Stroop. Los resultados muestran interacción entre la extraversión y los intervalos entre estímulos (IEE) por lo cual los extravertidos muestran un mayor efecto de inhibición durante intervalos IEE más cortos (400, 600 ms) comparado con los introvertidos, mientras que no hubo mucha diferencia durante los intervalos más largos (800 ms). La relación esperada entre las dos inhibiciones no se ha observado. Se discuten implicaciones para la teoría de extraversión e investigaciones sobre los procesos de inhibición.

Palabras claves: inhibición cognitiva, inhibición de retorno, efecto Stroop, personalidad, HEXACO, extraversión

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