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Affective Simon Effect: A study in children and adolescents

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Artículo Original

Abstract

In this study, a modified variant of the Affective Simon Task (De Houwer & Eelen, 1998) was used in children and adolescents. Thus, we designed a task in which the participants had to respond choosing a happy or sad face depending on whether the figure presented on the screen was an object or an animal, ignoring its affective valence (positive or negative). Our results showed that the Affective Simon effect was produced only in the children group. Likewise, it was found that performance improved with age, which indicates an improvement of the processes involved in the resolution of the Affective Simon effect. The results of this study are a first exploratory approach to the investigation of the Affective Simon effect in children and young populations.

Palabras clave: Affective Simon Task, pictorial stimuli, children, adolescents.

Resumen

Efecto Simon afectivo: un estudio en niños y adolescentes. En este trabajo, se utilizó una variante modificada de la Tarea de Simon Afectivo (De Houwer & Eelen, 1998) en niños y adolescentes. Así, se diseñó una tarea en la que los participantes debían responder eligiendo una cara feliz o triste en función de si la figura presentada en la pantalla era un objeto o un animal, ignorando su valencia afectiva (positiva o negativa). Los resultados mostraron que el efecto Simon afectivo se produjo sólo en el grupo de niños. Asimismo, se encontró que el desempeño mejoró con la edad, lo que indica una mejora de los procesos involucrados en la resolución del efecto Simon Afectivo. Los resultados de este estudio brindan un acercamiento a la investigación del efecto Simon afectivo en niños y adolescentes.

Keywords: Tarea de Simon Afectivo, estímulos visuales, niños, adolescentes.

Tabla de Contenido

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The Simon effect, and the tasks which make use of it, take as a premise the prepotent tendency of human beings to respond ipsilaterally (i.e., on the same side where the stimulus appears; Hommel et al., 2004; Lu & Proctor, 1995). According to De Houwer and Eelen (1998), three elements define the Simon paradigm: (1) a relevant feature of the stimulus which determines the correct response, (2) an irrelevant feature of the stimulus which must be ignored, and (3) a response which is related solely to the irrelevant feature. In this type of task, participants must press a corresponding key at the right or left side of the keyboard when the target stimulus appears on the screen. Whether they have to press the right or left key depends on a relevant feature of the stimulus (e.g., identity, color, or form), regardless of its location.

Experimentally, the effect is manifested in (a) a decrease of Reaction Times (RT) and in (b) an increase of accuracy when the correct response is ipsilateral to the stimulus, compared whit when the correct response is contralateral (Kornblum & Lee, 1995). In the latter case, the participant must inhibit the prepotent tendency to respond ipsilaterally. As the irrelevant feature (location) is processed jointly with the relevant feature, and both generate contradictory responses, a conflict appears (Fuentes Melero & García Sevilla, 2008). The stimulus location automatically activates the

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tendency to respond accordingly to that location. But this response competes with the one required by task instructions. Although location is irrelevant, people respond more slowly (additional delay 20-30ms approx.) when the stimulus appears on the opposite side of its associated response (Lu & Proctor, 1995; Pellicano et al., 2010; Proctor & Vu, 2006). In these conflicting tasks, the retention of an impulsive response is not the object of interest. Instead, what is assessed is the capacity to provide a new response which is incompatible with the prepotent response (Carlson & Moses, 2001; Cragg, 2016). This makes this type of task suitable for assessing complex, high-level processes such as response inhibition.

In the last few years, many classic paradigms used to assess stimuli characteristics (this is, to assess stimuli features such as color, or shape) have been adapted to explore the automatic processing of these characteristics and their subsequent control. Among them is the emotional Stroop Paradigm (Williams et al., 1996). In the emotional Stroop task, participants are asked to name the word color as fast as they can, ignoring their content (neutral or emotional). Emotional words show longer RTs. Pratto and John (1991) and Schimmack and Derryberry (2005) suggested the existence of automatic processing of negative emotional stimuli, which appeared as an evolutionary and critical for survival trait of danger awareness. Other paradigms adapted to explore this topic were the priming paradigm (also known as affective priming paradigm), the rapid serial visual presentation paradigm (i.e., attentional blink), and the Simon paradigm. Regarding the latter, in the last years, interest in the Simon effect has increased (Wentura, 2019). Findings allowed researchers to establish different approaches, like the Affective Simon effect (i.e., the Simon effect in emotionally salient contexts). The task is based on this paradigm, and is called the Affective Simon Task (AST). De Houwer and Eelen (1998) and De Houwer et al. (2001) agree that there are three elements of the Simon paradigm that can be found in the AST: (1) a relevant feature that determines the correct response (e.g., grammatical category or color); (2) an irrelevant feature that should be ignored (i.e., the stimulus valence); and (3) responses that are significantly related solely to the irrelevant feature.

In the AST, participants are asked to give an emotionally positive or negative response to the target stimuli based on a stimulus feature, while ignoring its emotional salience. For example, participants should say “good” whenever a word referred to the “people” category is presented, and say “bad” when a word referred to the “animal” category is presented. Results show that even though the target stimulus valence is irrelevant for the task –and must be ignored–, responses are faster when they are congruent with the target stimulus valence (e.g., responding “good” to the word “friend” because it belongs to the “people” category). On the contrary, responses are slower and less accurate in incongruent conditions (e.g., responding “good” to the word “enemy” because belongs to the “people” category; De Houwer et al., 2001, Experiment 1). Also, in addition to emotional words, figures with emotional valence have been used as stimuli (De Houwer et al., 2001, Experiment 3).

Different studies have explored the Affective Simon paradigm (De Houwer, 2003a, 2003b; De Houwer et al., 2001; De Houwer et al., 1998; De Houwer & Eelen, 1998; de Jong et al., 2003; Duscherer et al., 2008; Tipples, 2001; Voß et al., 2003). However, these studies have focused on the adult population. Although both, the classic Simon paradigm and the affective Simon paradigm, are formally equivalent in adult population, Duscherer et al. (2008) suggest that accurate interpretations of this effect require further analyses. Specifically, the analysis of the relationship between stimuli and responses, as well as of the population under study.

In this regard, the Simon effect in children and adolescents has only been studied using the classic paradigm. But the Affective Simon variant has never been analyzed in these populations. Regarding the classic Simon, it was found that, as children improve their fine motor skills, they become faster and more accurate (Amso & Casey, 2009). The fact that Simon effect size decreases with age suggests that as children grow up, they take less time to inhibit incongruent prepotent responses (Amso & Johnson, 2005; Davidson et al., 2006). According to Casey (2005), performance in this type of task continues improving during infancy until approximately twelve years of age. After this age and until approximately twenty years of age, performance in these tasks is better adjusted to a non-linear developmental trajectory, characterized by advances and setbacks, and even by stability periods (Casey, 2005; Constantinidis & Luna, 2019; Pauls et al., 2013). In contrast with adults, during childhood and adolescence cognitive processes develop at different speeds. Moreover, it seems that pubertal arousal and motivation changes precede the development of regulatory competence, creating a disjunction between the adolescent's affective experience and his/her ability to self-regulate (Dahl, 2001; Steinberg, 2005). Also, according to Casey (2015), adolescents and children show an imbalance between the limbic regions -functionally fully developed in adolescents- and the prefrontal cortex –not yet fully developed in children-. Therefore, it could be interesting to compare cognitive process development between children and adolescents.

De Houwer and Eelen (1998) argue that the AST is a flexible tool for studying the automatic vs. controlled affective processing because it allows the analysis of a biologically-determined response and its subsequent control. Hence, the AST might become a valid tool to assess automatic vs. controlled processes, and even further, to measure inhibitory control. Traditionally, response inhibition has been assessed using relatively abstract decontextualized tasks that lack a significant affective or motivational component. More recent characterizations of response inhibition have suggested that tasks vary in motivational significance, with emotionally significant tasks described as ‘‘hot’’ and more neutral tasks described as ‘‘cool’’ (Zelazo & Carlson, 2012; Zelazo & Cunningham, 2007). Hot tasks involve stimuli, decisions, and outcomes that are emotionally salient.

Also, in the AST, stimuli of any modality and complexity can be used. Moreover, different relevant features for each type of stimulus can be chosen. Despite this fact, in the classic AST, words were mostly used as stimuli, and their grammatical categories were chosen as the relevant features. And despite the extensive research in this field, literature shows a limited comprehension of this paradigm in children and adolescents. This issue is especially relevant because children's and adolescents' skills to assess information in emotionally significant contexts are different from adults' (Silvers et al., 2012). Since the similarity of this effect in children and adolescents has not been studied, this study aims to provide evidence about the Affective Simon effect on these populations. To that end, pictures of objects and animals were used, varying their affective valence and their relevant features. Likewise, the Affective Simon effect was analyzed in different children and adolescent's age groups aiming at studying age-related differences.

Method

Participants

The participants were 120 students (63 females and 57 males) from the same school (with elementary and high school level) in Mar del Plata city, Argentina. The age ranged from 9 to 17 years (*ME*= 12.88; *SD*= 2.57). The sample was grouped to yield comparable sample sizes within each group as follows: Group 1 [G1; *n*=38 (20 female, 18 male); range 9- 10 years], Group 2 [G2; *n*=25 (11 female, 14 male); range 11- 12-years], Group 3 [G3; *n*=28 (16 female, 12 male); range 13 -15 years], and Group 4 [G4; *n*=29 (16 female, 13 male); range 16- 17 years]. Grouping follows the criteria established in development studies (see Luciana et al., 2005). Sample size calculations were carried out using the *G*Power* Software (Faul et al., 2009). In this procedure, the data analysis planned to be applied was chosen (*F* statistics; Repeated Measures ANOVA, within - between interaction) and the estimation was based on the following data: np^2 = .25; alpha error probability = .05; power = .80; number of groups = 4; number of measures = 2; with nonsphericity correction. Results showed that a minimum sample size of 44 participants is required (11 subjects per group). Considering the selection of the sample and the eventual data loss, a sample size of 120 cases was considered adequate.

According to the survey carried out by the school, its socioeconomic and educational level is medium (Argentinean Social Debt Observatory, s.f.). All participants had normal IQ (according to the evaluation of the school's psychological staff) and normal or corrected vision. Exclusion criteria included current psychiatric or neurological disorders, cognitive or neurological impairments, and psychoactive medication. Three additional participants were tested but later excluded because of errors in data entry, or abnormal performance in responses (e.g., five errors differing in more than 3 standard deviations from their mean) that suggests they were not paying attention to the tasks.

Measures

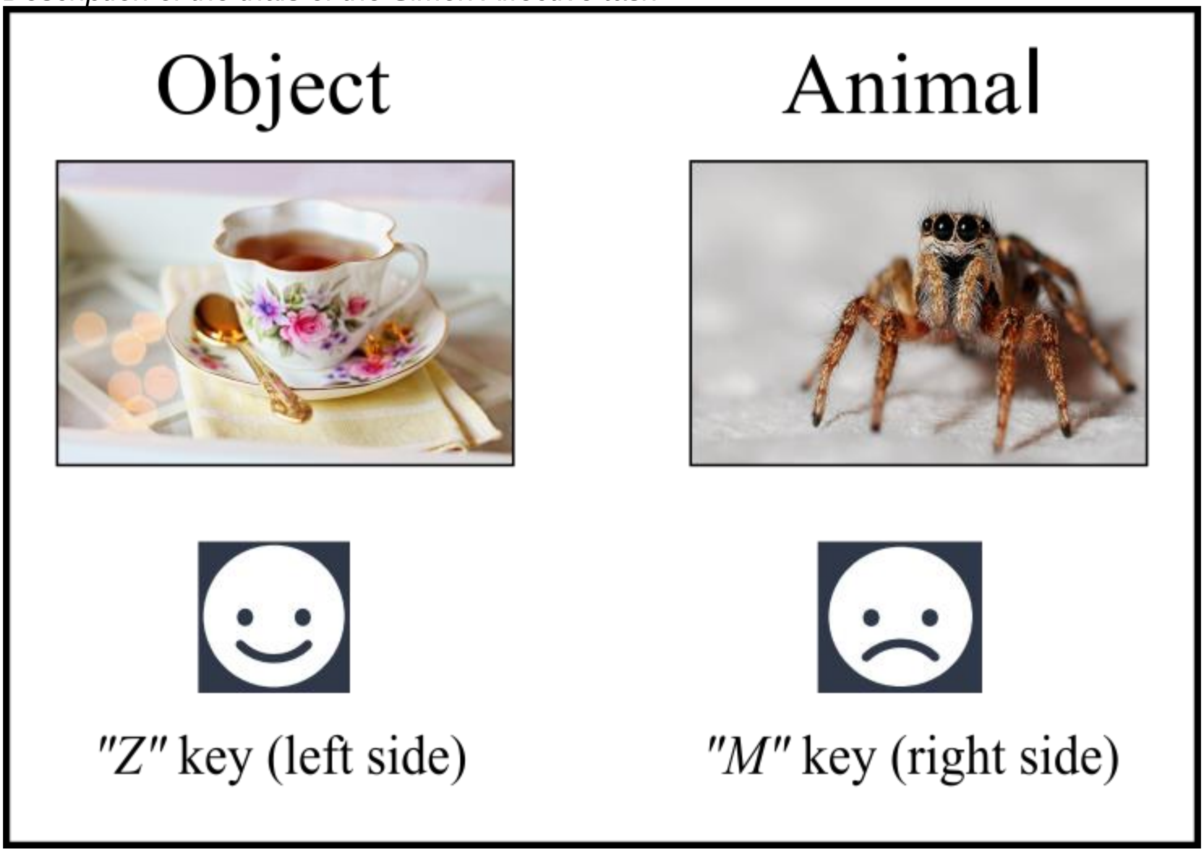
Affective Simon Task (AST)

A computerized task based on the Simon paradigm was designed (Simon & Rudell, 1967). The task introduces a variation called Affective Simon (De Houwer et al., 2001) with visual stimuli from the Nencki Affective Picture System (NAPS; Marchewka et al., 2014; Zamora et al., 2020). The distribution of the number of trials per condition (congruent and incongruent trials), as well as the stimuli exposure times and interval lengths were based on the Simon task developed by Bialystok et al. (2004). The task was designed in the free software *PsychoPy* (Peirce, 2007), which allows logging the participant's RT and accuracy. Participants were seated at 50 cm from a laptop PC with a 15" screen and a Spanish QWERTY keyboard.

In this task, the participant must respond according to a given category (animal or object, relevant dimension) of the stimulus shown on screen, ignoring its affective valence. Specifically, they were asked to respond by pressing the happy face key (Z key on the keyboard) when an object appears, and the sad face key (M key) when an animal appears. This is because, as explained to the children, the main character of the task named "Sam" dislikes animals but likes objects. Thus, participants must evaluate the category of each image and respond appropriately while ignoring its affective valence (see Figure 1). The experimental stimuli used were 16 affective images of animals and 16 affective images of objects. Half of each image category was composed of positive valence pictures and the other half with negative valence pictures.

Figure 1.

Description of the trials of the Simon Affective task



Note. All photographs are illustrative examples belonging to https://pixabay.com/es/

After the instructions, the task begins with 8 practice trials which must be responded correctly before advancing to the subsequent evaluation trials. Of the 32 evaluation trials, 16 belong to the congruent condition (response and valence coincide, i.e., *object-positive valence* and *animal-negative valence*) and 16 trials belong to the incongruent condition (response and valence are opposite, i.e., *object-negative valence* and *animal-positive valence*) (see Figure 2).

Figure 2.
Examples of congruent and incongruent trials

Note. All photographs are illustrative examples belonging to https://pixabay.com/es/

Each trial starts with a fixation cross in the center of the screen (which remains visible for 800 milliseconds), and two visual aids presented in the lower part of the screen. The two visual aids consist of drawings of a happy face on the left side of the screen (key corresponding to the happy face on the left side), and a sad face on the right side of the screen (key corresponding to the sad face on the right side). These visual aids are kept on screen for every trial. The fixation cross disappears during 250 milliseconds and then is replaced by an affective valence picture that remains visible in the center of the screen during 1000 milliseconds or until the participant responds (Bialystok et al., 2004).

All the pictures used belong to the NAPS (Marchewka et al., 2014) and have valence and arousal scores. For the younger children (G1 and G2), a NAPS-for-children subset (Zamora et al., 2020) was used in order to avoid the presentation of stimuli not suitable for children. The pictures of this subset have valence and arousal scores obtained from a 5-point (1 to 5) Likert scale. For the adolescents (G3 and G4), the original NAPS was used, in which the pictures have valence and arousal scores obtained from a 9-point Likert scale (1 to 9). However, despite these differences, negative, neutral, and positive valence, as well as low, medium, and high arousal scores, are comparable. As the only parameter chosen to analyze the affective Simon effect was valence, we selected pictures with medium arousal scores, in order to control the arousal effect. Positive stimuli selected for children of G1 had a valence mean of 4.59 (*SD* = .25) and an arousal mean of 2.95 (*SD* = .44). Negative stimuli had a valence mean of 1.75 (*SD* = .25) and an arousal mean of 2.39 (*SD* = .80). For children of G2, positive stimuli had a valence mean of 4.57 (*SD* = .26) and an arousal mean of 2.78 (*SD* = .43). Negative stimuli had a valence mean of 1.86 (*SD* = .40) and an arousal mean of 2.61 (*SD* = .58). For the adolescents of G3 and G4 (with a likert scale from 1 to 9 points), positive stimuli had a valence mean of 7.16 (*SD* = .30) and an arousal mean of 4.34 (*SD* = .77). Negative stimuli had a valence mean of 3 (*SD* = .55) and an arousal mean of 6.45 (*SD* = .41).

Procedure

The study was approved by the Ethics Committee in research of the Interdisciplinary Topics Program in Bioethics of University of Mar del Plata (Argentina). In the development of the current study, we followed the guidelines for ethical behavior in Social Sciences and Humanities given by the National Council for Scientific and Technological Research (Consejo Nacional de Investigaciones Científicas y Técnicas, 2006) of Argentina. We also followed the criteria recommended by the American Psychological Association (2010) for activities destined to study psychological processes in human beings, and the ethical principles for research with human beings stipulated by the Declaration of Helsinki (World Medical Association, 2013).

The project was presented to the educational institution where we carried out informational meetings about the objectives and procedures of the study with the teaching staff, the participants, and the parents/tutors. In the case of children under age 13, we provided an information sheet and invited the parents/tutors and the children to participate in the study. The formers had to sign the Informed Consent (IC). Likewise, children should assent their participation, having the possibility of quitting at any moment if they wanted to. Adolescents between ages 14 and 16 had to sign their own IC to participate, while their parents and/or tutors had to assent their participation. Those over age 16 only needed to sign the IC. The activity was carried out in a classroom of the school, specially destined for that purpose.

Data Analysis

Raw RTs for each trial, errors, and omissions (trials without response) were logged for each participant. Trials with anticipatory responses (RT < 200 milliseconds) were not detected. Mean RTs, the proportion of errors (PE), and the proportion of omissions (PO) were calculated for each condition and participant.

Generally, considering RT and errors separately can lead to a wrong interpretation of results, due to the possibility of a speed-accuracy trade-off effect. An alternative is to calculate a composite score from both variables (Vandierendonck, 2017; Draheim et al., 2016; Nweze & Nwani, 2020). Therefore, in this study we calculated the Linear-Integrated Speed-Accuracy Score (LISAS; Vandierendonck, 2017), combining RT, PE, and PO, as:

$$RT_j + \frac{s_{RT}}{s_{PO}} \times PO_j$$

Where RT_j is the mean RT for condition *j*, PO_j is the proportion of omissions for condition *j*, S_{RT} is the global standard deviation of participant's RTs, and S_{PO} is the global standard deviation of the participant's PO. Also, a variable called LISES PE was created, calculating the total committed errors. Task internal consistency was estimated through Split-half method by using the Spearman-Brown correction (Cohen & Swerdlik, 2010) based on 5000 random permutations. Reliability was calculated for the variables RT, PO, and PE, and for each condition (congruent and incongruent). The R package *split-half* (V. 0.5.3; Parsons, 2019) was used for this purpose.

In order to assess the effect of the different conditions (congruent and incongruent) over the dependent variable LISAS (PO and PE) we carried out two Analysis of Variance (ANOVA). We used a factorial design considering the condition as the within-subjects factor (with 2 levels: congruent and incongruent), and one dependent variable (LISAS PO or LISAS PE). Age group (G1, G2, G3, and G4) was considered as the between-subjects factor. For those cases where the Mauchly sphericity test was not passed, we used the Greenhouse-Geisser correction. In every significance test, we reported the effect size using ηp^2.

Despite the many advantages of LISAS, this method does not solve the problem of baseline speed differences between different groups. For this reason, a difference score was estimated to quantify interference (see Mullane et al., 2009). In this score, the RT means from trials with interference (incongruent condition) were extracted from the RT means from trials without interference (congruent condition). Then, to represent the null hypothesis, one-sample *t-tests* were performed comparing the difference score with the mean.

Finally, to assess the credibility of the experimental hypotheses (presence of an effect) against the null hypotheses (absence of an effect), Bayes' Factor analyses (BF_{10}) were performed. Values below 1 usually indicate that the null hypothesis is more credible than the experimental hypothesis (and vice versa for values above 1). Values below 1/3 are often considered too as a support to the null effect; and values above 3 are considered to support the presence of an effect

(Wagenmakers et al., 2018).

Results

Table 1 shows reliability coefficients discriminated by the condition.

Table 2 shows mean scores and standard deviations for the dependent variables of the study discriminated by condition and group.

Table 1.
Split–half coefficients using Spearman–Brown correction for RT, PE and PO

Measure	Condition	Split –half (CI)
RT	Congruent	**.78 (.71; .85)**
	Incongruent	**.77 (.63; .87)**
PE	Congruent	.38 (.14; .58)
	Incongruent	.22 (-.08; .46)
PO	Congruent	.36 (-.13; .71)
	Incongruent	.27 (-.20; .66)

Note. He results of 5.000 random splits were averaged. Confidence Intervals (CI) are between parentheses. Typical interpretations are: excellent (.8), good/substantial (.6), and moderate (.4) levels of reliability (Cicchetti & Sparrow, 1981; Fleiss, Levin & Paik, 1981).

Table 2.
Descriptive statistics of RT, Accuracy (PO and PE), LISAS PE and LISAS PO discriminated by condition and age group

Age Group			**G1**	**G2**	**G3**	**G4**	**Total**
Congruent Condition	RT (ms)	Mean	821.67	772.34	688.72	635.94	733.27
		SD	113.40	89.28	78.60	87.21	119.27
	PO	Mean	5.36	2.50	0.89	2.80	3.04
		SD	6.97	3.61	2.80	11.64	7.37
	PE	Mean	10.71	8.00	5.80	2.16	6.84
		SD	7.96	10.60	6.79	4.18	8.21
	LISAS PO (ms)	Mean	843.05	779.50	695.76	638.70	743.57
		SD	141.75	93.33	80.92	86.36	132.59
	LISAS PE (ms)	Mean	882.27	826.07	723.74	643.13	773.05
		SD	127.32	94.58	95.34	85.74	139.66
Incongruent Condition	RT (ms)	Mean	848.89	826.03	685.66	624.00	749.20
		SD	118.56	88.19	62.24	66.78	129.89
	PO	Mean	5.36	3.50	1.56	2.80	3.42
		SD	7.45	6.27	2.76	9.39	7.04
	PE	Mean	10.18	8.25	7.59	2.80	7.32
		SD	6.96	8.60	7.67	5.17	7.58
	LISAS PO (ms)	Mean	875.12	837.83	688.56	629.82	761.70
		SD	153.34	108.61	64.32	69.23	149.07
	LISAS PE (ms)	Mean	911.25	881.81	725.87	637.38	792.71
		SD	125.40	124.44	90.14	67.32	154.46

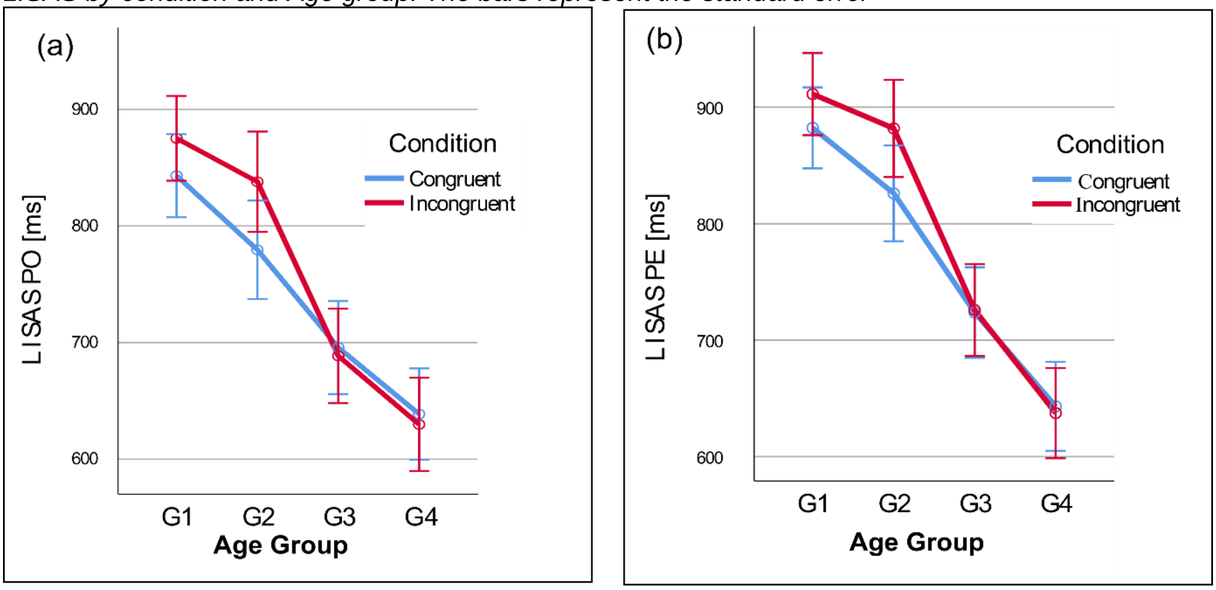
Note. RT: Reaction Time; ms: milliseconds, G1: Group 1, G2: Group 2, G3: Group 3, G4: Group 4.

A repeated measures ANOVA of LISAS PE showed a main effect of the condition (congruent, incongruent) [$F_{(1,113)}$ =7.550, p = .007, ηp^2 = .063] and the age group [$F_{(3, 113)}$ = 45.034, p < .001, ηp^2

= .985]. A significant condition x age-group interaction [$F_{(3,\ 113)}$ = 3.341, p = .022, ηp^2 = .081] was also revealed. The interaction can be appreciated in Figure 3 (a). A repeated measures ANOVA of LISAS PO showed a main effect of condition (congruent, incongruent) [$F_{(1,113)}$ =8.951, p = .003, ηp^2 = .073] and age group [$F_{(3,\ 113)}$ = 31.471, p < .001, ηp^2 = .455]. A significant condition x age-group interaction [$F_{(3,\ 113)}$ = 6.473, p < .001, ηp^2 = .147] was also revealed. This interaction can be appreciated in Figure 3 (b).

Figure 3.

LISAS by condition and Age group. The bars represent the standard error



Note. G1: Group 1, G2: Group 2, G3: Group 3, G4: Group 4.

To analyze both interactions, differences between conditions for each group and differences between age groups for each condition were calculated. Results are shown in Tables 3 and 4. Regarding LISAS PE differences between conditions for each group, a weak difference was found in G2 and a weak invariance was found in G3 and G4. Likewise, for the LISAS PO scores, a weak invariance was found in G3 and G4, but a strong difference was found in G2. Regarding LISAS PE differences between age groups for each condition, strong differences were found between almost all groups in both conditions. Only the difference between G1 and G2 showed a weak invariance for the incongruent condition and inconclusive results for the congruent condition (see Table 4). For the LISAS PO scores, strong differences were found between almost all groups in both conditions. However, a weak invariance was found between G1 and G2 for the incongruent condition, and inconclusive results were found between G1 and G2 for the congruent condition and between G3 and G4 for both conditions.

The one-sample *t-tests* revealed significant RT differences in G1 [*ME* = 27.2 ms, *SD* = 73; $t_{(34)} = 2.190$, p = .036, $BF_{10} = 1.175$] and G2 [*ME* = 53 ms, *SD*= 43); $t_{(24)} = 6.139$, $p < .001$, $BF_{10} > 1000$]. In contrast, a weak invariance was found in G3 [*ME* = 3.1 ms, *SD* = 56; $t_{(27)} = -.286$, $p = .77$, $BF_{01} = 6.587$] and inconclusive results in G4 [*ME*= 11.9 ms, *SD* = 45; $t_{(28)} = -1.421$, $p = .167$, $BF_{01} = 2.698$].

Table 3.
Post-hoc comparisons and Bayes factors between conditions for each age-group

LISAS PE					
Condition	**Groups**	***p***	**BF01**	**BF10**	**Interpretation**
Congruent	G1-G2	.25	1.08	0.93	Inconclusive
	G1-G3	< .01	< 0.01	>1000	Strong difference
	G1-G4	< .01	< 0.01	>1000	Strong difference
	G2-G3	< .01	0.01	100	Strong difference
	G2-G4	< .01	< 0.01	>1000	Strong difference
	G3-G4	.03	0.05	22.22	Strong difference
Incongruent	G1-G2	1	3.2	0.28	Weak invariance
	G1-G3	< .01	< 0.01	>1000	Strong difference
	G1-G4	< .01	< 0.01	>1000	Strong difference
	G2-G3	< .01	< 0.01	>1000	Strong difference
	G2-G4	< .01	< 0.01	>1000	Strong difference
	G3-G4	< .01	< 0.01	250	Strong difference
LISAS PO					
Condition	**Groups**	***p***	**BF01**	**BF10**	**Interpretation**
Congruent	G1-G2	.15	0.93	1.07	Inconclusive
	G1-G3	< .01	< 0.01	>1000	Strong difference
	G1-G4	< .01	< 0.01	>1000	Strong difference
	G2-G3	.03	0.03	31.25	Strong difference
	G2-G4	< .01	< 0.01	>1000	Strong difference
	G3-G4	.27	0.29	3.48	Inconclusive
Incongruent	G1-G2	1	3.11	0.32	Weak invariance
	G1-G3	< .01	< 0.01	>1000	Strong difference
	G1-G4	< .01	< 0.01	>1000	Strong difference
	G2-G3	< .01	< 0.01	>1000	Strong difference
	G2-G4	< .01	< 0.01	>1000	Strong difference
	G3-G4	.26	0.05	20	Inconclusive

Note. BF: Bayes' Factor analyses, G1: Group 1, G2: Group 2, G3: Group 3, G4: Group 4.

Discussion

In the Simon paradigm, participants must respond to a relevant feature while they ignore an irrelevant feature related to the response (Kornblum, 1992). While in the classic version of the paradigm, the irrelevant feature and the response are spatially related, in this study we introduced a variant. In the task participants had to respond by choosing a happy or sad face depending on whether the picture presented was an object or an animal, ignoring its affective valence. In some trials participants must respond congruently (a pleasant object, of positive valence), and in other trails they must respond incongruently (an unpleasant object, of negative valence). Results of Affective Simon in adult population show that, although participants were instructed to ignore the affective meaning, RTs are increased in incongruent conditions compared with congruent conditions (De Houwer et al., 1998; De Houwer et al., 2001; De Houwer, 2003a, 2003b; Duscherer et al., 2008; Tipples, 2001; Voß et al., 2003). However, until now, this effect had not been analyzed in children and adolescent, and thus neither was evidence about the generalization of the affective Simon effect to these populations.

Table 4.
Post hoc comparisons and Bayes factors by age-group for each condition

Age Group	*p*	BF01	BF10	Interpretation
LISAS PE				
G1	.07	1.51	0.66	Inconclusive
G2	< .01	0.12	8.14	Weak difference
G3	.89	6.80	0.15	Weak invariance
G4	.53	5.71	0.18	Weak invariance
LISAS PO				
Age Group	***p***	**BF01**	**BF10**	**Interpretation**
G1	.053	1.28	0.78	Inconclusive
G2	< .01	< 0.01	1391.70	Strong difference
G3	.51	5.56	0.18	Weak invariance
G4	.24	3.57	0.28	Weak invariance

Note. BF: Bayes' Factor analyses, G1: Group 1, G2: Group 2, G3: Group 3, G4: Group 4.

The results showed that children (G1 and G2) presented lower performance at the incongruent condition than at the congruent condition, which indicates the presence of the Affective Simon effect. This is evidenced by higher LISAS scores (PO and PE). Although the results for G1 are not conclusive (see Table 4), the strong difference observed in G2 in LISAS PO could be taken as evidence that the effect exists in G1. In contrast, in the adolescent group (G3 and G4) evidence of invariance between both conditions was found for both variables (LISAS PO and LISAS PE). RT interference scores also show significant differences for the G1 and G2 groups, and revealed an absence of the effect on G3. In the case of G4, the results of this index were not conclusive.

Therefore, these results provide some evidence that suggests that the Affective Simon effect only appear in children. These findings can be explained from different perspectives. Some developmental changes could explain the performance differences found between children and adolescents. For example, Davidson et al. (2006) point out that the motor interference generated by the Simon effect can be solved efficiently during this developmental stage. Authors also point out that it is to be expected that as long as there are age-related performance improvements, both conditions become increasingly similar. However, the Affective Simon effect has been reported in the adult population. This discrepancy can arise from differences between this study and previous ones. Specifically, in the AST designed by De Houwer et al. (2001) the affective pictures were associated with negative and positive valence scores (Experiment 3). According to Schimmack and Derryberry (2005), the picture's arousal could have explained the Affective Simon effect found, but it was not controlled in the stimuli selection process. This can be supported by the fact that, generally, extreme valence scores are also associated with high arousal scores. In contrast, in our study, arousal was controlled to be medium across all conditions and age groups, with valence as the only parameter determining whether the stimulus was negative or positive. Thus, our results show a valence-related Affective Simon effect only in children but not in adolescents. This implies that the Affective Simon effect reported in the adult population (e.g., De Houwer et al., 1998; De Houwer et al., 2001; Duscherer et al., 2008; Tipples, 2001; Voß et al. 2003) could be due to the arousal but not the valence scores of the pictures. Therefore, a possible arousal-related Affective Simon effect can be explored in future studies.

Also, results showed that performance in both conditions improved with age, in line with previous studies (Amso & Johnson, 2005; Casey, 2005). This could be attributed to the operative improvement during these developmental periods in diverse processes, such as processing speed or inhibition (Introzzi et al., 2019; Kail & Salthouse, 1994). Inhibition implies the capacity of resisting automatic and/or prepotent responses, in pursuit of an objective. Therefore, it is logical to expect that experience and maturation linked to development could affect the intensity of inhibition. The more intense the inhibition is, the faster and more accurate the responses are. And processing speed is the maximum execution speed of cognitive operations. Thus, the higher the processing speed, the better the performance in cognitive tasks that do not necessarily imply speed as the main component. Studies analyzing development through the classic Simon paradigm have found a significant improvement of the processes involved in all groups with differences between 7 and 11 years of age (e.g., Cragg, 2016; Dahl, 2001; Luna et al., 2004; Richardson et al., 2018). In our study, there were significant differences between almost all age groups, except between G1 and G2 (in which no age-associated differences were found in the congruent condition, and even a weak invariance was detected for the incongruent condition). However, a general age-related performance improvement can be seen, in line with the literature. Thus, adolescence could also be considered as a sensitive developmental period, due to the occurrence of significant cognitive and emotional changes (Casey, 2005; Constantinidis & Luna, 2019; Steinberg, 2005).

Worth to mention are the composite scores used in our results. Generally, accuracy and RTs have been used to analyze emotional interference and/or inhibition development. However, in this approach, the trade-off effect could lead to a wrong interpretation of the findings. This effect is often found during childhood and adolescence, where developmental changes occur fast, and cognitive performance improves. Likewise, using only RTs, without considering errors or omissions, could lead to biased results. Thus, by using a composite score as the LISAS (Draheim et al., 2016; Vandierendonck, 2017), it is possible to provide a more reliable and parsimonious measure of the performance of an executive function as, for example, inhibition (e.g., Nweze & Nwani, 2020). However, it is important that future studies consider both the possibility of analyzing other indexes for understanding subtler developmental changes (e.g., Cragg & Nation, 2008), and the possibility of working in different levels of analysis (e.g., neural, in addition to behavioral; Vara et al., 2014).

Although the idea of the Affective Simon effect results is attractive, the evidence is yet limited and inconclusive. Therefore, this study needs to be replicated, but adding some methodological modifications to overcome its limitations. One of the limitations of our study is the lack of counterbalancing in the response mapping of the task. This could have affected the results because participants' laterality was not controlled. Another possible source of error is the number of trials per condition. Although the task is based on previous studies, more trials per condition would improve its sensitivity to fatigue and lapsus (and the reliability of errors as a performance measure). Likewise, another limitation to highlight is that the reliability of PE and PO was low, so future studies could explore this type of effect. Also, stimuli used here must be discussed. While the child-adapted version of NAPS (Zamora et al., 2020) was used in G1 and G2, the adult version of NAPS was used in G3 and G4 (Marchewka et al., 2014). Thus, future studies including stimuli validated in the adolescent population could contribute to the replicability and robustness of the results. Larger and different (e.g., clinical population, different socio-cultural contexts) samples should also be considered. It would also be interesting to consider shorter age intervals, in order to analyze changes more accurately. Finally, we used a non-probabilistic sample, so generalization of results should be made with caution.

Regardless of the limitations, several contributions can be summarized. For instance, we applied a task based on the Affective Simon paradigm, which had not been previously applied in children and adolescents. This study contributes to a scarcely explored topic such as the assumption that an implicit activity (i.e., responding through faces), measures a real activity which underlies a behavior (i.e., association of the pleasant to the happy face and association of the unpleasant to the sad face). More importantly, we found that there is a valence-related affective Simon effect only in children which disappears in adolescents. And also, that the affective Simon effect reported in adults could be due to arousal and not valence of stimulus.

This paves the way to a series of new studies that could analyze the arousal-related Affective Simon effect, in both children and adult populations.

Data availability

The full dataset supporting the results of this study is available upon request to the contact author Eliana Vanesa Zamora.

Availability of analytical methods

The full suite of analytical methods supporting the results of this study is available upon request from the contact author Eliana Vanesa Zamora.

Availability of materials

The entire set of materials supporting the results of this study is available upon request to the contact author Eliana Vanesa Zamora.

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