Revista Argentina de Ciencias del Comportamiento

ISSN 1852-4206

Diciembre 2016, Vol. 8, N°3, 72-80

revistas.unc.edu.ar/index.php/racc

Towards development of criteria for stimulation of cognitive flexibility through digital games: empirically founded contributions.

Cervigni, Mauricio *, [a]; Bruno, Franco [b]; Alfonso, Guillermo [c]

Special Section: Videogames and Cognition

Abstract

Stimulation of executive functions (EF) using digital games is a practice that has experienced significant growth in different areas. In sight of the objective pursued, it is necessary to have clear software selection criterias. This article focuses on a correlational study between different EF transversely evaluated in a pediatric population (*N* = 40) of the second grade of elementary education in the city of Rosario (Argentina) and intends to organize the data obtained with existing theoretical models searching for the game selection criteria for the stimulation of cognitive flexibility. Significant –although moderate- correlations were found between this function and attention, memory and inhibitory control; links that underlie the lines suggested in the discussion.

Keywords:
Cognitive Flexibility, Cognitive Stimulation, Digital Games, Video Games, Executive Functions

Resumen

Hacia la elaboración de criterios para la estimulación de la flexibilidad cognitiva mediante juegos digitales: aportes fundados en un estudio empírico. La estimulación de las funciones ejecutivas (FE) mediante juegos digitales es una práctica que ha experimentado un importante crecimiento en diferentes ámbitos. En vista del objetivo que se persiga, resulta necesario contar con criterios precisos para la selección del *software* a utilizar. El presente artículo se centra en un estudio correlacional entre distintas FE evaluadas transversalmente en una población infantil (*N* = 40) del segundo grado de la educación primaria de la ciudad de Rosario (Argentina). Se propone articular los datos obtenidos con los modelos teóricos vigentes en busca de criterios para la selección de videojuegos aplicables a la estimulación de la flexibilidad cognitiva. Se han hallado correlaciones significativas, aunque de moderado valor, entre esta función, la atención, la memoria y el control inhibitorio; vínculos que fundamentan las pautas sugeridas en la discusión.

Palabras clave:
Flexibilidad Cognitiva, Estimulación Cognitiva, Juegos Digitales, Videojuegos, Funciones Ejecutivas

Tabla de Contenido

Received on March, 5th, 2015; Review received on May, 30th, 2015; Approved on June, 23th, 2016.
Edited by: Cecilia Reyna, María Micaela Marín, Débora Jeanette Mola and Estefanía Caicedo

1. Introduction

Since decades ago, digital games are part of the life of children and young boys. Per its attractive and ductility, it is usual to use these tools for stimulation of executive functions, both in healthy subjects like in those who needs rehabilitation programs (González Rodríguez & Muño Marrón, 2002). Videogames, transcending its ludic nature, have been transformed into valuable resources for clinical and education

[a] Director of the Center for Research in Neuroscience in Rosario (CINR-UNR) and of the Laboratory of cognition and emotion (LABce). Department of Science and Technology. Faculty of Psychology. National University of Rosario (CINR-UNR) - Researcher of the Interdisciplinary Center for Research in Mathematical and Experimental Psychology (CIIPME). National Council for Scientific and Technical Research (CONICET), Linked Group CIIPME/CONICET – Entre Rios.
[b] Student member at Center for Research in Neurosciences Rosario. Secretary of Science and Technology. Faculty of Psychology. National University of Rosario (CINR-UNR).
[c] Graduated member Center for Research in Neurosciences Rosario. Secretary of Science and Technology. Faculty of Psychology. National University of Rosario (CINR-UNR).
*Send correspondence to: Cervigni, M. E-mail: mcervigni@gmail.com; cinr.unr@gmail.com

Cite this article as: Cervigni, M., Bruno, F., & Alfonso, G. (2016). Towards development of criteria for stimulation of cognitive flexibility through digital games: empirically founded contributions. *Revista Argentina de Ciencias del Comportamiento, 8*(3), 72-80

purposes. Its spread is wide: in the United States, for example, 150 million people are engaged in them at least three hours per day. This phenomenon, -which not only includes children- is evaluated positively by most parents and generates profits for several billion dollars annually (Entertaiment Software Association, 2015).

In regard to the use of videogames for stimulation, Gros (2000) warn of the need to work with high quality software, understanding that this feature includes not only technical conditions, but also procedural appropriateness. The pick of a particular program must also consider the skills acquired by the child at their informal activity.

Some general guidelines are often established for game selection. For example, Graells (2002) proposed a protocol that focuses on the technical, functional and aesthetic aspects involved in cognitive demand. However, we must recognize that specific and differential criterias for each one of the EF does not exist yet. Considering that, we took special consideration of the existing theoretical models for each one and made some articulations with information from empirical assessments. Therefore, this study aimed to outline some guidelines for the selection of digital games applicable to the stimulation of a particular executive function –cognitive flexibility- considering results of a correlational study among different executive functions in second grade school children of elementary education in a public school in the city of Rosario (Argentina).

1.1. Executive functions

Executive functions (EF) comprises the set of cognitive processes involved in the choice of goals, the selection of behavior, the planning, and the control and the use of feedback (Miyake & Friedman, 2012; Sholberg & Mateer, 1989). Currently, there are plenty evidence to consider the frontal cortex of the brain as its functional headquarter (García-Molina, Enseñat-Cantallops, Tirapu-Ustárroz, & Roig-Rovira, 2009; Papazian, Alfonso, & Luzondo, 2006). However, the controversy regarding the level of correlation from one to each other, persists (Stelzer, Mazzoni, & Cervigni, 2014): some authors argue that keep close relations (Rodriguez-Aranda & Sudnet, 2006), while others indicate that the correlation between these capabilities is low (Letho, Juujarvi, Kooistra, & Pulkkinen, 2003). Some classically studied EF are: planning, working memory, cognitive flexibility, and inhibitory control (Denckla, 1994).

1.2. Cognitive flexibility

`Cognitive flexibility´ refers to the ability to detect the lack of effectiveness of certain behaviors or strategies addressed to particular circumstances, and the consequent ability to replace them with better aimed ones. On the other hand, it is possible to conceptualize cognitive flexibility as the ability to modify patterns of actions given contextual variations (Goldberg, 2002). Perseveration is considered the most characteristic alteration of this function, shown as an almost "paroxysmal" reiteration of an action scheme already experienced as ineffective in previous events, or maladjusted in the present to current goal objectives.

Executive domains have different development curves. Numerous researches have determinate that during the preschool and school period, many of them experiences significative improvements (Cervigni, Stelzer, Mazzoni, & Álvarez, 2012). Cognitive flexibility have a high development between 6 and 9 years old (García–Coni, Canet-Juric & Andrés, 2010), which seems to suggest that stimulation in this period may generate several impacts on subsequent performance. Additionally, it correlates with other functions, principally concentrated attention and inhibitory control (Galimberti, Martoni, Cavallini, Erzegovesi, & Bellodi, 2012).

1.3. Stimulation of cognitive flexibility

The current existence of several generations of digital-native students promotes a necessary application for such technologies (Hudgins & Anderson, 2015) by increasing the production and application of computerized tools to stimulate capacities in students. In a non-exhaustive list, those have been used to encourage artistic skills (Aboalgasm & Ward, 2014), strengthen language acquisition (Blake, 2013), and stimulate cognitive faculties (Gu, Zhu, & Guo, 2013).

There is enough evidence to support that cognitive flexibility can be stimulated and trained. Different experiences were made: direct interventions like drug application to modulate noradrenergic regulation (Beversdorf, Hughes, Steinberg, Lewis, & Heilman, 1999) or indirect procedurals, such as that provided by a diverse variety of protocols based on problem solving. These practices seems to be applicable to diverse populations, ranging from the high education level (Lima, Koehler, & Spiro, 2004), to preschool students (Diamond, Barnett, Thomas, & Munro, 2007). Considering its development period, modulation of cognitive flexibility should be easier in the early school years. The peculiarities of cognitive flexibility allow activities and training programs to also modulate other functions such as attention, memory, and inhibitory control.

Based on current knowledges, we understand that the relationship between cognitive flexibility and sustained attention can be misunderstood; although attention (broadly) seems to modulate performance on cognitive flexibility tests, the monotony of a task – as the one that gets in games with basic slogans which exclude unforeseen change of rules- could result in a player adaptation to the stimuli-responses pattern that temporarily impair its ability to change set, making him permeable to perseveration errors.

1.4. Stimulation by videogames

Videogames count with most of digital media advantages, reinforced by its high level of interaction. Constitute one of the fastest growing industries and steadily increase its market penetration in children and adolescents (Squire, 2003). As result, development of new educational technologies – together with the progress in the study of executive modulation– has promoted the use of games in educational contexts (Irwin & Gross, 1995).

Videogames shown great versatility for school programs (Goldin et al, 2014; Green & Bavelier 2006) As result, development of new educational technologies –together with the progress in the study of executive modulation– has promoted the use of games in educational contexts (Blumberg, Blades, & Oates, 2013; O´Donovan & Hussey, 2013; Granic, Lobel, & Engels, 2014). The available spectrum of genres and styles facilitates its use to enhance different faculties, highlighting experiences with strategy games to promote decision-making (Hamlen, 2011), and action games to stimulate cognitive flexibility (Colzato, van Leeuwen, van den Wildenberg, & Hommel, 2010).

2. Method

This paper is based on a non-experimental, correlational and cross-sectional study of exploratory scope.

2.1. Subjects

40 students with typical development of the second grade (x = 7 years old) from a public elementary school in Rosario (Argentina),

2.2. Inclusion and exclusion criteria

As general rule, it was established that subjects should not went through vital episodes that could have had adverse effects on their neurodevelopment and may condition their performance on test, such as maternal substance use during pregnancy, more than four weeks prematurity, weight lower birth to 2,500 kg (Organización Mundial de la Salud, 2009), prenatal hypoxia, malnutrition, infectious diseases affecting nervous system, severe head injuries, lack of overall educational stimulation or late scholar insertion.

2.3. Materials and instruments

- Permanent Home Poll (Indec, 2011) [*Adapted Version*].
- Raven test – Colored Scale (Raven & Court, 2000).
- SESH Neuropsychological Battery (Álvarez, 2000 Visual Memory Span Task (AMV), Sustainded Attention Task (ASS), Focused Attention Task (AC), Stroop Task (ST) and Wisconsin Card Sort Task (WSCT).

2.4. Process

2.4.1. Informed consent and survey of sociodemographic variables

At the first instance, parents and caregivers signed an informed consent after a detailed communication of the particularities and activity scope as well as the entire project goals. Subsequently, they completed a survey to obtain the inclusion and exclusion criteria data. It includes data of pre, peri and postnatal health status, general stimulation and material conditions of subject's life. The instrument was made by an adaptation of the Permanent Home Poll (Indec, 2011).

2.4.2. Global Intelligence

In order to obtain a first reference of the general cognitive level, the IQ of subjects was assessed using the Raven Test – Colored Scale (Raven & Court, 2000). Scores were refer to Aguacalientes (2001) scales.

2.4.3. Evaluation of cognitive functions

Cognitive functions of the subjects were assessed by standardized battery SESH (Álvarez, 2000). The tests and the variables considered for statistical analysis are briefly detailed and exposed:

- *Visual Memory Span Task (AMV):* Three geometric figures appears on the screen. The subject must remember and recognize them among nine that appear later. Analyzed variables: maximum achieved score, total score.

- *Sustained Attention Task (ASS):* based on Cotinuous Performance Task (CPT). It consists on the continuous exposure of target and distractor letters. Subject must respond only to those that are identical –considering also the color- to the pattern indicated. Analyzed variables: correct marks, incorrect marks, omissions, attention index.

- *Focused Attention Task (AC):* Based on Tolouse-Pieron Task. Subjects must select, at the highest possible speed, identical to a pattern abstract figures from a set that appears on the screen. Analyzed variables: correct marks, incorrect marks, omissions, time spent, index attention.

- *Stroop Task (ST):* Consist on the continued provision of written words in different colors. Subject should only respond when word appears colored like the rule indicates. Analyzed variables: correct responses, incorrect reactions.

- *Wisconsin Card Sort Task (WSCT):* three cards that differ in shape, color and number of elements appears on screen. Subject should pair others cards to the samples according to any of the named features, but only one of them is taken as correct. Without warning, the accepted one changes, so the response must be modified to solve the task correctly. Analyzed variables: correct responses, errors, perseverative mistakes, achieved categories, omissions.

2.5. Statistic analysis

The collected data was transcribed to a digital database (SPSS Software, Version 20) for statistical analysis. First, the descriptive indicators of Raven Test were calculated and graded according to Aguascalientes scale (2001). Subsequently, and after an evaluation of the sample normality regarding variables of WSCT (Komolgorov-Smirnov and Shapiro-Wilk test), correlation were analyzed (Pearson X^2) among those and the ones related to the remaining battery subtests. This procedure demonstrated the existence of some moderate significance linkages as outlined in the result sections. The exploration was completed by one-way ANOVA tests. In this regard, it should be noted that the group characteristics didn't allowed the application of post-hoc tests, so Type-1 errors existence could not be conclusively ruled out.

3. Resultados

3.1. IQ: Raven test

Table 1 refers to direct scores on the Raven test and Table 2 shows the weighting according to scale. Total average was 22.02 with a *SD* of 5.45. Minimal (15.00) and maximal (31.00) range was 16. Despite the small size of the sample, it exhibits a normal distribution (p = .086 on Kolmogorov-Smirnov test).

Table 1
Raven – Total score

Average	22.02
Median	22.00
Mode	18.00
S. D	5.45
Maximal	31.00
Minimal	15.00
Range	16.00
Percentile 25	18.00
Percentile 75	25.00

Table 2
Raven – Aguascalientes scale

Diagnose (Aguascalientes)	***N***	%
Higher	4	10.00%
Higher at mid term	8	20.00%
Mid term	14	35.00%
Lower to mid term	13	32.50%
Deficient	1	2.50%
Total	40	100.00%

3.2. Significant correlations among subtest of SESH Battery

This section presents the founded correlations between the results of attention task (ASS, AC), visual memory task (AMV), inhibitory control task (ST) and the one corresponding to cognitive flexibility evaluation (WSCT). Table 3 presents normality sample analysis regarding variables of the WSCT, based on the application of parametric procedures (Pearson X^2).

Table 3
Wisconsin test: Normality analysis

Wisconsin Test	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Est.	gl	*p*	Est.	gl	*p*
Correct marking – Score	0.149	35	.05	0.91	35	.01
Incorrect marking –	0.081	35	.200*	0.98	35	.79

Average time						
Errors	0.09	35	.200*	0.99	35	.92
Perseveration errors	0.104	35	.200*	0.98	35	.69
Achieved categories	0.273	35	0	0.88	35	0
Omissions	0.183	35	0	0.9	35	0

Nota: [a] Corrección de la significación de Lilliefors;
* Límite inferior de la significación

Following, obtained results are summarized:

3.2.1. Correlations between cognitive flexibility and sustained attention

Table 4 shows that correct reactions of Wisconsin Task (WCST) had negatively correlated with correct reactions on Sustained Attention Task (ASS) (-.331*). Conversely, it has positive linkages with the omissions of the ASS (.331*). Although *a priori* this data may seem counter-intuitive, we consider that it can be consistent with the conceptualization of both functions. As mentioned in the theoretical framework, cognitive flexibility refers to the capacity to detect the lack of effectiveness of certain behaviors or strategies and the consequent ability to alternate them with better addressed ones. Thus, a misadjusted scheme of perseverate responses is considered as a major deviation. Sustained or Continuous attention tasks, moreover, demand to maintain a response set during extended periods (Servera & Llabrés, 2004). That means that we cannot expect to make performance predictions between these functions one another. In the same vein, we consider that the linkages between WSCT's achieved categories, ASS's Correct Reactions (-.424**) and omissions (.424**), shows that this indicator of WCST reflexes with accuracy the ease or difficulty of the subject for set-swiching.

Table 4
Sustained Attention (ASS) * WSCT

			WSCT				
ASS			**Corr.**	**Err.**	**P. Err.**	**Cat.**	**Om.**
Correct marks	Pearson	*Pearson*	-.331*	0.148	-0.128	-.424**	0.249
		Sig.	0.040	0.37	0.437	0.007	0.127
	Anova	*F*	1.133	1.315	1.534	3.604	0.529
		Sig.	0.379	0.271	0.173	0.015	0.892
Incorrect marks	Pearson	*Pearson*	-0.155	0.198	-0.051	-0.114	-0.031
		Sig.	0.346	0.226	0.756	0.489	0.851
	Anova	*F*	0.636	1.772	0.764	0.475	0.607
		Sig.	0.801	0.106	0.695	0.754	0.833
Omissions	Pearson	*Pearson*	.331*	-0.148	0.128	.424**	-0.249
		Sig.	0.040	0.37	0.437	0.007	0.127
	Anova	*F*	1.133	1.315	1.534	3.604	0.529
		Sig.	0.379	0.271	0.173	0.015	0.892
Attention Index	Pearson	*Pearson*	-0.246	0.099	-0.06	-.357*	0.237
		Sig.	0.131	0.547	0.717	0.026	0.147
	Anova	*F*	1.343	1.261	1.080	3.301	0.413
		Sig.	0.254	0.302	0.420	0.022	0.956

Note: WSCT: Corr. = Correct marks; Err. = Errors; P. Err. = Perseverative errors; Cat. = Achieved Categories; Om. = Omissions
*Significant Pearson Correlation at 0.05 (bilateral)

3.2.2. Correlations between cognitive flexibility and focused attention

As Table 5 indicates, incorrect reactions on Focused Attention Task (AC) had negatively correlated with correct reactions of WCST (-.369*) and its achieved categories (-.337*). Conversely, Incorrect Reactions of AC correlated positively with WCST errors (.376*).

Subtest AC of SESH Battery is an adapted version of Tolouse-Pieron task, that consists in distinguish and cross out as quickly as possible certain patterns mixed with similar others (Pías, Fernández, Robaina Álvarez, & Álvarez, 2009). According to collected data, there was in this case a positive link between performance in both AC and WCST tasks. We consider, at least provisionally, that attentional focus is an indispensable tool to detect rules or situations shifts. Moreover, the AC demand differs of the proposed by the ASS, which is evaluated for long time periods and under the presence of monotonous stimuli (Pías et al., 2009).

3.2.3. Correlations between cognitive flexibility and inhibitory control

Correct reactions of Stroop Task had negatively correlated with errors (-.333*) and perseverative errors (-.339*) on WSCT (Table 6). Inhibitory control had deep links with cognitive flexibility, as it is understood like the ability to abolish a response form to certain stimuli and react appropriately in context (Pías et al., 2009).

Research on Attention Deficit Hyperactivity Disorder (ADHD) supports the indicators found on this study because there are changes in the concentrated attention and inhibitory control in children who suffer ADHD, which results in poor self-regulation and in behavioral problems (Acosta López, Cervantes Henríquez, Sánchez Rojas, Núñez Barragán, & Puentes Rozo, 2010), impulsivity and unproductive hyperactivity (Cervigni, Stelzer, Mazzoni, Gómez, & Martino, 2012). Moreover, impaired cognitive flexibility are found in about 38% of ADHD cases and seems to involve the same significant correlations between the results on Wisconsin Task and variables that respond to alertness series, selective attention, and inhibitory control (Etchepareborda & Mulas, 2004).

Table 5
Focused Attention (AC) * WSCT

			WSCT				
AC			**Corr.**	**Err.**	**P. Err.**	**Cat.**	**Om.**
Correct marks	Pearson	*Pearson*	-0.046	0.182	0.019	0.002	-0.063
		Sig.	0.784	0.274	0.908	0.991	0.708
	Anova	*F*	0.651	0.879	1.151	0.323	0.203
		Sig.	0.788	0.598	0.369	0.860	0.998
Incorrect marks	Pearson	*Pearson*	-.369*	.376*	0.285	-.337*	0.062
		Sig.	0.023	0.02	0.082	0.038	0.71
	Anova	*F*	2.649	3.748	0.666	2.255	0.331
		Sig.	0.190	0.003	0.775	0.084	0.982
Omissions	Pearson	*Pearson*	0.046	-0.182	-0.019	-0.002	0.063
		Sig.	0.784	0.274	0.908	0.991	0.708
	Anova	*F*	0.651	0.879	1.151	0.323	0.203
		Sig.	0.788	0.598	0.369	0.860	0.998
Total Time	Pearson	*Pearson*	-0.269	0.070	0.00	-0.318	0.26
		Sig.	0.103	0.676	1.00	0.052	0.114
	Anova	*F*	1.215	0.634	0.652	2.188	0.44
		Sig.	0.328	0.822	0.787	0.092	0.943
Attention Index	Pearson	*Pearson*	-0.005	0.139	-0.01	0.038	-0.067
		Sig.	0.975	0.407	0.951	0.821	0.69
	Anova	*F*	0.593	0.824	1.074	0.394	0.233
		Sig.	0.836	0.649	0.423	0.612	0.997

Note: WSCT: Corr. = Correct marks; Err. = Errors; P. Err. = Perseverative errors; Cat. = Achieved Categories; Om. = Omissions
*Significant Pearson Correlation at 0.05 (bilateral)
**Significant Pearson Correlation at 0.01 (bilateral)

Table 6
Stroop * WSCT

			WSCT				
ST			**Corr.**	**Err.**	**P. Err.**	**Cat.**	**Om.**
Correct marks	Pearson	*Pearson*	0.068	-.333*	-.399*	0.032	0.156
		Sig.	0.683	0.041	0.013	0.849	0.348
	Anova	*F*	0.863	1.499	1.302	1.177	1.271
		Sig.	0.598	0.189	0.28	0.339	0.296
Incorrect marks	Pearson	*Pearson*	-0.133	0.11	0.159	-0.082	0.048

	Sig.	0.427	0.509	0.342	0.625	0.775
Anova	*F*	0.743	0.469	0.678	0.520	0.471
	Sig.	0.707	0.936	0.779	0.722	0.926

Note: WSCT: Corr. = Correct marks; Err. = Errors; P. Err. = Perseverative errors; Cat. = Achieved Categories; Om. = Omissions
*Significant Pearson Correlation at 0.05 (bilateral)
**Significant Pearson Correlation at 0.01 (bilateral)

4. Discussion

Our study intends to outline guidelines for adequate digital games selection applicable to cognitive flexibility stimulation, considering the existing literature and the results of a cognitive assessment in school childrens. It focused on a small sample and the statistical analysis showed moderate correlation values. Therefore, its scope is limited and the verification of prospects here made requires further research. However, results of empirical study seem explicable by each EF model (cognitive flexibility, sustained attention, focused attention and inhibitory control). We believe that founded correlations could be useful for the goal of this paper as they seem to suggest that: 1) Concentration of attention is a *sine qua non* condition for the detection of rule changes, 2) Inhibition of previous patterns and inadequate response is the subsequent step. Moreover, negative relations among variables related to cognitive flexibility and sustained attention could indicate that: 3) sustained attention and repetitive monotonous rules may generate a tendency to perseveration which is not functional to cognitive flexibility training. This does not limit the relevance of an adequate stimulation in every cognitive domain, but suggest that the application of static guidelines could not be appropriate for cognitive flexibility stimulation.

It has been found that first person action videogames (*First Person Shooter)* stimulate cognitive flexibility by reducing difficulties on "task shifting" (*Task Switching Cost*) on players vs. non-players (Colzato et al., 2010). Authors explain these results viewing that modern videogames of this category not only demand the ability to "shoot" in a specific moment, but set up stages and contextual elements which enhance and enrich the variability of stimulus situation. We regard that this quality –however, not specific of the genre in question- is essential for proper training of cognitive flexibility.

Some practical examples may clarify the problem: a simple "shooting on targets" game would not present a challenging situation for cognitive flexibility. If a rule to avoid certain objects were added to the game (intrusive objects, teammates, etc.), it may involve an additional demand for inhibitory control. The addition of some extra conditions (transformations on stage, changes in the objectives in terms of a story, a complex and changing map) would improve the cognitive flexibility demand. For specific training purposes, we should pay attention to the procedural adequacy of the software (Gros, 2000) more than to the gender type. It is important to address this observation, since certain products –such as combat or First Person Shooter mentioned above- may not be suitable for certain people for its content, despite if those provide or not an adequate stimulation to cognitive flexibility.

Seems necessary to work on the production of quantitative indicators to guide the selection of videogames for cognitive training. Also, the contents of the games should be checked to avoid overlapping with contents tipically provided by general education (Oei & Patterson, 2014).

As synthesis, we can say that a videogame should convene the following conditions to adequately stimulate cognitive flexibility:

1) Presentation of changing and rich stages.
2) Unexpected shifts of rules and demands.
3) Expiration of previous response patterns.
4) Feedback about the adequacy or inadequacy of the response.
5) High demand of focused attention.
6) High demand of inhibitory control.
7) Low level of perseveration technique as a valid response pattern.

Estas These guidelines are subject to further assessment, and it is necessary to weigh them under consideration of future programs of stimulation in cognitive flexibility. It is necessary to stress once again that the mere stimulant value of a game does not determine its procedural and context fit, making necessary to advance on construction of scientific criteria for its selection. Stimulation of executive functions utilizing digital games is a growing field, so it is expected a gradual adjustment between theory and practice to increases the expected result and facilitate the widespread practices.

References

Aboalgasm, A. & Ward, R. (2014). The potential of digital tools in art lessons at junior school level to improve artistic ability using tamazight fonts. *International Journal of Social, Management, Economics and Business Engineering*, *8*(3), 1-6.

Acosta López, J., Cervantes Henríquez, M., Sánchez Rojas, M., Núñez Barragán, M., & Puentes Rozo, P. (2010). Déficit en habilidades sociales en niños con Trastorno Por Déficit de Atención-Hiperactividad evaluados con la escala BASC. *Psicogente*, *13*(24), 274-291. doi: 10.15446/rcp.v23n1.34332.

Álvarez, M. A. (2000). *Sistema único de seguimiento para pacientes hipotiroideos (Manual y Software)*. Cuba: Universidad de La Habana.

Beversdorf, D. Q., Hughes, J. D., Steinberg, B. A., Lewis, L. D., & Heilman, K. M. (1999). Noradrenergic modulation of cognitive flexibility in problem solving. *Neuroreport*, *10*(13), 2763-2767.

Blake, R. J. (2013). *Brave new digital classroom: Technology and foreign language learning*. Georgetown: University Press.

Blumberg, F. C., Blades, M., & Oates, C. (2013). Youth and new media: The appeal and educational ramifications of digital game play for children and adolescents. *Zeitschrift für Psychologie*, *221*(2), 67- 71. doi: 10.1027/2151 2604/a000133.

Cervigni M., Stelzer, F., Mazzoni, C., & Álvarez, M. Á. (2012). Desarrollo de las funciones ejecutivas en niños preescolares. Una revisión de su vínculo con el temperamento y el modo de crianza. *Pensando Psicología*, *8*(15), 128-139.

Cervigni, M., Stelzer, F., Mazzoni, C., Gómez, C., & Martino, P. (2012) Funcionamiento ejecutivo y TDAH. Aportes teóricos para un diagnóstico diferenciado entre una población infantil y adulta. *Revista Interamericana de Psicología*, *46*(2), 271- 276.

Colzato, L. S., van Leeuwen, P. J., van den Wildenberg, W., & Hommel, B. (2010). DOOM'd to switch: superior cognitive flexibility in players of first person shooter games. *Frontiers in Psychology*, *1*(8), 1-5. doi: 10.3389/fpsyg.2010.00008.

Denckla, M. B. (1994). Measurement of executive function. En G. R. Lyon (Ed.), *Frames of reference for the assessment of learning disabilities: new views on measurement issues* (pp.117-142). Baltimore, MD: Paul H Brooks.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science*, *318*(5855), 1387-1388. doi: 10.1126/science.1151148.

Entertainment Software Association. (2015). *Essential facts about the computer and video game industry*. Recuperado de: http://www.theesa.com/wp-content/uploads/2015/04/ESA-Essential-Facts-2015.pdf

Etchepareborda, M. C. & Mulas, F. (2004). Flexibilidad cognitiva, síntoma adicional del trastorno por déficit de atención con hiperactividad ¿Elemento predictor terapéutico? *Revista de Neurología*, *38*(1), 97-102.

Galimberti, E., Martoni, R. M., Cavallini, M. C., Erzegovesi, S., & Bellodi, L. (2012). Motor inhibition and cognitive flexibility in eating disorder subtypes. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *36*(2), 307-312.

García-Coni, A., Canet-Juric, L., & Andrés, M. L. (2010). Desarrollo de la flexibilidad cognitiva y de la memoria de trabajo en niños de 6 a 9 años de edad. *Revista Mexicana de Investigación en Psicología*, 2(1), 12-19.

García-Molina, A., Enseñat-Cantallops, A., Tirapu-Ustárroz, J., & Roig-Rovira, T. (2009). Maduración de la corteza prefrontal y desarrollo de las funciones ejecutivas durante los primeros cinco años de vida. *Revista de Neurología*, *48*(435), 40-45.

Goldberg, E. (2002). *The executive brain: Frontal lobes and the civilized mind*. Oxford: University Press.

González Rodríguez, B. & Muñoz Marrón, E. (2002). *Estimulación cognitiva por ordenador*. España: Universitat Oberta de Catalunya.

Graells, P. M. (2002). *Evaluación y selección de software educativo*. Recuperado de: http://dewey.uab.es/pmarques.

Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of playing video games. *American Psychologist*, *69*(1), 66-78. doi: 10.1037/a0034857

Goldin, A. P., Hermida, M. J., Shalom, D. E., Costa, M. E., Lopez-Rosenfeld, M., Segretin, M. S., & Sigman, M. (2014). Far transfer to language and math of a short software-based gaming intervention. *Proceedings of the National Academy of Sciences*, *111*(17), 6443-6448. doi: 10.1073/pnas.1320217111.

Green, C. S. & Bavelier, D. (2006). The cognitive neuroscience of video games. En P. Messaris & L. Humphreys (Eds.), *Digital media: Transformations in human communication* (pp. 211-223). New York: Peter Lang Publishing, Inc.

Gros, B (2000). Del software educativo a educar con software. *Quaderns Digital*, *24*, 440-482.

Gu, X., Zhu, Y., & Guo, X. (2013). Meeting the "Digital Natives": Understanding the acceptance of technology in classrooms. *Journal of Educational Technology Society*, *16*(1), 392-402.

Hamlen, K. R. (2011). Children's choices and strategies in video games. *Computers in Human Behavior*, *27*(1), 532-539. doi: 10.1016/j.chb.2010.10.001.

Hudgins, T. R. & Anderson, G (2015). Digital Natives: The revolution in teacher education programs. *National Social Science*, *44*(1), 20-28.

Instituto Nacional de Estadística y Censos (2001). *Encuesta permanente de hogares*. Recuperado de http://www.indec.gov.ar/redatam/NEW_EPH/EPH_hogar.pdf.

Irwin, A. R. & Gross, A. M. (1995). Cognitive tempo, violent video games, and aggressive behavior in young boys. *Journal of family violence*, *10*(3), 337- 350. doi: 10.1007/BF02110997.

Lehto, J. E., Juujärvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive functioning: Evidence from children. *British Journal of Developmental Psychology*, *21*(1), 59-80. doi: 10.1348/026151003321164627.

Lima, M., Koehler, M. J., & Spiro, R. J. (2004). Collaborative interactivity and integrated thinking in brazilian business schools using cognitive flexibility hypertexts: The panteon project. *Journal of Educational Computing Research*, *31*(4), 371-406. doi: 10.2190/TTK2-TDRP-D0DX-M8XN.

Miyake, A. & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: four general conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. doi: 10.1177/0963721411429458.

O'Donovan, C. & Hussey, J. (2012). Active video games as a form of exercise and the effect of gaming experience: a preliminary study in healthy young adults. *Physiotherapy*, *98*(3), 205-21. doi: 10.1016/j.physio.2012.05.001.

Oei, A. C. & Patterson, M. D. (2014). Are videogame training gains specific or general. *Frontiers in Systems Neuroscience*, *8*(54), 1-9. doi: 10.3389/fnsys.2014.00054.

Organización Mundial de la Salud (2009). Patrones de peso infantil: peso y talla para la edad. Recuperado de: http://www.who.int/childgrowth/standards/es/

Papazian, O., Alfonso, I., & Luzondo, R. J. (2006). Trastornos de las funciones ejecutivas. *Revista de Neurología*, *42*(3), 45-50.

Pías, N., Fernández, J., Robaina, R., & Álvarez, M. (2009). Evaluación del desarrollo neurocognitivo implementado mediante un sistema computarizado de pruebas psicométricas. *Bioingeniería y Física Médica Cubana*, *10*(3), 23-27.

Raven, J. C. & Court, J. H. (2000). *Test de matrices progresivas – Escala coloreada (manual)*. Buenos Aires: Paidós.

Rodriguez-Aranda, C. & Sundet, K. (2006). The frontal hypothesis of cognitive aging: Factor structure and age effects on four frontal tests among healthy individuals. *Journal of Genetic Psychology*, *167*, 269-287. doi: 10.3200/GNTP.167.3.269-287.

Servera, M. & Llabrés, J. (2004). *Tarea de Atención Sostenida en la Infancia*. Islas Baleares: TEA Ediciones.

Sholberg, M. M. & Mateer, C. A. (1989) Remediation of executive functions impairments. En M.M. Sholberg & C. A. Mateer (Eds.), *Introduction to cognitive rehabilitation* (pp. 232- 263). New York: The Guilford Press.

Squire, K. (2003). Video games in education. *International Journal of Intelligent Games & Simulation*, *2*(1), 49-62.

Stelzer, F., Mazzoni, C. C., & Cervigni, M. A. (2014). Cognitive models of executive functions development. Methodological limitations and theoretical challenges. *Anales de Psicología*, *30*(1), 329-336.