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Analysis of Reliability and Generalizability of One Instrument for Assessing Visual Attention Span: MenPas Mondrian Color

Rafael E. Reigal [1], Fernando González-Guirval [1], José L. Pastrana-Brincones [2], Sergio González-Ruiz [1], Antonio Hernández-Mendo [1] and Verónica Morales-Sánchez [1,*]

1 Faculty of Psychology, University of Malaga, 29071 Malaga, Spain; rafareigal@uma.es (R.E.R.); guirval@uma.es (F.G.-G.); hergio@gmail.com (S.G.-R.); mendo@uma.es (A.H.-M.)

2 School of Computer Science and Engineering, University of Malaga, 29071 Malaga, Spain; pastrana@lcc.uma.es

* Correspondence: vomorales@uma.es

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Abstract: Attention is one skill related to processes such as memory or learning, so, its evaluation is very interesting in areas such as clinical, educational or sports. The aim of this paper is to analyze the reliability and generalizability of one online computerized tool, named MenPas Mondrian Color, that has been developed for the visual attention span assessing and training. In addition, it has been intended to determine any existing relationships among the different parameters of the tasks performed in order to check the coherence of the results obtained in the executions. In 11,540 analyzed executions of 1064 users from different American, African and European countries, 6543 of them were performed by women (56.70%) and 4997 by men (43.30%). The age distribution showed that all of the participants were aged 18–55 years, with an average of 25.50 ± 8.91 years. The analyzed tool is called MenPas Mondrian Color which is included in the MENPAS 1.0 platform. Reliability (Cronbach's Alpha), variance components and generalizability analyses were carried out in order to analyze the quality of the data gathered by this tool. The obtained results indicated optimal scores in the analyses performed, suggesting that the data gathered are reliable, precise and statistically generalizable to a larger population. Likewise, correlation analyses indicated that the difficulty of the task is related to the effectiveness in its executions, indicating that this is a highly sensitive tool.

Keywords: attention; evaluation; computerized; cognition; assessment

1. Introduction

Attention is a brain function related to numerous processes such as perception, memory, or learning [1]. It contributes to the selection and adequate treatment of sensory information stored in the memory, facilitating the output of appropriate responses [2,3]. Therefore, it is considered as an ability linked to the processes that allow for human adaptation to the environment, and also what makes its study be especially interesting in areas such as clinical, educational, public health, labor or sports [4–7]. An adequate level of cognitive functioning and, specifically, a good attentional capacity, is an essential factor in human functioning, which affects their well-being [1,3,5].

Currently, most researchers argue that it is not a unitary mechanism, but rather a highly complex neuroanatomical and neurofunctional system, acting on various processes and taking shape anatomically in a wide range of brain areas [8,9]. In fact, it is based on an extensive network of cortical and subcortical connections, where structures such as the thalamus, limbic system, basal ganglia, anterior reticular system, parietal cortex, prefrontal cortex, anterior cingulate cortex, the upper midbrain collicles or the cerebellum are involved [10–13].

Traditionally, attention has been explained on the basis of a set of systems that manage its functioning, such as alert or arousal (level of consciousness), after-attention or perception (orientation) and prior or supervisory attention (execution). However, although those explanations are still in use, they coexist with others interacting with them in the management of this capacity, such as self-regulation or self-control—what is considered as the ability to control and manage thoughts, feelings and behavior [14,15]. Moreover, based on this functioning, different types of attention can be established, such as arousal, attentional span, shifting attention between visual fields, selective, serial, divided, sustained and inhibition [3,16].

Among the different types of attention mentioned before, the attentional span refers to the capacity to attend to a wide range of stimuli, keeping that information available to be used, being possible to differentiate diverse modalities such as the acoustic, auditory-verbal or visual [10,17]. Some of the tools used to evaluate the attentional span are the digit retention test (WISC-IV, WAIS), Corsi cubes, Koppitz VADS test, word span, auditory-verbal span, visual selective test of the TOMAL or the McCarthy test [18–23]. Specifically, the visual attention span can be defined as the number of visual elements that can be processed in parallel [24] or number of items processed at a glance [25].

Globally, attention can be considered as a basic cognitive ability affecting other cognitive processes. Many studies have highlighted that attention is closely related to other cognitive processes, such as memory. Specifically, it has been observed that attention interacts with short-term memory and working memory, even sharing neuroanatomical elements [26–29]. In fact, some difficulties found in cognitive processes that involve memory have their origin in the attentional capacity [30,31]. For this reason, it is very relevant to focus interest on these types of basic cognitive skills, such as attention, since they affect more complex cognitive and behavioral processes in the human being [32]. Attentional processes and memory are sometimes so closely associated to each other that there are cognitive training and evaluation tests integrating both processes [22,23].

Attention is one skill that can be modified in an interested manner, which has been highlighted by various researchers [2,33,34]. The impact of attention deficits and the benefits obtained after systematic training have been studied in situations such as widespread social phobia [35,36], states of anxiety [37,38] or attention deficit hyperactivity [39,40]. In the recent years, the number of computerized tools and platforms used to assess and train various cognitive functions, such as attention, have increased considerably [35,41,42]. Software tools have been emerging such as: *BrainTrain*® (Richmond, US) (www.braintrain.com), *Cognifit* (Nazrat Ilit, Israel) (www.cognifit.com), *Luminosity*® (San Francisco, US) (www.lumosity.com) or *Brain Fitness* (New York, US) (www.mindsparke.com) [43–46]. MenPas platform (www.menpas.com) [47,48] is inside that set of tools available for online assessment and training of attention. MenPas presents many different applications (Attentional Processes, MenPas Cell, Grid) [49,50], where some are Mondrian-type tasks (Colors, Photos, Pairs, Simon, Stroop), based on the creative styles of Pieter Cornelius Mondrian, and the scientific evidence indicating the activity present in the pre-stressed cortex when it is stimulated by the combination of the colored grids shown by this tool [51–53].

Specifically, MenPas Mondrian Colors is an exercise that evaluates the visual attentional span, and also short-term memory and working memory. The task consists of putting a series of colors in a matrix that has previously been shown as colored, but after a few seconds, those colors are hidden (see the Section 2.2). When the colors disappear from their initial location, a rectangle is presented as colors reminiscent of those that were present in the matrix. Then, you only have to click using the mouse on each color, and then they appear in the matrix. The task can be configured (number of colors, matrix size, execution time, displayed time, etc.), and facilitating the task can be adapted to the user and to the evaluation or training objectives. It is a computerized task that allows data to be stored in the MenPas platform [47,48], which can be consulted later to process them statistically.

This type of evaluation and intervention is used for a more specific treatment of the attention and it is adapted to the characteristics of the patient, improving old deficiencies and expanding the range of possibilities which existed a few years ago [54,55]. Moreover, these types of resources have the capacity to obtain a more exact response time, knowing exactly the time where one stimulus is displayed or the time interval between one stimulus and the following one [56]. In addition, computers allow the use of flexible and creative resources that increase the motivation during exercise (such as sounds, colors, images, etc.), which could be an important point in some cases [57,58].

This increment in the available resources consolidate the possibility of offering alternative and complementary routes to the pharmacological ones in the intervention on certain situations and population groups, which is one aspect where there is a high demand [59]. Additionally, it facilitates as the data management as the flow of information between the professionals using them, by optimizing the processes of intervention on these cognitive abilities [47]. However, as a result of the proliferation of these types of tools and their increasingly widespread use, one of the questions raised is about the reliability of these types of tools and the quality of the data obtained by them.

Therefore, and based on the related background, the purpose of this work is to present preliminary data about reliability, generalizability and some correlation results of several configuration variables of the MenPas Mondrian Color (MenPas Cell, MenPas) task. Therefore, this study will try to determine if: (a) the analyzed instrument generates reliable, precise and generalizable data, and (b) the exercise results are altered by the instrument configuration handling.

2. Materials and Methods

2.1. Participants

A total of 11,540 executions were carried out by 1064 users from different countries in America ($n = 651$; 5.64%), Africa ($n = 36$; 0.31%) and Europe ($n = 10{,}853$; 94.04%)—most of them from Spain ($n = 10{,}609$; 91.93%). Of the total executions, 6543 were taken by female (56.70%) and 4997 by male (43.30%). Participants' ages were between 18 and 55 years, where the average age was 25.50 ± 8.91 years. The inclusion criteria were: (a) carry out the test between 2009 and 2013; (b) be between 18 and 55 years old; (c) make less than 40 errors during the execution of the exercise; (d) perform the exercise from 30 to 300 s; (e) perform the exercise with a displayed time from 5 to 30 s; (f) use a matrix size from 2×2 to 5×5.

2.2. Instruments and Measures

MenPas Mondrian Color. This computerized tool is used to evaluate and train the visual attention span, although it also involves other cognitive aspects such as short-term memory and working memory. This tool allows the creation of a color matrix, making up what is known as a *Mondrian*. The task consisted in visualizing a set of colors, located in a specific position of the matrix, and after a time of exposure, pointing to where they were located. It was hosted in MenPas Cell, downloadable from the MenPas online Psychosocial Evaluation Platform (www.menpas.com) [47,48,51]. This software is a Windows desktop application developed under the NET platform in the C# programming language and with the Visual Studio programming Integrated Development Environment (IDE). When starting the application, the program asks for the MenPas platform username and password. The test configurator allows one to set the size of the matrix (rows and columns), the number of colors, the displayed time and the time of the test. When the test starts, the test matrix appears with colors located in a position (see Figure 1). The colors disappear when the displayed time ends. Starting from here, the participant must point out where each color was located (see Figure 2). In order to do this, the participant must click by using the mouse on a color (the set of possible colors appears below the matrix) and then on the rectangle that he/she thinks was the color. Hits and errors of each run are stored in a database, which can be retrieved later.

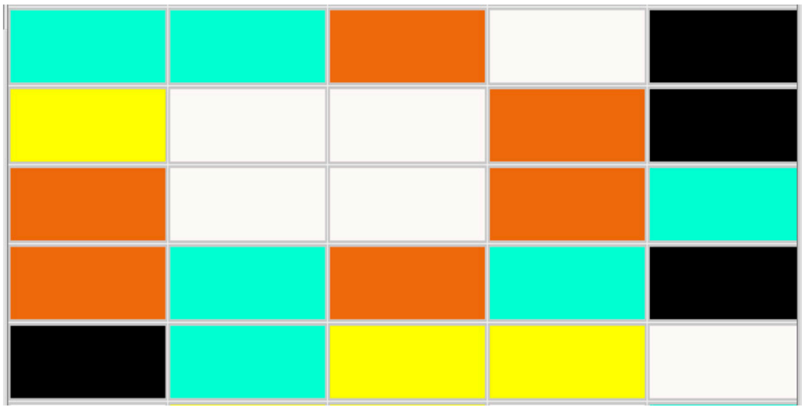

Figure 1. MenPas Mondrian Color (colored matrix during the displayed time).

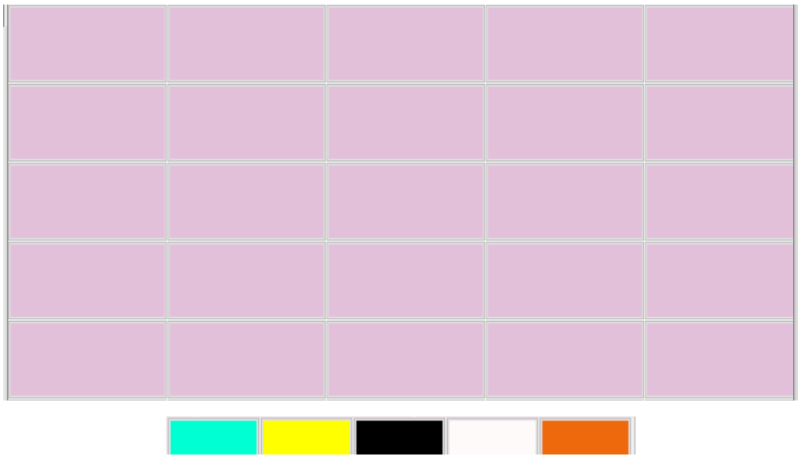

Figure 2. MenPas Mondrian Color (matrix without colors during the task time).

2.3. Procedure

Data have been gathered by the research team collecting information from many MenPas Mondrian Color runs from January 2009 to December 2013. The request to participate in the study and the use of this tool was disseminated through the MenPas platform where the program is hosted. Thus, the participants could perform their exercises from home. Further, these data were stored in the database of the online platform. In order to get an informed consent, end-users were informed about what data are being gathered, who will have access to them, and how they will be used when users are registered on the platform, where their approval is mandatory for storing and processing those scores. Data processing is, obviously, anonymous. The exercises recorded took from 30 to 300 s, had a matrix size from 2×2 to 5×5, used 10 colors maximum and a displayed time from 5 to 30 s. The ethical principles of the Declaration of Helsinki [60] were respected throughout the research process. The study was approved by an ethics committee (CEUMA, no. 243, 19-2015-H) of the University of Málaga (Spain).

2.4. Data Analysis

Descriptive and inferential analyses of the data have been taken. In order to explore the quality of the data obtained, analyses of variance components were carried out using Minimum Square (VARCOMP method = type1) and Maximum Likelihood (GLM) procedures, as well as generalizability [61–67]. Reliability analyses have also been carried out using Cronbach's Alpha statistician [68]. Correlation analyses have been carried out using the Spearman's test. SAS v.9.1 software (SAS Institute Inc., Cary, NC, USA, 1999) [69], SAGTv.1.0 (University of Málaga, Málaga, Spain) [70] and the statistical program SPSS v.20.0 (IBM Corp., Armonk, NY, USA) have been used for the statistical processing of the data.

3. Results

In order to analyze the quality, reliability and generalizability of the data obtained (hits and errors for a specific execution (structure of the task matrix = rows × columns)), they were estimated according to the variables: gender (model 1), origin (model 2), age (model 3) and level of study (model 4).

Model 1: Hits, errors and structure according to the gender.

Table 1 shows the analyses carried out according to gender, as well as the reliability estimated using Cronbach's Alpha. As can be seen, both male and female reliability indices are greater than 0.70.

Table 1. Descriptive and reliable data by gender.

	Male n = 4997			Female n = 6543		
	M	**DT**	**α**	**M**	**DT**	**α**
Hits	8.95	6.31		8.28	5.71	
Errors	4.51	6.98	0.73	5.09	7.16	0.71
Structure	11.19	7.08		10.57	4.88	

Note: α = Cronbach's Alpha (hits × errors × structure).

An analysis of variance components has been carried out using a Minimum Square (VARCOMP method = type1) and a Maximum Likelihood (GLM) procedure. In the g×h×e×s model (where [g] gender, [h] hits, [e] errors, [s] structure), the error variance in both procedures is the same, so it is assumed that the sample is normal, linear and homoscedastic [71,72]. Furthermore, the model and all its facets and interactions are significant (<0.0001) and explains 71.38% of the variance; and a Coefficient of Variation of 62.08, indicates that the data set is homogeneous. When a generalizability analysis was carried out, the following results have been obtained (Table 2), indicating that data are reliable and generalizable.

Table 2. Generalizability analysis (relative and absolute G-coefficients) for the hit × error × structure × gender model.

Model	Relative G-Coefficient	Absolute G-Coefficient
[g] [e] [s]/[h]	0.98	0.97
[h] [e] [s]/[g]	1	1
[g] [h] [s]/[e]	0.97	0.95
[g] [h] [e]/[s]	0.99	0.99

Model 2: Hits, errors and structure according to the origin of its participants.

Table 3 shows the analyses carried out according to the origin of the participants, as well as the reliability estimated using Cronbach's Alpha. As can be seen, reliability indices are greater than 0.70, except for the executions carried out in America where the index is 0.68.

Table 3. Descriptive and reliable data according to origin.

	Spain n = 10,609			Europe n = 244			America n = 651			Africa n = 36		
	M	**DT**	**α**	**M**	**DT**	**α**	**M**	**DT**	**α**	**M**	**DT**	**α**
Hits	8.56	5.98		7.70	6.96		9.25	5.56		6.11	5.29	
Errors	4.66	6.90	0.72	6.50	9.19	0.74	7.18	8.58	0.68	4.11	7.18	0.79
Structure	10.77	5.90		10.87	6.46		11.99	6.34		9.42	3.69	

Note: α = Cronbach's Alpha (hits × errors × structure).

An analysis of variance components has been carried out using a Minimum Square (VARCOMP method = type1) and a Maximum Likelihood (GLM) procedure. In the o×h×e×s model (where [n] origin-nation, [h] hits, [e] errors, [s] structure), the error variance in both procedures is the same, and all its facets and interactions are significant (<0.0001), except for the h×e×s interaction, and explains 73.67% of the variance with a Coefficient of Variation of 59.50. Likewise, in the t×a×f×r model (where [c] continent-origin, [h] hits, [e] errors, [s] structure), the error variance in both procedures is the same, all its facets and interactions are significant (<0.0001), with the exception of the interaction c×e×s, and explains 71.07% of the variance and a Coefficient of Variation of 62.02. Therefore, in both cases, the homogeneity of the data set can be assumed, and also that the sample is normal, linear and homoscedastic [71,72]. In addition, generalizability analyses have been carried out (Table 4), indicating that data are reliable and generalizable.

Table 4. Generalizability analysis (relative and absolute G-coefficients) for the success × error × structure × source model.

Components of the Model	Model	Relative G-Coefficient	Absolute G-Coefficient
n×h×e×s [n] nation-origin, [h] hits, [e] errors, [s] structure	[h] [e] [s]/[n]	0.99	0.99
	[n] [e] [s]/[h]	0.98	0.98
	[n] [h] [s]/[e]	0.98	0.96
	[n] [h] [e]/[s]	0.99	0.99
c×h×e×s [c] continent-origin, [h] hits, [e] errors, [s] structure	[h] [e] [s]/[c]	0.99	0.99
	[c] [e] [s]/[h]	0.98	0.97
	[c] [h] [s]/[e]	0.98	0.96
	[c] [h] [e]/[s]	0.99	0.90

Model 3: Hits, errors and structure according to age

Table 5 shows the analyses carried out according to the age of the participants, as well as the reliability estimated using Cronbach's Alpha. As can be seen, reliability indices are greater than 0.71 for all age intervals.

Table 5. Descriptive and reliable data by age.

	18 to 25 Years *n* = 7839			26 to 35 Years *n* = 2307			36 to 45 Years *n* = 599			46 to 55 Years *n* = 795		
	M	**DT**	**α**	**M**	**DT**	**α**	**M**	**DT**	**α**	**M**	**DT**	**α**
Hits	8.35	6.02		10.03	5.77		7.55	4.74		7.31	6.27	
Errors	4.71	6.82	0.72	5.16	7.28	0.73	3.03	4.47	0.73	6.52	9.80	0.71
Structure	10.70	6.02		11.94	6.05		9.27	3.74		10.22	5.69	

Note: α = Cronbach's Alpha (hits × errors × structure).

An analysis of variance components has been carried out using a Minimum Square (VARCOMP method = type1) and a Maximum Likelihood (GLM) procedure. In the a×h×e×s model (where [a] age, [h] hits, [e] errors, [s] structure), the error variance in both procedures is the same, all its facets and interactions are significant (<0.0001), explains 87.41% of the variance, and shows a Coefficient of Variation of 45.56. In the i×a×f×r model (where [i] age-intervals, [h] hits, [e] errors, [s] structure), the error variance in both procedures is the same, all its facets and interactions are significant (<0.0001), explains 76.76% of the variance, and shows a Coefficient of Variation of 56.54. Therefore, in both cases the homogeneity of the data set can be assumed, as well as the sample being normal, linear and homoscedastic [71,72]. Additionally, generalizability analyses have been carried out (Table 6), indicating that data are reliable and generalizable.

Table 6. Generalizability analysis (relative and absolute G-coefficients) for the success × error × structure × age model.

Components of the Model	Model	Relative G-Coefficient	Absolute G-Coefficient
a×h×e×s [a] age, [h] hits, [e] errors, [s] structure	[h] [e] [s]/[a]	0.97	0.97
	[a] [e] [s]/[h]	0.97	0.96
	[a] [h] [s]/[e]	0.98	0.97
	[a] [h] [e]/[s]	0.99	0.99
i×h×e×s [i] age-intervals, [h] hits, [e] errors, [s] structure	[h] [e] [s]/[i]	1	1
	[i] [e] [s]/[h]	0.98	0.97
	[i] [h] [s]/[e]	0.97	0.96
	[i] [h] [e]/[s]	0.99	0.98

Model 4: Hits, errors and structure according to the level of studies of the participants.

Table 7 shows the analyses carried out according to the educational level of the participants, as well as the reliability estimated using Cronbach's Alpha. As can be seen, reliability indices are greater than 0.71 for all age intervals.

Table 7. Descriptive and reliable data according to educational level.

	Primary n **= 532**			**Media** n **= 2876**			**Superiors** n **= 8132**		
	M	**DT**	**α**	**M**	**DT**	**α**	**M**	**DT**	**α**
Hits	7.15	5.50		8.64	6.62		8.64	5.76	
Errors	3.54	5.74	0.74	4.43	6.93	0.74	5.07	7.21	0.71
Structure	9.20	4.51		11.05	6.66		10.87	5.74	

Note: α = Cronbach's Alpha (hits × errors × structure).

An analysis of variance components has been carried out using a Minimum Square (VARCOMP method = type1) and a Maximum Likelihood (GLM) procedure. In the t×h×e×s model (where [t] studies, [h] hits, [e] errors, [s] structure), the error variance in both procedures is the same, so it can be assumed that the sample is normal, linear and homoscedastic [71,72]. Furthermore, in the model, all its facets and interactions are significant (<0.0001), except for t×h×e×s, and explains 70.30% of the variance, and a Coefficient of Variation of 63.46, indicating that the data set analyzed is homogeneous. When a generalizability analysis has been carried out, the following results are obtained (Table 8), suggesting that data are reliable and generalizable.

Table 8. Generalizability analysis (relative and absolute G-coefficients) for the success × error × structure × level of education model.

Model	Relative G-Coefficient	Absolute G-Coefficient
[h] [e] [s]/[t]	1	1
[t] [e] [s]/[h]	0.98	0.97
[t] [h] [s]/[e]	0.97	0.96
[t] [h] [e]/[s]	0.99	0.99

Analysis of correlations between the waiting time variables and the number of colors with hits and errors depending on the size of the matrix.

Table 9 shows the descriptive statistics and normality of the variables' successes, errors, displayed time and number of colors used during the task according to the size of the matrix used. Structures used for these analyses have been executed in more than 100 cases. Specifically, 2 × 2 (n = 968), 2 × 3 (n = 686), 3 × 3 (n = 6209), 3 × 4 (n = 689), 4 × 4 (n = 1884), 4 × 5 (n = 225) and 5 × 5 (n = 470) matrices have been analyzed. These structures, all together, are the 96.46% of the total. The correlation values between the hit and error variables with displayed time and number of colors are also shown.

Table 9. Descriptive and normality statistics for the variables' successes, errors, number of colors and display time according to the size of the structures. Correlation analyses between hit and error variables with number of colors and displayed time are also shown.

Matrix		*M*	*DT*	%	*A*	*K*	*K-S*	*r*	
								Colors	Displayed Time
2 × 2	Hits	3.04	1.52	56.09	−1.20	−0.28	0.41 ***	−0.39 **	0.14 **
	Errors	2.38	4.36	43.91	3.43	14.35	0.29 ***	0.24 **	−0.28 **
	Colors	3.61	1.48	-	3.89	23.36	0.35 ***		
	Displayed time	7.78	4.96	-	6.30	82.19	0.30 ***		
2 × 3	Hits	4.95	1.77	57.03	−1.58	1.23	0.38 ***	−0.35 **	0.09 *
	Errors	3.73	4.81	42.97	1.91	4.60	0.22 ***	0.45 **	−0.20 **
	Colors	3.65	1.46	-	4.62	28.46	0.33 ***		
	Displayed time	6.52	3.73	-	3.68	16.97	0.45 ***		
3 × 3	Hits	6.34	3.19	64.43	−0.78	−0.86	0.29 ***	−0.69 **	0.38 **
	Errors	3.50	5.85	35.57	3.98	20.52	0.31 ***	0.29 **	−0.15 **
	Colors	3.73	1.45	-	4.01	22.56	0.34 ***		
	Displayed time	7.18	5.95	-	5.31	46.11	0.43 ***		
3 × 4	Hits	10.91	2.69	72.64	−2.63	6.08	0.47 ***	−0.48 **	0.22 **
	Errors	4.11	5.75	27.36	2.83	12.49	0.24 ***	0.39 **	−0.06
	Colors	4.47	3.52	-	2.49	4.65	0.39 ***		
	Displayed time	9.10	7.33	-	4.59	33.45	0.30 ***		
4 × 4	Hits	14.29	3.72	65.31	−2.36	4.75	0.42 ***	−0.30 **	−0.11 **
	Errors	7.59	7.93	34.69	1.73	3.74	0.17 ***	0.23 **	−0.02
	Colors	5.43	4.41	-	1.55	0.74	40 ***		
	Displayed time	10.10	8.57	-	3.09	12.47	0.30 ***		
4 × 5	Hits	17.10	4.76	65.22	−1.87	2.87	0.29 ***	−0.36 **	0.22 **
	Errors	9.12	6.70	34.78	0.96	1.28	0.10 ***	0.27 **	−0.12
	Colors	8.46	5.62	-	0.21	−1.83	0.28 ***		
	Displayed time	11.60	11.59	-	4.01	20.58	0.35 ***		
5 × 5	Hits	21.37	6.67	58.42	−1.77	1.89	0.38 ***	−0.44 **	−0.15 **
	Errors	15.21	10.86	41.58	1.08	1.19	0.10 ***	0.24 **	−0.04
	Colors	9.06	5.70	-	0.00	−1.91	0.31 ***		
	Displayed time	9.01	8.08	-	2.76	10.13	0.39 ***		

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

As can be seen, the values of asymmetry, kurtosis and Kolmogorov–Smirnov indicate that the data distributions were not normal. Thus, Spearman's test has been used for correlation analysis. As can be seen, the number of colors is positively related to errors and negatively related to hits. Taking into account the displayed time, in smaller structures (2 × 2, 2 × 3 and 3 × 3), there is a positive relationship with the hits and a negative relationship with the errors. However, it is not significantly related to the number of errors in the rest of the structures, because it is positively related to the hits in the 3 × 4 and 4 × 5 matrix, but negatively in the 4 × 4 and 5 × 5 structures.

4. Discussion

The aim of the present work is to analyze the reliability and generalizability of the data obtained by the MenPas Mondrian Color software (MenPas Cell, MenPas). In order to do that, Cronbach's Alpha analysis, variance and generalizability components have been carried out. The results show optimal values, which suggest an adequate quality of the data obtained. We also have tried to determine any relationships between the difficulty of the task (the number of colors in each matrix and the displayed time of the exercise prior to its execution have been analyzed) and the hits/errors made, observing that there is a congruent association between these parameters.

In order to evaluate the psychometric characteristics of the tool, different models have been tested, with the aim of checking the sensitivity of the tool in a wide spectrum of executions and diverse characteristic participants. All of them have shown that data are accurate and reliable, as well as generalizable, suggesting that it is an appropriate tool to be used for that evaluation. In addition, these results show an appropriate response to different variables such as age, gender, origin or education level, which allows us to infer that its capacity to provide quality data when assessing diverse populations is not affected. Among other reasons, this tool lacks cultural elements [73], because it uses simple stimuli common to all cultures, such as colors. This feature is important, as has been highlighted in previous studies with instruments of the same nature [74]. It is not influenced by prior learning, nor is it necessary to interpret a particular knowledge in a context. Therefore, it is considered a useful tool to be widely used.

Data found also indicated that a greater size structure of the used matrix generates a higher level of hits and a higher level of errors, maintaining a proportional and coherent relationship with the structure of the matrix used. The aim of using this tool is that when the size of the task matrix increases, then the participant is forced to retain a greater number of items. Therefore, the probability of making a greater number of errors is increased. That difficulty, and the ability of the tool to force more errors when the structure increases, allows for differentiation of expertise at each level of work. If this effect will not be generated, the discriminatory capacity of the tool would decrease and would make it less suitable for measuring this capacity. In addition, the phenomenon described above allows the training of the attentional amplitude. When the size of the task increases, a greater number of stimuli must be recognized and there is a greater probability of error, causing greater stimulation and effort to execute the task correctly. The possibility of voluntarily modifying these elements facilitates the control of the evaluation and training, encouraging the possibilities of using this tool [55].

The number of colors and the displayed time of the group of colors to be remembered later can also be manipulated. In addition to what we previously commented on about the versatility of the task, it allows the participant to tune and condition the user's motivation [55,58]. It has been observed that the increment in the number of colors makes the hits more difficult and increases the number of errors, which suggests that the possibility of manipulating these parameters becomes a positive aspect of the instrument by being able to condition the learning and evaluation of the participants. In previous studies, in which computerized attention assessment instruments have been used, it also has been observed that increasing the stimuli that must be managed during the test determines errors and fewer hits [50]. Likewise, it has been observed how the previously displayed time of the task is related to the successes and errors. It has been observed that up to nine items have a positive association with the successes and negative association with the errors, indicating that this exposure time facilitates the subsequent search for the stimulus. However, when up to 12 items, the relationships are not so clear, and this pattern disappears. This could suggest that the initial visualization during a longer time facilitates the memorization and later visualization of the objective stimuli, although it disappears when the amount of items to be attended is increased. This is consistent with theories that have described the limited capacity of people to retain and use a certain number of units of information [75]. The ability to retain visual information is limited, although it is determined by various parameters such as prior training, the type of information to be retained, or the precision with which the stimulus is recalled. Hence, it is difficult to make exact parallels between performances between tests. Still, it is perceived that based on a quantity of information, there is a pattern in the test presented in this study that shows a decline in the ability to use previously memorized information accurately, which coincides with what has been postulated by other authors [75,76].

The results found show that this instrument is reliable and could be used in various situations as a useful tool for training and cognitive evaluation. Furthermore, it is sensitive to different configurations, which is why it is suggested that this is a test that can be adapted to the needs of users. This test could be applied in schoolchildren, the elderly, cognitive training in athletes or workers who need to improve their cognitive performance. Even in pathologies with cognitive impairment, it could be used as a complementary instrument to assess the cognitive level, even though it is not a diagnostic test.

This work has limitations inherent to the fact that it is a preliminary study of the psychometric characteristics of the tool evaluated. This is a tool with a lot of characteristics that can be modulated, which increases the difficulty of validating all of them. Therefore, future research will try to solve these questions, determining the quality of the data offered by MenPas Mondrian Color. It will also be necessary to analyze its convergent validity to delve into its ability to assess the amplitude of attention. However, these preliminary results are promising, and the results obtained show that it could be a useful, versatile and appropriate tool to explore this capacity. Future works will try to analyze the validity of this instrument in order to confirm that this instrument can evaluate the attentional span.

5. Conclusions

Reliability (Cronbach's Alpha), variance components and generalizability analyses showed that the data were reliable, precise and generalizable. Additionally, correlation analyses indicated that some task characteristics were related to execution effectiveness. Therefore, a greater number of colors decrease the hits and the errors, and the initial visualization of items facilitates the memorization of the objective stimuli when the matrix is small or moderate in size.

The results obtained in this investigation indicated that the analyzed instrument offers quality data and could be appropriate to be used in evaluations and cognitive training, although it is necessary to develop a validity analysis to confirm the properties of this tool. For example, it would be appropriate to perform convergent and discriminant validity analyses. If these analyses were appropriate, we would be facing a test that could be used for evaluation or intervention in areas such as education, sports or the clinic, among others. Since it is a computerized test, it facilitates its application and data collection. Thus, this research offers interesting data on a new resource to be applied in the field of cognitive functioning.

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References

1. Nussenbaum, K.; Amso, D.; Markant, J. When increasing distraction helps learning: Distractor number and content interact in their effects on memory. *Atten. Percept. Psychophys.* **2017**, *79*, 2606–2619. [CrossRef] [PubMed]
2. Carrasco, M.; Barbot, A. Spatial attention alters visual appearance. *Curr. Opin. Psych.* **2019**, *29*, 56–64. [CrossRef] [PubMed]
3. Estévez-González, A.; García-Sánchez, C.; Junqué, C. La atención: Una compleja función cerebral. *Rev. Neurol.* **1997**, *25*, 1989–1997. [PubMed]
4. Gray, R.; Gaska, J.; Winterbottom, M. Relationship between sustained, orientated, divided, and selective attention and simulated aviation performance: Training & pressure effects. *J. Appl. Res. Mem. Cogn.* **2016**, *5*, 34–42. [CrossRef]
5. Jangmo, A.; Stålhandske, A.; Chang, Z.; Chen, Q.; Almqvist, C.; Feldman, I.; Bulik, C.M.; Lichtenstein, P.; D'Onofrio, B.; Kuja-Halkola, R.; et al. Attention-deficit/hyperactivity disorder, school performance, and effect of medication. *J. Am. Acad. Child. Adolesc. Psychiatr.* **2019**, *58*, 423–432. [CrossRef] [PubMed]
6. Hüttermann, S.; Ford, P.R.; Williams, A.M.; Varga, M.; Smeeton, N.J. Attention, perception, and action in a simulated decision-making task. *J. Sport. Exerc. Psy.* **2019**, *41*, 230–241. [CrossRef]
7. Rusciano, A.; Corradini, G.; Stoianov, I. Neuroplus biofeedback improves attention, resilience, and injury prevention in elite soccer players. *Psychophysiology* **2017**, *54*, 916–926. [CrossRef]
8. Colmenero, J.M.; Catena, A.; Fuentes, L.J. Atención visual: Una revisión sobre las redes atencionales del cerebro. *Psicologia* **2001**, *17*, 45–67.
9. Mirdamadi, J.L.; Suzuki, L.Y.; Meehan, S.K. Attention modulates specific motor cortical circuits recruited by transcranial magnetic stimulation. *Neuroscience* **2017**, *359*, 151–158. [CrossRef]

10. Etchepareborda, M.C.; Abad-Mas, L. Sustrato biológico y evaluación de la atención. *Rev. Neurol. Clin.* **2001**, *2*, 113–124.
11. Holroyd, C.B.; Nieuwenhuis, S.; Mars, R.B.; Coles, M.G. Anterior cingulate cortex, selection for action, and error processing. In *Cognitive Neuroscience of Attention*; Posner, M.I., Ed.; Guilford Press: New York, NY, USA, 2004; pp. 219–231.
12. Jiménez, J.E.; Hernández, S.; García, E.; Díaz, A.; Rodríguez, C.; Martín, R. Test de atención D-2: Datos normativos y desarrollo evolutivo de la atención en educación primaria. *Eur. J. Educ. Psychol.* **2012**, *5*, 93–106. [CrossRef]
13. Petersen, S.E.; Posner, M.I. The attention system of the human brain: 20 years after. *Annu. Rev. Neurosci.* **2012**, *35*, 73–89. [CrossRef] [PubMed]
14. MacLeod, J.W.; Lawrence, M.A.; McConnell, M.M.; Eskes, G.A.; Klein, R.M.; Shore, D.I. Appraising the ANT: Psychometric and theoretical considerations of the Attention Network Test. *Neuropsychology* **2010**, *24*, 637. [CrossRef] [PubMed]
15. Posner, M.I.; Rothbart, M.K. Temperament and brain networks of attention. *Philos. Trans. R. Soc. B-Biol. Sci.* **2018**, *373*, 20170254. [CrossRef] [PubMed]
16. Posner, M.I.; Petersen, S.E. The attention system of the human brain. *Annu. Rev. Neurosci.* **1990**, *13*, 25–42. [CrossRef]
17. Etchepareborda, M.C. Bases experimentales para la evaluación de la atención en el trastorno por déficit de atención con hiperactividad. *Rev. Neurol.* **2004**, *38*, 137–144. [CrossRef]
18. Koppitz, E.M. *The Visual Aural Digit Span Test*; Grune and Stratton: New York, NY, USA, 1977. [CrossRef]
19. Madoz-Gúrpide, A.; Ochoa-Mangado, E. Alteraciones de funciones cognitivas y ejecutivas en pacientes dependientes de cocaína: Estudio de casos y controles. *Rev. Neurol.* **2012**, *54*, 199–208. [CrossRef]
20. Reynolds, C.R.; Bigler, E.D. *TOMAL. Test. de Memoria y Aprendizaje*; TEA: Madrid, Spain, 2001.
21. Soprano, A.M. *Cómo Evaluar la Atención y Las Funciones Ejecutivas en Los Niños y Adolescents*; Paidós: Buenos Aires, Argentina, 2009.
22. Wechsler, D. *Escala de Inteligencia de Wechsler Para Adultos-III (WAIS-III)*; TEA: Madrid, Spain, 1999.
23. Wechsler, D. *Manual de Aplicación y Corrección del WISC-IV*; TEA: Madrid, Spain, 2005.
24. Bosse, M.L.; Tainturier, M.J.; Valdois, S. Developmental dyslexia: The visual attention span deficit hypothesis. *Cognition* **2007**, *104*, 198–230. [CrossRef]
25. Ans, B.; Carbonnel, S.; Valdois, S. A connectionist multiple-trace memory model for polysyllabic word reading. *Psychol. Rev.* **1998**, *105*, 678–723. [CrossRef]
26. Souza, A.S.; Oberauer, K. The contributions of visual and central attention to visual working memory. *Atten. Percept. Psychophys.* **2017**, *79*, 1897–1916. [CrossRef]
27. Olivers, C.N. Interactions between visual working memory and visual attention. *Front. Biosci.* **2008**, *13*, 1182–1191. [CrossRef] [PubMed]
28. Wood, G.; Hartley, G.; Furley, P.A.; Wilson, M.R. Working memory capacity, visual attention and hazard perception in driving. *J. Appl. Res. Mem. Cogn.* **2016**, *5*, 454–462. [CrossRef]
29. Carlisle, N.B.; Kristjánsson, Á. How visual working memory contents influence priming of visual attention. *Psychol. Res.* **2018**, *82*, 833–839. [CrossRef] [PubMed]
30. Smith, P.L.; Lilburn, S.D.; Corbett, E.A.; Sewell, D.K.; Kyllingsbæk, S. The attention-weighted sample-size model of visual short-term memory: Attention capture predicts resource allocation and memory load. *Cogn. Psychol.* **2016**, *89*, 71–105. [CrossRef] [PubMed]
31. Ortega, R.; López, V.; Carrasco, X.; Escobar, M.J.; García, A.M.; Parra, M.A.; Aboitiz, F. Neurocognitive mechanisms underlying working memory encoding and retrieval in Attention-Deficit/Hyperactivity Disorder. *Sci. Rep.* **2020**, *10*, 1–13. [CrossRef] [PubMed]
32. Ramey, M.M.; Henderson, J.M.; Yonelinas, A.P. The spatial distribution of attention predicts familiarity strength during encoding and retrieval. *J. Exp. Psychol. Gen.* **2020**. [CrossRef] [PubMed]
33. Álvarez, P.; González-Castro, P.; Núñez, J.C.; González-Pineda, J.; Bernardo, A. Evaluación y control de la activación cortical en los déficit de atención sostenida. *Int. J. Clin. Health Psychol.* **2008**, *8*, 509–524.
34. Peng, P.; Miller, A.C. Does attention training work? A selective meta-analysis to explore the effects of attention training and moderators. *Learn. Individ. Differ.* **2016**, *45*, 77–87. [CrossRef]
35. Amir, N.; Taylor, C.T.; Elías, J.; Donohue, M.C. Predictors of response to an attention modification program in generalized social phobia. *J. Consult. Clin. Psychol.* **2011**, *79*, 533–541. [CrossRef]

36. Amorós-Boix, M.; Rosa Alcázar, A.I.; Olivares-Olivares, P.J. Papel de la focalización de la atención en el tratamiento de la fobia social generalizada en adolescents. *Psicologia* **2011**, *27*, 718–728.
37. Goodwin, H.; Yiend, J.; Hirsch, C.R. Generalized Anxiety Disorder, worry and attention to threat: A systematic review. *Clin. Psychol. Rev.* **2017**, *54*, 107–122. [CrossRef]
38. Eldar, S.; Bar-Haim, Y. Neural plasticity in response to attention training in anxiety. *Psychol. Med.* **2010**, *40*, 667–677. [CrossRef] [PubMed]
39. Christiansen, H.; Oades, R.D. Negative priming within a stroop task in children and adolescents with attention-deficit hyperactivity disorder, their siblings, and independent controls. *J. Atten. Disord.* **2010**, *13*, 497–504. [CrossRef] [PubMed]
40. Bikic, A.; Leckman, J.F.; Christensen, T.Ø.; Bilenberg, N.; Dalsgaard, S. Attention and executive functions computer training for attention-deficit/hyperactivity disorder (ADHD): Results from a randomized, controlled trial. *Eur. Child. Adoles. Psy.* **2018**, *27*, 1563–1574. [CrossRef]
41. Chamberlain, S.R.; Robbins, T.W.; Winder-Rhodes, S.; Müller, U.; Sahakian, B.J.; Blackwell, A.D.; Barnett, J.H. Translational approaches to frontostriatal dysfunction in attention-deficit/hyperactivity disorder using a computerized neuropsychological battery. *Biol. Psychiatry* **2011**, *69*, 1192–1203. [CrossRef] [PubMed]
42. Reid, D.; Babani, H.; Jon, E. Development of a computerized visual search test. *Int. J. Rehabil. Res.* **2009**, *32*, 205–212. [CrossRef]
43. Kletzel, S.L.; Cary, M.P.; Ciro, C.; Berbrayer, D.; Dawson, D.; Hoffecker, L.; Machtinger, J.; Pham, P.; Thai, M.; Heyn, P.C. Brain Gaming: A User's Product Guide for the Clinician. *Arch. Phys. Med. Rehabil.* **2016**, *97*, 1399–1400. [CrossRef]
44. Morrison, G.E.; Simone, C.M.; Ng, N.F.; Hardy, J.L. Reliability and validity of the NeuroCognitive Performance Test, a web-based neuropsychological assessment. *Front. Psychol.* **2015**, *6*, 1652. [CrossRef]
45. Rabiner, D.L.; Murray, D.W.; Skinner, A.T.; Malone, P.S. A randomized trial of two promising computer-based interventions for students with attention difficulties. *J. Abnorm. Child. Psychol.* **2010**, *38*, 131–142. [CrossRef]
46. Shatil, E.; Mikulecka, J.; Bellotti, F.; Bureš, V. Novel television-based cognitive training improves working memory and executive function. *PLoS ONE* **2014**, *9*, e101472. [CrossRef]
47. González-Ruiz, S.L.; Domínguez-Alfonso, R.; Chica-Merino, E.; Pastrana-Brincones, J.L.; Hernández-Mendo, A. Una plataforma virtual para la evaluación e investigación on-line: Menpas. *Cuad. Psicol. Deporte* **2018**, *18*, 26–48.
48. González-Ruiz, S.L.; Hernández-Mendo, A.; Pastrana-Brincones, J.L. Herramienta software para la evaluación psicosocial de deportistas y entornos deportivos. *EF Deportes* **2010**, *15*, 144. Available online: http://www.efdeportes.com/efd144/evaluacion-psicosocial-de-deportistas.htm (accessed on 29 January 2020).
49. Hernández-Mendo, A.; Martínez-Jiménez, M.A.; Pastrana-Brincones, J.L.; Morales-Sánchez, V. Programa informático para evaluación y entrenamiento de la atención. *Rev. Iberoam. Psicol. Ejerc. Deporte* **2012**, *7*, 339–358.
50. Reigal, R.E.; González-Guirval, F.; Morillo-Baro, J.P.; Morales-Sánchez, V.; De Mier, R.J.-R.; Hernández-Mendo, A. Effects of a Computerized Training on Attentional Capacity of Young Soccer Players. *Front. Psychol.* **2019**, *10*, 2279. [CrossRef] [PubMed]
51. Hernández-Mendo, A.; Ramos-Pollán, R. El uso de la informática en la psicología del deporte. *EF Deportes* **2000**, *5*, 19. Available online: http://www.efdeportes.com/efd19/infpsi.htm (accessed on 15 January 2020).
52. Zeki, S.; Shipp, S. The functional logic of cortical connections. *Nature* **1988**, *335*, 311–317. [CrossRef] [PubMed]
53. Zeki, S. La imagen visual en la mente y en el cerebro. *Investig. Cienc.* **1992**, *194*, 27–35.
54. Shafiei, H.; Zare, H. Effectiveness of attention bias modification by computerized attention training on reducing social anxiety of adolescents. *Adv. Cog. Sci.* **2019**, *21*, 108–120. [CrossRef]
55. Abend, R.; Rosenfelder, A.; Shamai, D.; Pine, D.S.; Tavor, I.; Assaf, Y.; Bar-Haim, Y. Brain structure changes induced by attention bias modification training. *Biol. Psychol.* **2019**, *146*, 107736. [CrossRef]
56. González de la Torre, G.; González de la Torre, A. Evaluación de la Atención mediante el Test de Cancelación Simple y Cancelación Condicionada [Batería Neuropsicológica Sevilla (BNS)] en niños con Transtorno por Déficit de Atención e Hiperactividad (TDAH). *Rev. Esp. Neuropsicol.* **2003**, *5*, 177–193.
57. Fernández-Calvo, B.; Rodríguez-Pérez, R.; Contador, I.; Rubio-Santorum, A.; Ramos, F. Eficacia del entrenamiento cognitivo basado en nuevas tecnologías en pacientes con demencia tipo Alzheimer. *Psicothema* **2011**, *23*, 44–50. [PubMed]

58. Harris, D.J.; Wilson, M.R.; Vine, S.J. A systematic review of commercial cognitive training devices: Implications for use in sport. *Front. Psychol.* **2018**, *9*, 709. [CrossRef] [PubMed]
59. Green, C.T.; Long, D.L.; Green, D.; Losif, A.M.; Dixon, J.F.; Miller, M.R.; Fassbender, C.; Schweitzer, J.B. Will working memory training generalize to improve off-task behavior in children with attention-deficit/hyperactivity disorder? *Neurotherapeutics* **2012**, *9*, 639–648. [CrossRef] [PubMed]
60. World Medical Association. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *J. Am. Med. Assoc.* **2013**, *310*, 2191–2194. [CrossRef]
61. Blanco-Villaseñor, A.; Castellano, J.; Hernández-Mendo, A.; Sánchez-López, C.R.; Usabiaga, O. Aplicación de la TG en el deporte para el estudio de la fiabilidad, validez y estimación de la muestra. *Rev. Psicol. Deporte* **2014**, *23*, 131–137.
62. Blanco-Villaseñor, A.; Castellano, J.; Hernández-Mendo, A. Generalizabilidad de las observaciones de la acción del juego en el fútbol. *Psicothema* **2000**, *12*, 81–86.
63. Briesch, A.M.; Swaminathan, H.; Welsh, M.; Chafouleas, S.M. Generalizability theory: A practical guide to study design, implementation, and interpretation. *J. Sch. Psychol.* **2014**, *52*, 13–35. [CrossRef]
64. Cronbach, L.J.; Rajaratnam, N.; Gelser, G.C. Theory of generalizability: A liberalization of reliability theory. *Brit. J. Stat. Psych.* **1963**, *16*, 137–163. [CrossRef]
65. Cronbach, L.J.; Gleser, G.C.; Nanda, H.; Rajaratnam, N. *The Dependability of Behavioral Measurements*; Wiley: New York, NY, USA, 1972.
66. Mendo, A.M.; Díaz, F.; Sánchez, M. Construcción de una herramienta observacional para evaluar las conductas prosociales en las clases de educación física. *Rev. Psicol. Deporte* **2010**, *19*, 305–318.
67. Maneiro, R.; Blanco-Villaseñor, Á.; Amatria, M. Analysis of the Variability of the Game Space in High Performance Football: Implementation of the Generalizability Theory. *Front. Psychol.* **2020**, *11*, 534. [CrossRef]
68. Cronbach, L.J. Coefficient alpha and the internal structure of test. *Psychometrika* **1951**, *16*, 297–334. [CrossRef]
69. Schlotzhauer, S.D.; Littell, R.C. *SAS System for Elementary Statical Analysis*; SAS Institute Inc.: Cary, NC, USA, 1997.
70. Hernández-Mendo, A.; Blanco-Villaseñor, A.; Pastrana, J.L.; Morales-Sánchez, V.; Ramos-Pérez, F.J. SAGT: New software for generalizability analysis. *Rev. Iberoam. Psicol. Ejerc. Deporte* **2016**, *11*, 77–89.
71. Hemmerle, W.; Hartley, H. Computing maximum likelihood estimates for the mixed AOV Model using the w-transformation. *Technometrics* **1973**, *15*, 819–831. [CrossRef]
72. Searle, S.; Casella, G.; McCulloch, C. *Variance Components*; John Wiley: New York, NY, USA, 1992. [CrossRef]
73. Hall, G.N.; Ibaraki, A.Y.; Huang, E.R.; Marti, C.N.; Stice, E. A meta-analysis of cultural adaptations of psychological interventions. *Behav. Ther.* **2016**, *47*, 993–1014. [CrossRef] [PubMed]
74. González-Guirval, F.; Reigal, R.E.; Morillo-Baro, J.P.; Juárez-de Mier, R.; Hernández-Mendo, A.; Morales-Sánchez, V. Análisis de la validez convergente de un instrumento informatizado para evaluar la atención en deportistas: Rejilla 1.0. *Cuad. Psicol. Deporte* **2020**, *20*, 83–94. [CrossRef]
75. Bays, P.M.; Husain, M. Dynamic shifts of limited working memory resources in human vision. *Science* **2008**, *321*, 851–854. [CrossRef]
76. Adam, K.C.; Vogel, E.K.; Awh, E. Clear evidence for item limits in visual working memory. *Cog. Psychol.* **2017**, *97*, 79–97. [CrossRef]