ATTENTION AND VISUOSPATIAL ABILITIES: A NEUROPSYCHOLOGICAL APPROACH IN FIELD-DEPENDENT AND FIELD-INDEPENDENT SCHOOLCHILDREN

M. Adelina GUISANDE, Carolina TINAJERO, Fernando CADAVEIRA,
M. Fernanda PÁRAMO

Department of Developmental and Educational Psychology
Faculty of Psychology, University of Santiago de Compostela
Campus Vida, 15782 Santiago de Compostela, Spain
E-mail: carolina.tinajero@usc.es

Abstract: The aim of this study was to explore cognitive processes that may underlie the poor school performance of children with a field-dependent cognitive style. One-hundred-and forty-nine children between the ages of 8 and 11 were evaluated using the Children Embedded Figures Test (CEFT) and classified as field-dependent, field-independent, or intermediate field-dependent-independent (FDI). The Digit Span and Digit Symbol, as well as the Visual Search and Attention Test (VSAT) were administered as tests of attentional function. The Block Design and the Rey-Osterrieth Complex Figure Test were administered as tests of visuospatial abilities. Field-independent children obtained higher scores than field-dependent children on the tests of attentional function. With regard to visuospatial tasks, field-independent children obtained higher scores than both field-dependent and intermediate FDI children on the Block Design test. On the Rey-Osterrieth Complex Figure test, field-dependent children obtained lower scores than both field-independent and intermediate-FDI children.

Key words: field-dependence-independence, attentional function, visuospatial abilities

Cognitive styles have been defined as forms of functioning revealed through perceptive and intellectual activities and also manifested in affective and social spheres of the individual since they are based in consistent ways of organizing and obtaining information and experience (Rayner, Riding, 1997; Riding, 1997). In particular, field dependence-independence is considered one of the most heuristic cognitive style constructs (Sternberg, Grigorenko, Zhang, 2008). It is conceived as a bipolar dimension in which individuals are situated according to their confidence in internal or external references. In the cognitive domain, it fundamentally refers to a greater or lesser tendency to assume the organization inherent to the information which must be dealt with, and a higher or lower restructuring ability in order to impose personal organization (Witkin, Goodenough, Oltman, 1979). Field-independent individuals, who are characterized by their confidence in internal references, tend to assume an analytical approach towards information, which allows them to break it down into its component parts and restructure it according to their needs (Witkin et al., 1962).

Field dependence-independence has been shown to manifest across a wide spectrum of situations. Specifically, this dimension seems to have important educational implications, since it has been shown consistently to determine academic professional trajectory (Guisande et al., 2007), the way teachers teach (Evans, 2004) and the type of interaction between teacher and student (Saracho, 2000). Moreover, depending on the proximity to the extremes of the dimension, individuals show diverse ways of information processing which seem to modulate their instructional preferences (Tinajero et al., 2011), their learning strategies (Tinajero et al., 2010; Tinajero et al., 2012), and their academic achievement. In fact, we can assert that field-dependence places students at risk for poor school outcomes, whereas field-independence favors a student's success (Cano, 2006; Danili, Reid, 2006; Garton, Ball, Dyer, 2002; Hederich, 2004; Tinajero, Páramo, 1997, 1998; Zhang, Sternberg, 2005).

Differences between field-dependent and field-independent individuals may depend on the suitability of preferred information processing strategies to the requirements of the situation that is been handled. This idea has inspired investigations exploring the relation of cognitive style with a wide range of cognitive tasks (e.g., Davis, Cochran, 1990; Guisande et al., 2007).

Studies on the implication of defining features of field dependence-independence have been prominent. Thus, a study by Clark and Roof (1988) showed that, during the completion of several WAIS-R subtests, field-independent individuals tended to use strategies based on analyzing parts of the stimuli, while their field-dependent counterparts tended to consider the stimuli as a whole. Rozencwajg (1991) obtained similar results with adolescents completing the Block Design. These results are consistent with those from different investigations using tasks based on perceptual discrimination (Guisande et al., 2007; Marendaz, 1985), concept acquisition (Johnson, Prior, Artuso, 2000; Rickards et al., 1997), sorting (O'Connor, Blowers, 1980; Ohlmann, Carbonnel, 1983) or associative learning (Tsakanikos, 2006). When working on tasks which necessarily demand an analytical approach, field-dependent individuals seem to be dominated by the salient cues of the supplied information (O'Connor, Blowers, 1980; Ohlmann, Carbonnel, 1983).

In general, field-dependent individuals accept the stimulus field as given, showing more difficulty than field-independent ones when processing complex images, especially when analyzing and identifying particular elements within an embedding context (Dwyer, Moore, 1997/98; Reardon, Moore, 1988). From a neuropsychology standpoint, a variety of studies have shown significant differences favoring field-independent individuals on visuoperceptive and visuoconstructive tasks (Cadaveira et al., 1999; Kogan, Block, 1991). According to this line of research, a key differentiation between field-independent and field-dependent individuals is visual perceptiveness and discrimination.

Finally, some studies focusing on tasks assessing working memory, have reported that individuals' efficiency of use of attentional resources modulate the performance of field-dependent and field-independent individuals on diverse cognitive tasks, such as reading and listening comprehension, vocabulary acquisition, and complex learning (Bahar, Hansell, 2000; Bennink, 1982; Globerson, 1989; Goode, Goddard, Pascual-Leone, 2002; Miyake, Witzki, Emerson, 2001). According to these studies, field-dependent individuals are characterized by less effective control processes, leading to a lower efficiency in the use of attentional resources. In particular, Goode and collaborators (2002), registered event-related potentials in field-dependent and field-independent groups during a serial-order recall task, and found that in tasks with high memory requirement the Field-dependent group mobilized inhibitory processes to change their global-perceptual attentional strategy for processing task information, which may have resulted in less mental-attentional resources available to them during the task's retention phase.

In spite of the fact that most of these studies have begun to identify the cognitive processes that underlie field dependence-independence cognitive style, most of them have considered only a single cognitive process, offering a fragmentary picture of the nature of cognitive style. Another common limitation in the studies reviewed is that, generally, they have only treated field dependence-independence as a categorical and independent variable. In this study, cognitive style was also treated as a quantitative and dependent variable and its relation with different components of attention and visuospatial ability was analyzed. Finally, unlike most studies on field dependence-independence that only include individuals with extreme scores in this dimension, the present study considered individuals with intermediate-FDI as well.

The main objective of this study was analyzing to what extent field dependence-independence cognitive style can explain the performance in the attentional and visuospatial tasks. Specifically, a) to determine whether individuals with different cognitive styles show performance differences on tasks which explore different attention processes and b) determining whether individuals with a different cognitive style show differences in their ability for visuospatial information processing. An additional objective in this study was determining whether these neuropsychological tests can predict the scores in the field dependence-independence cognitive style.

Taking into account the implications of attentional and visuospatial processes for developmental problems, both objectives, together with the close relationship of field dependence-independence with age, would allow to assess the possibility of using this cognitive style as a dimension to characterize the neuropsychological development in children.

On the other hand, the objectives formulated in this study would permit giving an answer to questions raised in the literature about cognitive style and inspired by research and practical concerns. Thus, for example, they may contribute to elucidating the controversy over the neutral value of field dependence independence. Second, they may serve as the basis for intervention proposals on academic failure probably caused by ineffective information processing strategies which are typically manifested in extreme field-dependent children.

METHOD

Participants

One hundred and forty-nine children aged between 8 and 11 years (M = 9.53, SD = 1.10) participated in the study. Of the 149 children, 79 were boys and 70 were girls (33 eight-year-olds, 19 boys and 14 girls; 42 nine-year-olds, 25 boys and 17 girls; 36 ten-year-olds, 15 boys and 21 girls; and 38 eleven-year-olds, 20 boys and 18 girls). Gender representation was not significantly different among the four age groups, $\chi^2(3) = 2.83$, $p > .05$. All the children resided in or near Santiago de Compostela (northwest Spain), and attended two urban elementary schools (3rd - 6th grade). The mean SES of the sample was primarily middle-class based on parent education and occupation.

Instruments

The field dependence-independence was assessed using the Children's Embedded Figures Test (CEFT, Karp, Konstadt, 1971). This test is administered individually, and requires detecting a simple shape (a triangle and an irregular pentagon) within a complex, meaningful drawing. It includes 25 test items; the score is the number of correct responses. It is also often used in neuropsychological assessment as an indication of perceptive ability in individuals and, particularly, of their ability to break down an organized visual field and extract a part from the whole.

The *attentional functioning* was evaluated with four tests selected for their sensitivity to different attentional processes. The Digits Forward Span task of the Wechsler Intelligence Scale for Children (WISC-IV) (Wechsler, 1974/2005) is used as a measure of attentional space, resistance to distraction, and immediate recall (Coklin et al., 2007). The Digits Backward Span task (WISC-IV) (Wechsler, 1974/2005) is considered a measure of verbal working memory, involving transformation of information, verbal manipulation and visuospatial imagination (Coklin et al., 2007; Hale, Hoeppner, Fiorello, 2002; Zhu, Weiss, 2005). *Complex attention* was assessed with the Digit Symbol subtest (WISC-IV) (Wechsler, 1974/2005), since it requires that the individual's focus shifts and maintains attention. The Visual Search and Attention Test (VSAT) (Trenerry et al., 1990) is a cancellation test basically aimed at exploring the vigilance component or sustained attention, despite influence of additional cognitive functions, such as visual search ability or the capability to activate and inhibit rapid motor responses.

The *visuospatial abilities* were assessed with two tests. The Block Design subtest (WISC-IV) (Wechsler, 1974/2005) requires adept motor control and visuospatial and nonverbal reasoning abilities. Finally on the Rey-Osterrieth Complex Figure (ROCF), a complex geometric figure must be copied, demanding visuospatial construction, planning and organization skills.

Procedure

Before administering the test protocol, we obtained, from the parents or legal guardian of each child, written informed consent to their child's participation in the study. Parents completed a structured questionnaire designed for this study which included questions regarding family demographic characteristics (e.g., information on educational level and professional situation). The assessment was conducted by an experienced psychologist in neuropsychological assessment and took place in a quiet area of the children's school. The tasks were administered individually in the same order for all participants, and the administration time did not exceed 90 minutes. Each child received a small gift (e.g., a box of crayons or candy) for participating in the study. The statistic package IBM SPSS Statistics Program (version 19.0 for *Windows*) was used for the statistical analyses.

RESULTS

Demographic Variables and Cognitive Style

In order to respond to the first of the objectives of this study, participants were assigned to the field-dependent, to the intermediate-FDI, or to the field-independent groups, according to whether their CEFT scores were in the top, middle or bottom third of each group of age (8, 9, 10 or 11). The mean CEFT score for the total sample was 17.64 (SD = 4.40). As can be seen from Table 1, the mean CEFT scores improve with age (although minimum and maximum scores showed little variation with age). A one-way ANOVA indicated significant variation in the CEFT with age [$F(3,148) = 5.834$, $MSE = 17.601$, $p < .001$, $\eta^2 = .108$], although post-hoc Scheffé tests indicated significant differences only between the extreme age groups (8 and 11) (CEFT scores 15.39 vs. 19.55, difference between means = 4.16, $p < .001$).

Preliminary analyses ruled out any influence of sex [$t(147) = -.779$, $p = .437$] or family's socioeconomic status [$\chi^2(2, N = 149) = 2.056$, $p = .358$] in the CEFT score, and these variables were thus not considered in the next analyses.

Cognitive Functioning and Cognitive Style

Analyses of variance (ANOVA) were carried out to assess whether performance on the different tasks varied depending on field dependence-independence. The dependent variables were scores obtained on each of the tests of the neuropsychological battery used. Distribution of the mean scores and standard deviations are shown in Table 2 for each cognitive functioning task in the three field dependence-independence groups.

Field-independent children obtained the highest scores on all tests, while the field-dependent counterparts obtained the lowest scores. Variance analyses indicated that the cognitive style had a statistically significant effect in all neuropsychological tasks considered except for the Digits Forward Span task [$F(2, 148) = 2.836$, $MSE = 2.324$, $p > .05$, $\eta_p^2 = .037$]. Specifically, significant score differences among the three field dependence-independence groups were observed on the Digits Backward Span task [$F(2, 148) = 16.041$, $MSE = 1.571$, $p < .001$, $\eta_p^2 = .180$], on the Digit Symbol test [$F(2, 148) = 7.348$, $MSE = 75.434$, $p \leq .001$, $\eta_p^2 = .091$], and on the Visual Search and Attention Test [$F(2, 148) = 4.580$, $MSE = 297.083$, $p < .05$, $\eta_p^2 = .059$]. Post-hoc Scheffé results allowed to

Table 1. Means, standard deviations and minimum and maximum scores on the Children's Embedded Figures Test (CEFT), in children of different ages

Age	n	CEFT			
		M	SD	Min.	Max.
8	33	15.39	4.82	6	22
9	42	17.47	3.83	7	23
10	36	17.83	4.43	7	24
11	38	19.55	3.76	8	25

Table 2. Means and standard deviations in the neuropsychological battery, as obtained by children in the three field dependence-independence groups

Test	Field dependence-independence group					
	Field-dependence (n = 52)		Intermediate-FDI (n = 54)		Field-independence (n = 43)	
	M	SD	M	SD	M	SD
Digits Forward	5.31	1.23	5.74	1.67	6.05	1.65
Digits Backward	4.83	1.15	5.06	1.47	6.21	1.06
Digit Symbol	42.67	9.58	46.43	9.11	49.49	6.80
Visual Search and Attention Test	84.62	18.44	92.00	18.13	94.84	14.33
Block Design	28.21	9.56	32.80	8.79	39.16	9.37
Rey-Osterrieth Complex Figure (Organization)	7.48	3.31	9.54	3.40	10.79	2.47

confirm that field-independent children obtained significantly higher scores than field-dependent children in the Digits Backward Span task (difference between means = 1.38, $p < .001$), in the Digit Symbol test (difference between means = 6.82, $p \leq .001$), and in the Visual Search and Attention Test (difference between means = 10.22, $p < .05$); and than intermediate-FDI children in the Digits Backward Span task (difference between means = 1.15, $p < .001$).

Finally, the results of the ANOVAS on the data of visuospatial tasks showed statistically significant effects of the field dependence-independence factor in both the Block Design test [$F(2, 148) = 16.580$, $MSE = 85.269$, $p < .001$, $\eta_p^2 = .185$] and Rey-Osterrieth Complex Figure (Organization) [$F(2, 148) = 13.754$, $MSE = 9.764$, $p < .001$, $\eta_p^2 = .159$]. Post-hoc Scheffé tests indicated in the Block Design test, that field-independent children obtained significantly higher scores than field-dependent children (difference between means = 10.95, $p < .001$) and intermediate-FDI children (difference between means = 6.37, $p < .01$). In the Rey-Osterrieth Complex Figure (Organization), field-dependent children obtained significantly lower scores than intermediate-FDI children (difference between means = -2.06, $p < .01$) and field-independent children (difference between means = -3.31, $p < .001$).

Predictors of Cognitive Style

Table 3 shows the correlations matrix between the different neuropsychological tests used in our study. The absolute values of these correlations ranged between .18 and .67, and all coefficients reached the level of significance.

Based on results of Pearson correlations conducted on the data, linear regression analysis (stepwise) was used to assess

Table 3. Inter-correlation matrix

Variables	1	2	3	4	5	6	7
1 - Children Embedded Figures Test	-						
2 - Digits Forward	.27**	-					
3 - Digits Backward	.38***	.42***	-				
4 - Digit Symbol	.46***	.27**	.39***	-			
5 - Visual Search and Attention Test	.39***	.25**	.18*	.67***	-		
6 - Block Design	.56***	.36***	.39***	.44***	.51***	-	
7 - Rey-Osterrieth Complex Figure (Organization)	.47***	.25**	.31***	.35***	.41***	.54***	-

Note: * p < .05, ** p < .01, *** p < .001

which cognitive tasks can predict performance on the CEFT. The number of correct responses on the CEFT was the dependent variable. The overall equation was significant, $F(3,145) = 30.019$, $p < .001$, and it accounted for 38% of the total variance. Table 4 shows the regression coefficients for the predictor variables. Specifically, the Block Designs task was the strongest predictor of performance on the CEFT (31%), and only marginal additional variance was explained by Digit Symbol test and Rey-Osterrieth Complex Figure (Organization), with very similar percentages of variance, 4% and 3% respectively.

DISCUSSION

This paper presents the data obtained in a sample of schoolchildren who completed a comprehensive series of neuropsychological tests for the assessment of attentional and visuospatial processes. Their cognitive style was also examined and field independence was found to increase with age, a tendency already found by Witkin, Goodenough and Karp (1967) and strongly supported since their longitudinal study.

The obtained results suggest that individuals with a different cognitive style show

Table 4. Predictor variables for the number of correct responses on the Children Embedded Figures Test

Predictor variable	B	SE B	β	t
Block Design	.15	.04	.35	4.239***
Digit Symbol	.10	.04	.20	2.577*
Rey-Osterrieth Complex Figure (Organization)	.26	.10	.20	2.501*

Note: * p < .05, *** p < .001

a different performance in attentional and visuospatial tasks, supporting critical positions regarding the assumed neutral value of the field dependence-independence construct on cognitive functioning (Guisande et al., 2007; Páramo, Tinajero, 1990).

Analysis of our data for several attention tasks shows that field-independent children scored better than field-dependent and intermediate-FDI children. The differences in performance were statistically significant for the Digits Backward Span task, the Digit Symbol test, and the Visual Search and Attention Test.

A first relevant result of the present study is that field-independent children seem to be able to utilize their attentional capacity more efficiently. Judging from their performance on the Digits Forward Span task, field-independent children show no better short-term retentive capacity than field-dependent and intermediate-FDI children. Nevertheless, their superior performance on the Digits Backward Span task indicates a more effective use of control strategies of allocation of attentional resources. Thus, difficulties of field-dependent and intermediate-FDI children do not show in the storage capacity of short-term memory, but in their ability to mentally work with the stored information, in this case reversing the order of digits.

With regards to the possible meaning of these differences, we must point out that they are not indications of pathology because they are within normality ranges. Dempster (1981), in a study that analyzes the contribution of a variety of factors to the individual differences in storage capacity in short-term memory, suggests that the most influential variable is "stimulus identification", which refers to the speed when categorizing stimuli. Dempster considers that those individuals that need more time for this process will use less resources for storage and, as a result, will retain less information than those who are faster when identifying stimuli. Thus, digit retention differences due to cognitive styles could be explained by the time needed for the stimulus assessment, which would limit the capacity of the attention system.

Our results also fit with those obtained by Pascual-Leone (1997), who suggests that field-independent individuals have as much attentional capacity as those field-dependent of the same age, but use executive schemes more effectively to mobilize and/or allocate their attentional capacity. Specifically, from the model defended by Baddeley (Baddeley, Logie, 1999), it is claimed that individual differences in field dependence-independence probably arise due to individuals differing in the effectiveness of the functioning of the attentional control system for limited capacity denominated central executive or, more specifically, in the effectiveness of several subfunctions carried out by this executive, particularly the operations of information updating, shifting and monitoring (Miyake et al., 2001; Rittschof, 2010). As suggested by investigations carried out by Sarmány (1984, 1985, 1987) the stability of these subfunctions *during changes* in *chronobiological* rhythms might also vary with cognitive style.

Another remarkable result in our work is that differences were observed between field-dependent and field-independent children in their ability to maintain attention on the relevant stimuli while focusing their attention as the task was carried out. In our research, we assessed these attentional aspects by the Visual Search and Attention Test (VSAT) and the Digit Symbol test, respectively. They both require visualization and spatial orientation, as well as visual search processes and field-dependent children performed worse in them. Our results, suggest that field-dependent individuals show a greater difficulty maintaining attention on a given piece of information and selectively attending to relevant cues, particularly in the presence of distracting ones, which is in accordance with less efficient executive control processes. They enable the segregation of relevant and irrelevant information and the assignment of attention resources to the former while inhibiting the later.

The examination of visuospatial tasks has revealed statistically significant differences related to cognitive style in the degree of organization reached in the Complex Figure Copying Test and the Block Designs task. In the first task, field-dependent children performed significantly worse than their intermediate-FDI and field-independent counterparts, while in the second task, field-independent children obtained better results than the other two groups of children.

A correct perception of the elements of a model is required both in the Complex Figure Copying Test and the Block Design, thus demanding analyzing, visualization and spatial orientation. These requirements are also present in other perceptual restructuring tasks where field-independent individuals consistently perform better than field-dependent ones (Kogan, Block, 1991; Rittschof, 2010; Tinajero, Páramo, 1996). Considering jointly the results of the present study, both the analytic ability and executive control processes may have contributed to differences in visuoconstructive tasks. Given the relation of cognitive style with age and sex, a possible mediation effect of these variables could be expected.

Further studies are necessary in order to identify which of those cognitive processes are critically linked to poor intellectual performance and to academic failure; this would constitute a solid basis for the design of intervention strategies specifically aimed at remedying the deficiencies detected. A few attempts have been made in this line (see e.g., Ludwig, Lachnit, 2004; Pennings, 1991; Rush, Moore, 1991); although offering promising results, they have been limited to defining characteristics of field dependence-independence (such as perceptive disembedding or analytical processing).

Another research line, which may contribute to explaining the interindividual variability in cognitive and academic performance due to field dependence-independence, should study in depth the physiological bases of differences in perceptive competence. To date, some studies of the relation of cognitive style with hemispheric specialization (Riding, Glass, Douglas, 1993; Silverman, 1991; Tinajero et al., 1993) and with nervous system operating during cognitive tasks are available (Cadaveira et al., 1999; Goode et al., 2002; McKay, Fischler, Dunn, 2003; Riding et al., 1997).

The first approach (differences in the cortical function) has been prompted by the possible connection between neurophysiological differentiation (hemispheric specialization) and psychological differentiation (a characteristic process of onthogenetics). The second approach has resorted to psychophysiological techniques and event-related potentials. Both approaches, though extremely interesting, are quite new and have not yet produced relevant data for intervention design.

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POZORNOSŤ A ZRAKOVO-PRIESTOROVÉ SCHOPNOSTI: NEUROPSYCHOLOGICKÝ PRÍSTUP U ŽIAKOV ZÁVISLÝCH A NEZÁVISLÝCH OD POĽA

M. A. Guisande, C. Tinajero, F. Cadaveira, M. F. Páramo

Súhrn: Štúdia skúma kognitívne procesy, na ktorých spočíva zlý školský výkon u žiakov s kogitívnym štýlom závislý od poľa. Výskumnú vzorku tvorilo 149 detí vo veku 8 – 11 rokov, použili sme Children Embedded Figures Test (CEFT), deti boli zatriedené eko závislé od poľa, nezávislé od poľa alebo stredne závislé-nezávislé od poľa (FDI). Na testovanie pozornosti sme administrovali Digit Span a Digit Symbol ako aj Visual Search and Attention Test (VSAT). Zrakovo-priestorové schopnosti sme testovali pomocou Block Design a Rey-Osterrieth Complex Figure Test. Deti nezávislé od poľa dosiahli vyššie skóre ako deti závislé od poľa v testoch funkcie pozornosti. Pri zrakovo-priestorových úlohách dosiahli deti nezávislé od poľa vyššie skóre ako deti závislé od poľa ako aj deti stredne závislé-nezávislé od poľa v teste Block Design. V teste Rey-Osterrieth Complex Figure dosiahli deti závislé od poľa nižšie skóre ako deti nezávislé od poľa ako aj deti stredne závislé-nezávislé od poľa.