

## Field dependence-independence (FDI) cognitive style: An analysis of attentional functioning

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Previous research has indicated that field-dependent children display poorer performance than field-independent children in almost all academic subjects and cognitive tasks. However, the processes underlying this poorer performance remain unclear. The present study aimed to assess whether children with different FDI cognitive styles show differences in performance of tasks measuring aspects of attentional functioning. Specifically, 149 children aged 8 - 11 years were classified according to FDI cognitive style (field-dependent, intermediate, or field-independent), and to storage capacity (Digits Forward Test), verbal working memory (Digits Backward Test), capacity to focus, shift, and maintain attention (Digit Symbol Test), and capacity for sustained attention (Visual Search and Attention Test). Field-independent children displayed better performance than intermediate and field-dependent children on all tests except the Digits Forward Test. Theoretical and practical implications of these results are discussed.

*Estilo cognitivo dependencia-independencia de campo: un análisis del funcionamiento atencional.* Investigaciones previas han indicado que los niños dependientes de campo obtienen peores rendimientos que los independientes de campo en casi todas las asignaturas escolares y en diferentes tareas cognitivas. Sin embargo, los procesos que subyacen a este peor rendimiento no están lo suficientemente delimitados. El objetivo de este artículo es analizar si niños con diferentes estilos cognitivos manifiestan diferencias en tareas que miden aspectos concretos del funcionamiento atencional. Específicamente, se explora el rendimiento de 149 niños entre 8 y 11 años en cuatro tareas que evalúan, capacidad de almacenamiento (Dígitos en orden directo), memoria de trabajo verbal (Dígitos en orden inverso), capacidad para dirigir, cambiar y mantener la atención (Claves) y atención sostenida (Test de atención y búsqueda visual). Los resultados indican que los niños independientes de campo mostraron un mejor rendimiento que los dependientes de campo y los del grupo intermedio en todas las tareas a excepción de la prueba de Dígitos en orden directo. Se discuten algunas implicaciones para la teoría y la práctica.

The dimensions of cognitive style facilitate a qualitative approach to intellectual differences, revealing forms of functioning that are consistently manifested in the cognitive sphere. Cognitive styles are usually conceptualized as the characteristic ways in which individuals perceive environmental stimuli, and organize and cue information (Messick, 1984). A cognitive style influences how people look at their environment for information, how they organize and interpret this information, and how they use these interpretations to guide their actions (Hayes & Allinson, 1998).

The field dependence-independence (FDI) construct is among the most widely studied of the range of cognitive style dimensions appearing in the literature. FDI describes two contrasting ways of processing information. Individuals are positioned along a continuum running from extreme field-dependence (FD) to

extreme field-independence (FI). Individuals located towards the FD end of the continuum have difficulty in separating incoming information from its contextual surroundings, and are more likely to be influenced by external cues and to be non-selective in their information uptake. FI individuals have less difficulty in separating the most essential information from its context, and are more likely to be influenced by internal than external cues, and to be selective in their information input (Riding & Cheema, 1991; Zhang, 2004).

Although FDI can be considered as an adaptively neutral style dimension, it seems clear that children at opposite extremes of the FDI continuum differ in their performance of diverse school tasks. Studies of the relationship between cognitive style and academic achievement have shown that FI subjects obtain consistently better results than FD subjects, in all areas of knowledge (e.g. Roszkowski & Snelbecker, 1987; Tinajero & Páramo, 1997).

From a cognitive perspective, some authors have suggested that these differences in achievement may reflect the mode of intellectual functioning. These differences are manifested more strongly when the processing requirements for the task are not well met by the cognitive style (Hayes & Allison, 1998; Leo-

Rhynie, 1985). However, the differences in cognitive processing that underlie these variations in achievement have not yet been sufficiently delineated, and indeed this is one of the main outstanding questions in FDI research.

In efforts to explain the differences in performance on diverse cognitive tasks between FI and FD subjects, attentional processes have attracted particular interest (Davis & Cochran, 1990; Zelniker, 1989). This work has drawn on data and theoretical interpretations deriving basically from three lines of research, centred on different but complementary aspects: a first line of research focusing on the associations between cognitive style tests and vigilance tasks, a second line focusing on differences between FI and FD subjects in selective attention tasks, and a third that has attempted to clarify the relationships between cognitive style and use of attentional resources.

Studies of vigilance tasks have obtained rather inconsistent results. In these studies, the results have depended strongly on the type of stimulus used (sensory modality, complexity), on subject age, and even on the type of test used to measure FDI. Thus, while studies with children have found that FI subjects are more effective than FD subjects at detecting critical signs, or target symbols or letters (Amador & Kirchner, 1999; Páramo, Corral, Rodríguez, Tinajero, & Cadaveira, 1999), most studies with adults have not detected any difference in stimulus detection (Fernández Ballesteros et al., 1980; Kirchner, Forns, & Amador, 1990).

Secondly, studies of selective attention tasks have analysed the mechanism of selection from two different perspectives: in terms of global versus analytical approaches to information, and in terms of attention to relevant and irrelevant stimuli. On the one hand, depending on their cognitive style subjects seem to attend to different aspects of information: FD subjects tend to focus their attention on global aspects of the information to be processed, while FI subjects tend to focus on partial aspects. This difference has been confirmed both in children (e.g. Guisande, Tinajero, Rodríguez, Cadaveira, & Páramo, 2004; Ohlmann & Carbonnel, 1983; Rozencwajg, 1991) and in adults (e.g. Clark & Roof, 1988; Marendaz, 1985; Tsakanikos, 2006). On the other hand, FDI also appears to affect responses to relevant stimuli, particularly in the presence of distracting stimuli, in auditory and visual tasks: FD adults experience greater difficulty in selectively attending to relevant cues when more salient distracting aspects are present (Avolio, Alexander, Barrett, & Sterns, 1981; Burton, Moore, & Holmes, 1995).

Thirdly, some studies have considered the relationship between FDI and the efficient use of the limited attentional resources, i.e. the extent to which the subject can focus and sustain attention on the information of interest, and at the same time inhibit attention to irrelevant information (Macizo, Bajo, & Soriano, 2006). These researchers have reported that subjects' efficiency of use of attentional resources will modulate the performance of FD and FI subjects on diverse cognitive tasks, such as reading and listening comprehension, vocabulary acquisition, and complex learning, whether in children (e.g. Baillargeon, Pascual-Leone, & Roncadin, 1998; Guisande, Tinajero, & Páramo, 2005; Mansfield, 1997), adolescents (e.g. Bahar & Hansell, 2000; Mansfield, 1997; Páramo et al., 1999) or adults (e.g. Bennink, 1982; Cochran & Davis, 1987; Goode, Goddard, & Pascual-Leone, 2002; Miyake, Witzki, & Emerson, 2001). According to these studies, FD subjects are characterized by less effective process control, leading to lower efficiency in the use of attentional resources.

There is no doubt that these three approaches have supplied relevant information on attentional function in subjects with different cognitive styles, but it is necessary to progress further to overcome certain limitations. Many of these studies have considered only a single attentional process, and few studies have simultaneously considered different specific aspects of attentional functioning in children with different cognitive styles. In the present study we have used one task to evaluate each attentional component, although at the microanalytical level (see Engle & Kane, 2004). Another common limitation has been the insufficient consideration of variables that are highly relevant to FDI, like sex, socioeconomic status and level of intelligence. A third common limitation has been to include only subjects at the extremes of the FDI continuum. Consideration of subjects with intermediate FDI may facilitate elucidation of the relationships with other cognitive variables and clarify, for example, the traditional question about the putative adaptive neutrality of FDI.

The aim of the present study was to evaluate whether subjects with different cognitive styles show differences in performance on tasks measuring specific aspects of attentional functioning. Specifically, we investigated subjects' performances on tasks evaluating storage capacity and resistance to distraction (the Digits Forward test), verbal working memory (the Digits Backward test), capacity to focus, shift and maintain attention (the Digit Symbol test), and vigilance or sustained attention (the Visual Search and Attention Test). If FDI cognitive style is associated with these attentional processes, FI subjects should obtain a higher score on all of these tasks, except the Digits Forward test. In this latter test we do not expect differences between FD and FI children, because children with different cognitive styles show a similar capacity for information storage (Globerson, 1985), especially for storage of verbal information already showing structure (Rickards, Fajen, Sullivan, & Gillespie, 1997). Intelligence was controlled for, in order to differentiate effects of intelligence and cognitive style on attentional performance. Finally, all subjects in the sample were included in the analysis (i.e. intermediate-FDI children as well as FD and FI children).

## Method

### *Participants*

A total of 149 children (79 boys and 70 girls) aged between 8 and 11 years ( $M=9.53$ ;  $SD=1.10$ ) (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) took part in the study. All the children were resident in or near to Santiago de Compostela (northwest Spain), and attending elementary school (3<sup>rd</sup> - 6<sup>th</sup> grade). Children receiving medical or psychological treatment, with learning difficulties, attending special-education classes or repeating a grade were not included in the study. The great majority of the children belong to middle-class families.

### *Instruments*

FDI was assessed using the Children's Embedded Figures Test (CEFT), an adaptation of the Embedded Figures Test (EFT) (Witkin, Oltman, Raskin, & Karp, 1971) designed by Karp and Konstadt in 1971 for children aged less than 12 years. This test is

administered individually, and comprises 25 sheets each with a complex design, plus two cut-outs of simple figures (a triangle and an irregular pentangle). Within each complex figure is one of the simple figures, which the subject must locate. The test is scored following the procedure indicated by the original authors, i.e. score = number of designs (0 - 25) in which the subject correctly locates the simple figure. In addition, we also recorded execution time, with subjects given a maximum of three minutes for each item. A high score on this test indicates greater field independence. The internal consistency coefficients for the CEFT ranged from .81 to .87.

Intelligence was evaluated using the Spanish version (TEA, 1986) of Cattell's Culture-Fair Intelligence Test (Cattell & Cattell, 1973). This is a nonverbal test requiring the subject to perceive relationships between abstract forms and figures. The items are divided into four categories: progressive series completion, classification, matrices, and conditions. The score is given by the sum of the number of items correctly resolved in each category.

Attentional functioning was evaluated by three tests selected in view of their sensitivity in the detection of various aspects related to attentional processes: the Digit Span and Digit Symbol subtests of the Wechsler Intelligence Scale for Children (WISC-IV) (Wechsler, 1974/2005), and the Visual Search and Attention Test (VSAT) (Trenerry, Crosson, DeBoe, & Leber, 1990).

The first of these subtests comprises two parts: Digits Forward and Digits Backward. In the Digits Forward part, the examiner reads out progressively longer series of numbers, each series only once; after each series, the subject is required to repeat it in the correct order. According to Lezak (1995), performance on this subtest is a measure of short-term storage capacity, and of resistance to distraction. In the Digits Backward part, the subject is required to repeat each series in reverse order. This subtest is considered a measure of verbal working memory (Saito, 2001; Zelazo, Müller, Frye et al., 2003), associated with attentional processes and executive functions (Gathercole & Pickering, 2000; Hale, Hoepfner, & Fiorello, 2002; Hutton & Towse, 2001), though also involving transformation of information, verbal manipulation and visual-spatial imagination (Zhu & Weiss, 2005).

The Digit Symbol subtest consists of four rows of 25 squares, each containing in their upper part a randomly selected number between 1 and 9 inclusive. Each of the numbers has a symbol assigned, and the subject's task is to write the symbol corresponding to each number in each square as rapidly as possible. The task has a time limit of 2 minutes, and the final score is given by the number of symbols correctly placed. Lezak (1995) considers it a useful measure of what she calls «complex attention», since it requires that the subject focus, shifts and maintains attention.

Finally, the VSAT consists of four tasks that require the subject to cross out letters and symbols that are identical to a target. There is a time limit of 60 sec for each task. The first and second tasks are not scored; the score is given by the number of correct cross-outs in the two remaining tasks. This is a visual search task basically designed for evaluation of vigilance and sustained attention. The coefficient of internal consistency was .96.

#### Procedure

After permission from schools, we contacted the families. Specifically, children were given an envelope to take home to their

parents, containing a cover letter from the head teacher guaranteeing the professionalism and rigour of the research, a letter of introduction from the research team outlining the nature and aims of the study, and a form to be completed by the parent(s)/guardian(s), requesting names and address and other family data, information on educational level, and professional situation. Each child was evaluated in a single session, with the tests in all cases presented in the same order. All children were evaluated by the same person. Evaluations were performed during normal school hours in the morning or afternoon, with break periods.

#### Design

The independent variable was CEFT score. For the data analysis, the sample was divided into three groups: field-dependent, intermediate, and field-independent, according to whether CEFT score was in the top, middle or bottom third for subjects of the same age (8, 9, 10 or 11 years). As can be seen from Table 1, mean CEFT score increased with age (although minimum and maximum scores showed little variation with age). Thus the CEFT cut-offs were different for each age-group. One-way ANOVA indicated significant variation in CEFT with on age [ $F(3,148)= 5.834, p<.001$ ], although post hoc Scheffé tests indicated significant differences only between the extreme age groups (8 and 11 years) (CEFT scores 15.39 vs 19.55, difference between means= 4.16,  $p<.001$ ).

The dependent variables were scores obtained on each of the tests used to evaluate attentional functioning. Analyses of covariance were carried out to assess whether performance on the attentional functioning tasks varied depending on FDI. The covariate was score on Cattell's Culture-Fair Intelligence Test. Preliminary analyses ruled out any influence of sex [ $t(147)= -.779, p= .437$ ] or family's socioeconomic status [ $\chi^2(2, N= 149)= 2.056, p= .358$ ], and these variables were thus not considered in the main analyses.

#### Results

Mean scores and standard deviations are presented in Table 2 for each attentional functioning task in the three FDI groups. As can be seen, on all four attentional functioning tests the highest scores were obtained by the FI children and the lowest scores by the FD children.

Analyses of covariance indicated that the covariate intelligence had a statistically significant effect only on verbal working memory (Digits Backward) [ $F(1, 145)= 7.778, p < .01, \eta_p^2= .051$ ], indicating adequate control of this covariate, and allowing us to separate the influence of FDI and intelligence on Digits Backward

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

score. Secondly, in these analyses we observed significant variation among the three FDI groups in score on the Digits Backward test [ $F(2, 145) = 11.652, p < .001, \eta_p^2 = .138$ ], on the Digit Symbol test [ $F(2, 145) = 6.594, p < .01, \eta_p^2 = .083$ ], and on the Visual Search and Attention Test [ $F(2, 145) = 4.586, p < .05, \eta_p^2 = .059$ ]. These results indicate that, after taking into account the effect of intelligence, FDI still has a significant effect on performance on these attentional tasks. In contrast, score on the Digits Forward test did not show significant among-group variation. Post-hoc Scheffé tests indicated that in the Digits Backward subtest, the FI children obtained significantly higher scores than intermediate-FDI children (difference between means = 1.1,  $p < .001$ ) and FD children (difference between means = 1.4,  $p < .001$ ), with no significant differences between the intermediate-FDI and FD groups. In the Digit Symbol test and the VSAT, the FI children obtained significantly higher scores than FD children (Digit Symbol test, difference between means = 6.8,  $p < .01$ ; VSAT, difference between means = 10.2,  $p < .05$ ), with no significant differences between the FI and intermediate-FDI groups, or between the intermediate-FDI and FD groups.

In conclusion, after controlling for the effect of intelligence, field-independent children showed better performance than field-dependent children on the verbal working memory, complex attention and sustained attention/vigilance tasks. Children with intermediate-FDI showed significantly poorer performance than FI children only in the Digits Backward test.

#### Discussion

Analysis of our data for several attention tasks shows that field-independent children typically show better performance than both field-dependent children and intermediate-FDI children. The differences in performance were statistically significant for the Digits Backward subtest, the Digit Symbol subtest, and the VSAT. Thus, our results confirm that attentional processes are indeed influenced at early ages by the child's cognitive style. Notably, FI children seem to be able to take better advantage of their attentional capacity. Judging from their performance on the Digits Forward subtest, FI children show no better short-term retentive capacity than more FD children. However, the fact that they showed better performance on the Digits Backward subtest indicates more effective use of control strategies and allocation of attentional resources.

According to Robinson and Bennink (1978), the differences between FI and FD subjects arise at the moment of assigning active memory space to the retentive task. These authors conclude that inter-subject differences in FDI correspond to differences in the efficiency with which subjects adapt their active memory space to the double function of storage and processing.

In our opinion, and considering Pascual-Leone's (1987) theory of constructive operators, the better results obtained by FI children in the Digits Backward test may be related to the efficiency with which they use their full attentional capacity, which becomes occupied by those schemes most relevant for the task. In contrast, FD children are saturated by perceptive data (i.e. auditory aspects of the items), which impedes effective use of their operative capacity. FD subjects, as a result, perform at below their potential.

In view of the present results, then, and within the framework of Pascual-Leone's (1997) constructivist dialectic model, FI subjects have as much attentional capacity as FD subjects of the same age, but use executive schemes more effectively to mobilize and/or allocate the attentional capacity in an appropriate way. From this perspective, FDI can be interpreted as a performance rather than a competence variable, i.e. a capacity deficit.

Our results are also in line with certain aspects of Baddeley and Logie's (1999) theory of working memory. The individual variation in FDI probably arises because individuals differ in the efficiency of the limited-capacity attentional control system denominated the central executive, or more specifically the efficiency of various sub-functions performed by this executive, particularly shifting, updating, and monitoring operation of information (Miyake et al., 2001).

Another important result of the present study is that differences were detected between FI and FD children in the capacity to maintain attention to relevant stimuli and to direct attention appropriately as the task is performed. We evaluated these two aspects by the Visual Search and Attention Test and the Digit Symbol subtest, respectively; these two tasks require a motor response and a visual search for the target letter or symbol, and in both cases FD children showed relatively poor performance. In our opinion, this may be related to the fact that these tasks require visualization and spatial orientation, i.e. similar visual search processes to those required for the CEFT.

We agree with Huteau's (1987) suggestion that the observed differences between subjects with different FDI style may reflect differences in the perception of relevant elements in situations and/or stimuli. This hypothesis is additionally supported by studies which have related FDI with the capacity to maintain attention on specific sectors of information (Avolio et al., 1981; Burton et al., 1995; Zelner, 1989). Our results, like those of these previous studies, suggest that FD subjects have greater difficulty in maintaining attention on a given aspect of information and in attending selectively to relevant cues, particularly in the presence of distracting elements. Specifically, our results suggest that we are more likely to find performance differences associated with cognitive style in those tasks in which relevant and irrelevant stimuli are integrated along a continuum or within a whole, additionally requiring a perceptual restructuring by the subject. In this connection, it is important to take note of Huteau's (1987) comments on perceptual configurations. This author points out that the differences between these types of subject in restructuring ability are manifested in those configurations in which the context masks relevant elements, contributing to the differences between FD and FI

Table 2

Mean scores (M) and standard deviations (SD) in the attentional functioning tests, as obtained by children in the three field dependence/independence groups

Test	Field dependence/independence group					
	FD (n = 52)		Intermediate (n = 54)		FI (n = 43)	
	M	SD	M	SD	M	SD
Digits Forward	5.3	1.23	5.7	1.67	6.1	1.65
Digits Backward	4.8	1.15	5.1	1.47	6.2	1.06
Digit Symbol	42.7	9.58	46.4	9.11	49.5	6.80
Visual Search and Attention Test (VSAT)	84.6	18.44	92.0	18.13	94.8	14.33



subjects. However, differences will not be seen in those other configurations for which context is simply a source of distraction.

Another important implication of the present results is that the differences among subjects with different cognitive styles are perhaps more complicated than has previously been thought. Most studies have included only subjects at the extremes of the FDI continuum in their analyses. Without considering subjects with intermediate FDI, the majority of these studies tend to interpret the poorer performance of FD subjects as a cognitive deficit. In the present study, however, we have included intermediate-FDI subjects, and our results question the validity of that interpretation. In some tasks, our results indicate that FD children indeed show poorer performance than FI and intermediate children, but in other tasks they do not show any difference with respect to intermediate children.

These questions have important implications both for our understanding of the nature of FDI, and in the design of strategies

for improving children's academic achievement. For example, we can expect FD subjects to experience difficulties when extracting information from a masking or misleading context, or when required to focus and maintain attention in a complex or sustained task, or when faced with tasks in which both relevant and irrelevant stimuli are present. These latter tasks require greater effort, and suggest a need for greater structuring of classroom and curriculum content, to facilitate learning by FD subjects. In this connection, it would certainly of interest to consider ways of adapting teaching strategies, materials and evaluation procedures to children's different cognitive styles. In addition, FD children can also be trained in certain cognitive and learning strategies not included in their habitual repertoires: reflexive thinking, self-control and metacognition procedures can to some extent be taught, in order to promote the capacity to process information from different contexts.

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