Performance on the A-not-B Task of Argentinean Infants from Unsatisfied and Satisfied Basic Needs Homes

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Abstract

Studies based on animal and human models have shown structural and functional alterations in the Central Nervous System after exposure to early enriched, or deprived, environments. Poverty, as a complex phenomenon of environmental deprivation, was repeatedly associated with deleterious consequences for early cognitive functioning. This study compares the performance of 280 Argentinean infants (six- to 14-month-old) from Unsatisfied and Satisfied Basic Needs homes on the *A-not-B* task, as an early executive function predictor. In this task, infants watch as an object is hidden in one of two hiding places (left-right locations), and after a delay period they are allowed to search for that object. Results showed that infants from poor homes performed fewer consecutive correct responses, and made more perseverative and non-perseverative errors than non-poor infants (p<0.05). Findings suggest that poor home environments bring about a condition that affects the management of resources involved in *A-not-B* task resolution.

Keywords: A-not-B task; cognitive development; poverty; infants.

Desempeño en la Prueba A-no-B de Infantes Argentinos Provenientes de Hogares con y sin Necesidades Básicas Satisfechas

Resumen

Estudios basados en modelos animales y humanos han mostrado alteraciones estructurales y funcionales del Sistema Nervioso Central después de la exposición temprana a ambientes empobrecidos o enriquecidos. La pobreza, como fenómeno complejo de deprivación ambiental, ha sido reiteradamente asociada con efectos deletéreos del funcionamiento cognitivo temprano. El presente estudio compara el desempeño de 280 infantes argentinos (seis a 14 meses de edad) provenientes de hogares con y sin necesidades básicas satisfechas, en la prueba *A-no-B* (predictor temprano de funcionamiento ejecutivo). En ella, los infantes observan el ocultamiento de un premio en una de dos localizaciones espaciales posibles, para buscarlo luego de un retardo. Los resultados muestran que los infantes de hogares con NBI efectuaron menos respuestas correctas consecutivas y más errores perseverativos y no perseverativos que los de hogares con NBS (p<0.05). Los resultados sugieren que la condición NBI afecta la plasticidad de los recursos cognitivos involucrados en la prueba.

Palabras clave: Prueba *A-no-B*; desarrollo cognitivo; pobreza; infantes.

Executive functioning (EF) refers to a complex and still provisional cognitive construct that involves general-purpose control mechanisms that modulate the operation of various cognitive subprocesses and regulate the dynamics of cognition. Specifically, goal-directed behavior subsume a set of higher order parallel skills such as strategic planning, problem solving, organized search, abstract thinking, concept formation, inhibitory control, self-monitoring and cognitive flexibility (Anderson, 1998; Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; De Luca et al., 2003; Hughes, 2002; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Complementary, to solve EF tasks also demands domain-specific cognitive processes such as language, memory, attention and motor abilities (Anderson et al., 2001; Miyake et al., 2000).

Cerebral organization and cognitive functioning models initially presented EF as an adult capacity that reaches maturity around puberty (Welsh & Pennington, 1988). Recently, improvements in EF have been found to correlate with increased myelination and synaptogenesis of frontal

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brain regions, which occurs throughout development and well into the second decade of life (Diamond, 2001a; Klingberg, Forssberg, & Westerberg, 2002; Stuss & Alexander, 2000; Wood & Grafman, 2003). Furthermore, research has identified a stage-like sequence of executive function development characterized by "spurts" in executive abilities beginning from 12 months of age, with the majority of functions coming around the age of eight (Case, 1992; Luciana & Nelson, 1998). Whereas some studies argued that EF only can be identified in four-year-olds and older children (Anderson, 1998; Luciana & Nelson, 1998), others proposed that it appears much earlier (Diamond, 1985, 1990, 2001a; Diamond, Kirkham, & Amso, 2002; Espy, Kaufman, Glisky, & McDiarmid, 2001; Welsh & Pennington, 1988). When age-appropriate tasks demanding integration, effortful, formal and content novelty are available (Phillips, 1997), an increase in non-verbal executive competence in infant (Diamond, 1985, 2001a; Diamond & Goldman-Rakic, 1989; Welsh & Pennington, 1988) and preschool-aged children (Diamond et al., 2002; Espy et al., 2001; Hughes, 1998; Klenberg, Korkman, & Lahti-Nuutila, 2001; Luciana & Nelson, 1998; Zelazo, Carter, Reznick, & Frye, 1997), has been reported in several studies. Complementary, results of developmental studies based on exploratory and confirmatory factor analyses suggest that EF is not homogeneous and that a multistage development of different components proceeds from infancy to adolescence (Anderson et al., 2001; Espy, Kaufman, McDiarmid, & Glisky, 1999; Klenberg et al., 2001; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003). Finally, at least two EF components were proposed at the core of cognitive development: inhibition of prepotent responses and working memory (Lehto et al., 2003; Miyake et al., 2000; Rusell, 1999).

Specifically, performance on the *A-not-B* task is often held to be one of the first signs of emerging executive functioning in infancy (Diamond, 1985, 1990, 2001a; Diamond & Goldman-Rakic, 1989; Espy et al., 1999; Goldman-Rakic, 1987; Rusell, 1999; Welsh & Pennington, 1988). The standard *A-not-B* search task is a variant of the delayed-response paradigm devised to study the effects of delay on search behavior in human infants and nonhuman animals (Marcovitch & Zelazo, 1999). In this task, an infant sits on his or her mother's lap and watches as a desired object is hidden in one of two identical wells. The well in which the object is first placed is referred to as the A well and the other as the B well. The infant is allowed to reach into the A well and obtain the object. In the next trial, the infant sees the object placed into the B well and again attempts to retrieve the object. Infants between the ages of seven and nine months typically fail at this task when a delay of two-three seconds is interposed between cueing and searching (Diamond, 1985). Although they are able to find the object inside the A well, when the object is hidden in the B well, they search for it in A, even though they have just seen the object being placed inside B. Piaget proposed that the *A-not-B* error is caused by conceptual difficulties such as a failure to understand specific properties of the desired object (Piaget, 1954). Although some theorists followed piagetian approach (Butterworth, 1977; Gratch, Appel, Evans, Le Compte, & Wright, 1974; Harris, 1987), others have emphasized basic cognitive processes such as deficits in short-term memory (Cummings & Bjork, 1983), the combination of memory deficits and lack of inhibitory control (Diamond, 1985; Diamond & Goldman-Rakic, 1989), or means-end behavior (Baillargeon & Graber, 1988; Berthental, 1996). Other theoretical approach proposed the repetition of motoric schemes as the underlying process (Smith, Thelen, Titzer, & McLin, 1999; Beer, 2000), but it used a different version of the task (Diamond, 2001b). Finally, the Competing-Systems account proposes two hierarchically organized dissociable systems: a) the response-based, activated by motor experience and the effect of the reaches to a particular location; b) the conscious representational, made active by the infant's conscious representation of the location of the hidden object (Zelazo, Reznick, & Spinazzola, 1998). Results from the most updated meta-analytic study suggest that age and the distance between locations are positive predictors of the proportion of infants who search correctly, while the number of A trials and delay between hiding and search are negative predictors (Marcovitch & Zelazo, 1999).

Performance on *A-not-B*, as well as Delayed Response tasks, has also been significantly associated with the maturation and function (or immaturity for the *A-not-B* error) of dorsolateral circuits in the prefrontal cortex (Diamond, 2001a; Diamond & Goldman-Rakic, 1989; Nelson et al., 2000). Similar perseverative error patterns on *A-not-B* and Delayed Response tasks were observed in frontally ablated adult monkeys (Diamond & Goldman-Rakic, 1989), intact and frontally ablated infant monkeys (Diamond & Goldman-Rakic, 1989), and intact seven- to 12- month-old human infants (Diamond, 1985). Furthermore, resting frontal EEG activity and increased anterior to posterior EEG coherence (Bell & Fox, 1992) also discriminated *A-not-B* performance in infants. Based on these evidences, Diamond and Goldman-Rakic (Diamond, 1990, 2001b; Goldman-Rakic, 1987) concluded that frontal lobe maturation underlies the development of *A-not-B* performance in infancy.

Based on previous longitudinal studies, infants' performance is expected to increase between months seven and 12, with an average rise in the delay of 1.5-2 seconds per month before infants would make the *A-not-B* error (Bell & Fox, 1992; Diamond, 1985; Gratch & Landers, 1971). Complementary, errors tend to be confined to the reversal trials and to the trials immediately following a reversal error when the reward continues to be hidden at a new location (Diamond, 1985, 1990, 2001a). In cross-sectional studies, the *A-not-B* error has been found at delays a few seconds shorter at each age than is found in longitudinal studies. Explanations proposed for this difference included practice effects in longitudinal studies or the unfamiliar condition of experimenter and testing room in cross-sectional studies (Diamond, 1985).

Evidence from experimental contexts have largely demonstrated that in different species certain structural and functional features of the Central Nervous System, such as the resolution of cognitive tasks, can be modulated through the manipulation of environmental conditions during early development (Greenough & Volkmar, 1973; Rosenzweig & Bennet, 1996). Human home environment quality could be associated with deprived or enriched environments, depending on the presence or absence of poverty. Poverty is usually associated with a low home environment quality, and children living in occasional and even persistent poverty present alterations in their cognitive development (Bradley et al., 1989; Brooks-Gunn & Duncan, 1997; McLloyd, 1998). It has been further demonstrated that different aspects of language and spatial processing development, examined through general intelligence or developmental paradigms, are affected in subjects from low-income families and in ethnic minorities (Brooks-Gunn & Klebanov, 1996; Burchinal, Campbell, Bryant, Wasik, & Ramey, 1997; Brooks-Gunn & Duncan, 1997; McLloyd, 1998). Cognitive stimulation in the home, parenting style, physical environment of the home and poor child health were proposed as mediating factors that are affected by lack of income and that influence children's cognitive development (Georgieff & Rao, 2001; Grantham-McGregor & Ani, 1999; Guo & Mullan-Harris, 2000; Mendola, Selevan, Gutter, & Rice, 2002; Ornoy, 2003). Furthermore, systematic differences between societies regarding their cultural patterns, schooling practices and psychological environment, impact performance on both verbal and non-verbal tests (Rogoff & Chavajay, 1995; Sattler, 2001). Thus, skills prescribed by a culture, together with the cognitive strategies that vary among cultures, interact with inherent patterns of brain organization (Eviatar, 2000). Attempts to develop tests that are culture fair have not been successful, and great caution is needed in using a non-verbal test with individuals from cultures different from the one that provided the normative sample (Roselli & Ardila, 2003; Sattler, 2001). Interpretations of performance of individuals from different cultures using Anglo-Saxon sample norms might result in significant errors in assessment, particularly if the experimenter plans to evaluate the integrative of the brain-behavior relationship (Roselli & Ardila, 2003). Particularly, there are neither evidences of studies on EF in latino-american infants nor impact of poverty on Latin-American infants EF's performance.

The aim of this study was to analyze potential differences between Argentinean infants from poor and non-poor homes on performance in the *A-not-B* task. Theoretical and methodological reasons for such objective include: a) to evaluate effects of poverty on early cognitive performance (infancy) in order to add empirical evidence of such effect to studies carried out with school-age children; b) to use an alternative approach to the intelligence or developmental quotients paradigms, considering working memory and inhibitory control processes as relevant for the first years of cognitive development; c) to obtain data in the *A-not-B* task from a non-Anglo-Saxon sample to analyze potential cross-cultural performance differences.

Method

Participants

The sample comprised 280 normal Argentinean children (Hispanics or Latinos of any race), ranging in age from 6 to 14 months (see Table 1 for sample sizes by group, age and gender). These participants were recruited from a sanitary control at *Pedro de Elizalde Pediatric Hospital* in the city of Buenos Aires between 1996 and 1999. Most families inhabited the poorest regions in Southern Gran Buenos Aires: Florencio Varela, Quilmes, and Avellaneda. Entry into the sample followed strict criteria: Spanish as a first maternal language, normal or corrected vision and hearing, no record of serious medical conditions, no family history of psychiatric illness, no history of significant head injury, seizures, or neurological disease, no maternal substance abuse or dependence. Infants showed no symptoms of acute disease, were born at term, with weight and height suitable for gestational age (see Table 3 for gestation, obstetric, and delivery histories). The study was conducted in accordance with APA ethical standards in the treatment of the study sample. Each mother before administration of the task provided written informed consent. Ethics Committee at the *Pedro de Elizalde Pediatric Hospital* approved this study.

Table 1.
Sample Sizes by Group, Age and Gender of the Argentinean Children

	Group			
	SBN		UBN	
Age*	Boys	Girls	Boys	Girls
6	8	9	8	8
7	7	13	6	7
8	8	10	6	8
9	9	8	7	7
10	8	9	7	8
11	8	6	6	9
12	7	6	13	6
13	8	7	7	6
14	9	8	7	6
Total	72	76	67	65

Note: SBN=Satisfied Basic Needs; UBN=Unsatisfied Basic Needs; *: in months.

Table 2.
Mean Scores of Socioeconomic Variables by Group of the Argentinean Children

	Group				
	SBN		UBN		
	M	*SD*	*M*	*SD*	*p*
Education	6,47	2,47	5,86	2,61	NS
Occupation	5,91	1,82	4,18	2,51	< 0,01
Dwelling	11,53	1,09	8,73	2,39	< 0,01
Overcrowding conditions	7,78	1,48	5,59	1,65	< 0,01
Total Score	31,69	4,34	24,36	5,47	< 0,01

Note: SBN=Satisfied Basic Needs; UBN=Unsatisfied Basic Needs; NS = non significant; *p*.

Poverty Measure

Before performing on the task, a socioeconomic scale (NES; see Appendix A for details) was administered to infant mothers. NES scale, used in other studies in Argentina (for example, CESNI, 1995), is derived from the Unsatisfied Basic Needs (UBN) direct method for measure poverty (Boltvinik, 2000; INDEC, 1994). It includes several indicators that attempt to capture different dimensions of poverty at the household and individual levels. Income direct method was not used in this study due to either lack of information or of reliable information. A total score (TS) was obtained based on scores from parents educational background (Ed), parents occupational background (Oc), dwelling (Dw) and overcrowding conditions (Ov) (TS=Ed + Oc + Dw + Ov). TS, Ed, Oc, Dw and Ed were the dependent variables. Scores were assigned directly to parents for educational and occupational backgrounds, but only the higher was considered for the Total Score. In the case of dwelling, first scores assigned to each item were summed (SS) (type, floor, water, bathroom, ceiling, external walls and home property), and then a final score (FS) was assigned to this figure according to the following criteria: for SS between zero and five the FS was three; for SS between six and 11 the FS was six; for SS between 12 and 17 the FS was nine; for SS between 18 and 22 the FS was twelve. Finally, for overcrowding conditions rates (R) were calculated (Persons per room) and then a score (S) was assigned according to the following criteria: for R between one and two the S was nine; for R between 2.1 and four the S was six; for R between 4.1 and six the S was three; for R between 6.1 and more the S was zero. In summary, poor households and individuals may tend to obtain the lowest TS.

A-not-B Apparatus

This study followed Diamond (2001b) recommendations for apparatus characteristics and task procedures to assure the measurement of *A-not-B* error (perseverative errors). A tetragonal wooden table measuring 35 inches in length and 15 inches in width was used, in which two wells were fixed measuring four inches in diameter and two inches in depth. Both wells were separated by 11 inches, and were equidistant from one another and from the borders. White cloths with sides of approximately ten inches were used as covers. Several toys were used in each testing session. Their size was suitable for hiding in the wells and they varied in shape and color to get children's attention.

Measures and Procedure

Infants were tested individually in a quiet testing room at the hospital. Testing was scheduled at times reported by mothers not to interfere with regular meals. Examiners were blind to the hypotheses of the study. Infants were seated in the mother's lap facing the experimenter across the testing table. A second experimenter was placed behind and recorded data. A collection of toys was available so the experimenter could find a toy that was attractive to each infant. If the infant lost interest in the current toy, a different toy was used. A single trial consisted of the parent holding the infant's hands. The experimenter then hid the toy in one well and covered both wells with the cloths, making sure the infant was watching as the toy was being hidden. When the wells were covered, the delay began. The experimenter held the infant's attention away from the wells during the delay by talking or counting out loud (infants experienced both delay and distraction). Mothers were asked to prevent their infants from reaching or leaning toward the wells until the experimenter signaled the end of the delay. At that moment, the infant was allowed to search for the toy. Mothers were instructed not to give infants any cues as to the location of the toy, and all of them complied.

Reaching was scored according to the first cloth the infant removed. A correct reach was rewarded by praise and the opportunity to retrieve and play with the toy. Reward was contingent on removal of the correct cloth to maximize motivation to reach correctly. Any response other than a correct retrieval was scored as incorrect. Infants were scored as making an error if they reached to the empty, covered well, if they reached simultaneously to both wells, or if they did not reach at all. As in other studies (Diamond, 1985; Diamond & Goldman-Rakic, 1989; Matthews, Ellis, & Nelson, 1996), the most common type of error was reaching to the empty, covered well. When infants did not reach correctly, the mother and the experimenter remained neutral, and the experimenter removed the correct cloth and retrieved the toy as the infant watched. When an infant retrieved the toy correctly from the same well two trials in a row, the toy was hidden in the other well. The delay between covering of the wells and release of the infant's hands was varied from less than one to ten seconds. The task was first administered with delays lower than 1 second. When each child reached 90% efficiency (correct trials/ administered trials), the delay was increased to five seconds. Again, once the efficiency criterion was reached, the delay was increased to ten seconds, repeating the criterion one last time. Each infant received between ten and 15 trials per delay. If there was no response 30 seconds after the delay, the trial was considered over (did not reach at all) and the next trial was administered. The cut criteria were five consecutive incorrect trials. The administration of the task took about 20 minutes per infant.

Five dependent variables were calculated following Espy et al., (1999, 2001) criteria: 1) *correct responses,* defined as the total number of correct retrievals pondered by the total number of administered trials per delay (efficiency); 2) *consecutive correct responses,* defined as the total number of consecutive correct trials pondered by the total number of administered trials per delay [for example, if in a given delay an infant correctly responded on all the following trials AABBAABBAA, his consecutive correct responses score was 9/10=0.90; but if responded correctly only in the trials with italics letters AA*B*BA*ABB*AA, his *consecutive correct responses* score was 4/10=0.40 (only the underlined letters)]; 3) *perseverative errors* (*A-not-B* errors), defined as the total incorrect responses made immediately after a reversal trial; 4) *non-perseverative errors,* defined as the total incorrect responses made in any trial excepting reversals; 5) *A Trials,* defined as the total number of trials before the first reach criteria (two consecutive correct trials). As in Espy et al., (1999, 2001), not all errors were perseverative, as perseverative errors were counted only for trials that occurred after the infant had correctly retrieved the reward consecutively for two trials. These measures were chosen to achieve measurement consistency across individual infants.

Experimental Design and Analysis Strategy

Two multivariate analysis of variance (MANOVA) designs were used to examine group-related NES characteristics and group-related performance. In the MANOVA of group-related NES characteristics, *group [UBN* (poor): Unsatisfied Basic Needs; *SBN* (non-poor): Satified Basic Needs] was the fixed factor, and *total score* (TS), *educational background* (Ed), *occupational background* (Oc), *dwelling* (Dw), and *overcrowding condition* (Ov) were the dependent variables. In the MANOVA of group related-performance, *group* (*UBN*, *SBN*) was the fixed factor; *age* (6 to 14 months) and *delay* (*1*: less than one second; *2*: five seconds; *3*: ten seconds) were the covariates (Design: Intercept+Age+Delay+Group); and *correct responses*, *consecutive correct responses*, *perseverative errors*, and *non-perseverative errors* were the dependent variables. *A Trials* dependent variable was not included in the MANOVA because it did not correlate with any of the other dependent variables of the task. To analyze group-related performance on this variable a T-Test was used. In addition, T-Test and Mann-Withney tests were used to compare obstetric history and delivery variables in both groups. Kolgomorov-Smirnof test was used to test the hypothesis that samples came from a normal distribution. Runs Test was used to test nonrandom (dependent) ordering. Quadratic and arc sine transformations for standardized variances, Box's Test of Equality of Covariance Matrices, Bartlett's and Levene's Tests of Equality of Error Variances were used in all cases. The probability of a Type I error was maintained at .05 for all analyses. All analyses were conducted with Stata Version 7.0.

Results

NES Scale Analysis

MANOVA results indicated a significant overall effect of *group,* Wilk´s λ=0.41, $F(4,238)=78.14$, $p<0.01$. Comparisons between groups showed that the *UBN* group obtained significantly less scores in *occupational background* mean score, $F(1,239)=34.28$, $p<0.01$; *dwelling* mean score, $F(1,239)=135.12$, $p<0.01$; *overcrowding* conditions mean score, $F(1,239)=103.93$, $p<0.01$; and *total score*, $F(1,239)=119.91$, $p<0.01$. Marginal differences between groups were observed in *educational background* mean score, $F(1,239)=3.02$, $p=0.08$ (See Table 2 for mean scores and standard deviations by group and variable). Error variances of the dependent variables were equal in both groups (Levene's Test).

Prenatal and Perinatal Groups Characteristics

Comparisons of prenatal, perinatal and postnatal conditions in both groups indicated (See Table 3 for mean

Table 3.

Mean Values and Comparison of Pre and Perinatal Variables by Group of the Argentinean Children

	Group						
	SBN			UBN			
Variable	*M*	*SE*	*n*	*M*	*SE*	*n*	*p*
Obstetric history							
Previous pregnancies	1,85	0,11	122	1,80	0,09	105	NS
Previous deliveries	1,20	0,08	122	1,51	0,09	105	**
Previous abortions	0,46	0,06	122	0,17	0,04	105	**
Previous cesareans	0,25	0,05	122	0,06	0,02	93	**
Prenatal care							
First examination (month)	2,26	0,11	122	2,56	0,14	87	NS
Obstetric examinations	7,31	0,23	98	6,78	0,34	93	NS
Maternal smoking	0,26	0,04	122	1,42	0,03	109	**
High temperature episodes	0,04	0,01	122	0,06	0,02	99	NS
Hemorrhages	0,09	0,02	122	0,11	0,03	105	NS
Diabetes Mellitus	-	-	116	-	-	100	
Maternal anemia	0,20	0,03	122	0,12	0,03	100	NS
Urinary infections	0,21	0,03	116	0,30	0,04	100	NS
Exposure to radiologic studies	-	-	122	0,13	0,03	93	
Pregnancy-related hypertensive episodes	0,09	0,02	122	0,19	0,04	100	**
Delivery							
APGAR 8	8,51	0,77	92	8,91	0,28	89	NS
APGAR 10	9,92	0,29	92	9,91	0,27	89	NS
Weight at birth	3155,46	29,22	122	3256,55	49,97	105	NS
Weeks os pregnancy	39,02	0,09	104	39,21	0,13	99	NS
Anesthesia in delivery	0,65	0,09	102	0,70	0,06	98	NS
Stress in delivery	-	-	122	-	-	105	NS
Neonatal Data							
Intensive care unit (ICU)	0,13	0,03	100	0,07	0,03	100	NS
Reanimation	-	-	110	-	-	105	
Jaundice	0,41	0,05	116	0,31	0,05	105	NS
Puerperium							
Post-partum depression	-	-	122	-	-	105	
Breast feeding	0,90	0,03	122	0,88	0,03	103	NS
Iron supplement	0,75	0,04	104	0,94	0,02	100	**
Infant present data							
Present weight	9407,12	84,17	122	9100,45	138,71	105	NS
Present height	72,97	0,27	122	72,03	0,33	105	NS
Present cephalic Perimeter	45,81	0,15	116	45,50	0,13	105	NS
Vaccination program	0,95	0,02	116	1,901	0,03	105	NS

Note: NS = non significant; ***p*<0,01

values and comparisons of variables by group): a) *Obstetric history*: more previous deliveries (*T*-test, $p<0.01$), with fewer previous abortions and cesareans (*T*-Test, $p<0.01$) in the *UBN* group; b) *Prenatal care*: more cases of maternal smoking (*T*-Test, $p<0.01$) and pregnancy-related hypertensive episodes (Mann-Whitney, $p<0.01$) in the *UBN* group; c) *Infant present data*: Iron supplement was more frequently observed in the *UBN* group (Mann-Whitney, $p<0.01$).

Performance Analysis

The covariance matrices of the dependent variables were equal in both groups, M=25.14, F=1.66, p=0.07 (Box's Test). MANOVA results showed a significant overall effect of *age*, Wilk´s λ=0.90, $F(4,436)$=12.08, $p<0.01$; *delay*, Wilk´s λ=0.94, $F(4,436)$=6.53, $p<0.01$; and *group*, Wilk´s δ=0.96, $F(4,436)$=4.90, $p<0.01$. Error variances of the dependent variables were equal in both groups, except for *correct responses*, $F(1,441)$=7.13, $p<0.01$, (Levene's

Test). For this reason the variable was eliminated from subsequent analysis.

Regarding *age*, the *consecutive correct responses*, $F(1,442)=38.59$, $p<0.01$, $B=0.57$, increased and *non-perseverative errors*, $F(1,442)=28.38$, $p<0.01$, $B=-0.38$, decreased with age in both groups. In contrast, *perseverative errors* was steady across ages, $F(1,442)=2.65$, $p<0.10$, $B=-0.04$. Comparisons of these variables with *Delay* revealed that in both groups the *consecutive correct responses* significantly decreased at longer delays, $F(1,442)=11.42$, $p<0.001$, $B=-0.131$, while the *perseverative errors*, $F(1,442)=0.15$, $p=0.69$, and *non-perseverative errors*, $F(1,442)=0.04$, $p=0.84$, remained unchanged. Subjects of both groups and all ages made *perseverative errors* including in the condition of less than 1 second delay (Figure 1).

Comparisons between groups showed that the *UBN* group made fewer *consecutive correct responses*, $F(1,443)=8.54$, $p=0.03$, $B=-0.198$, and more *perseverative responses*, $F(1,442)=8.54$, $p<0.01$, $B=0.06$, and *non-perseverative errors*, $F(1,442)=5.27$, $p=0.02$, $B=0.01$ (See Table 4 for Means and Standard Deviations).

Finally, no differences were observed in T-Test results comparing *A trials* before the first reach of inversion criteria, $F(1,355)=0.91$, $p=0.34$. Mean and standard deviations were 3.21 ± 2.24 (n= 197) for *SBN* group, and 2.99 ± 2.08 (n=160) for poor group.

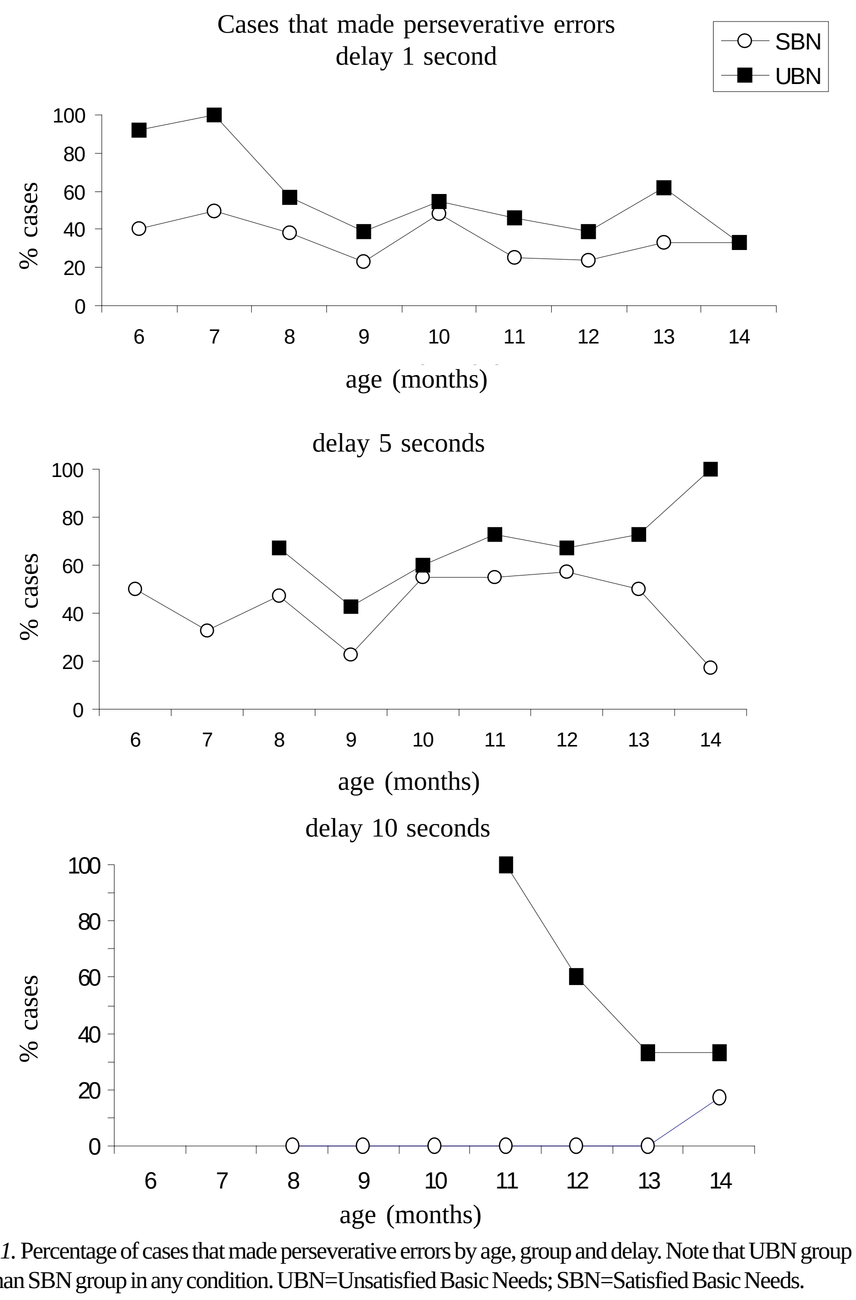

Figure 1. Percentage of cases that made perseverative errors by age, group and delay. Note that UBN group always made more than SBN group in any condition. UBN=Unsatisfied Basic Needs; SBN=Satisfied Basic Needs.

Table 4.
Means and Standard Deviations of A-not-B Dependent Variables by Group, Age and Delay

	Dependent Variable[1]																	
	Consecutive Correct Responses						Perseverative Errors						Non-Perseverative Errors					
	SBN			UBN			SBN			UBN			SBN			UBN		
Age[2]	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
								1-second delay										
6	0,5	0,3	15	0,3	0,2	12	0	0	15	0,1	0,1	12	0,1	0	15	0,2	0,1	12
7	0,4	0,3	23	0,3	0,2	11	0,1	0	23	0,1	0,1	11	0,2	0,1	23	0,2	0,1	11
8	0,7	0,2	19	0,5	0,3	16	0	0	19	0,1	0	16	0,3	0,3	19	0,5	0,2	16
9	0,6	0,3	13	0,6	0,3	11	0	0	13	0	0	11	0,1	0,1	13	0,1	0,1	11
10	0,7	0,2	27	0,6	0,3	12	0	0	27	0	0,1	12	0,1	0,1	27	0,1	0,1	12
11	0,7	0,2	12	0,7	0,3	12	0	0	12	0	0	12	0	0,1	12	0,1	0,2	12
12	0,6	0,2	11	0,7	0,2	18	0	0	11	0,1	0	18	0	0,1	11	0,1	0,1	18
13	0,6	0,1	7	0,6	0,3	11	0	0	7	0	0	11	0,2	0,1	7	0,2	0,1	11
14	0,8	0,2	5	0,8	0,1	5	0	0	5	0	0	5	0	0	5	0	0	5
								5-second delay										
6	0	0	5	´-	´-	´-	0	0	5	´-	´-	´-	0,5	0,1	5	´-	´-	´-
7	0,4	0,3	5	´-	´-	´-	0	0	5	´-	´-	´-	0,3	0,2	5	´-	´-	´-
8	0,3	0,2	12	0,2	0,2	5	0	0	12	0,1	0,1	5	0,2	0,2	12	0,3	0,2	5
9	0,5	0,3	8	0,3	0,3	5	0	0	8	0,1	0,1	5	0,1	0,1	8	0,2	0,1	5
10	0,5	0,2	19	0,4	0,2	7	0,1	0,1	19	0,1	0,1	7	0,1	0,2	19	0,2	0,2	7
11	0,6	0,2	9	0,4	0,1	9	0,1	0,1	9	0,1	0,1	9	0,1	0,2	9	0,1	0,1	9
12	0,6	0,2	8	0,5	0,3	12	0	0,1	8	0,1	0,1	12	0,1	0,1	8	0,2	0,1	12
13	0,4	0,2	5	0,5	0,1	6	0,1	0,1	5	0,1	0,1	6	0,3	0,2	5	0,3	0,1	6
14	0,8	0,1	4	0,3	0,3	3	0	0	4	0,1	0	3	0	0	4	0,2	0,3	3
								10-second delay										
6	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-
7	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-
8	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-	´-
9	0,9	0,1	3	´-	´-	´-	0,1	0,1	3	´-	´-	´-	0,1	0,1	3	´-	´-	´-
10	0,9	0	2	´-	´-	´-	0	0	2	´-	´-	´-	0	0	2	´-	´-	´-
11	0,7	0,2	3	0,6	0,3	3	0	0	3	0,1	0	2	0	0,1	3	0,1	0	1
12	0,5	0,4	3	0,5	0,4	3	0	0	3	0,1	0,1	3	0,2	0,2	3	0,1	0	3
13	0,7	0,6	2	0,6	0,5	2	0	0	2	0	0	2	0	0	2	0	0	2
14	0,7	0,1	3	´-	´-	´-	0	0	3	´-	´-	´-	0	0	3	´-	´-	´-

Note: SBN=Satisfied Basic Needs group; UBN=Unsatisfied Basic Needs group; [1]*correct responses* was eliminated (see Results); [2]in months.

Discussion

Performance on the *A-not-B* appeared to be affected by three factors: *age*, *delay* and *group*. First, with respect to age, *consecutive correct responses* augmented and *non-perseverative errors* diminished, as age increased. Although *perseverative errors* also appeared to diminish with age, differences did not reach statistical difference, probably due to sample size. Nevertheless, this profile was similar to those described in previous studies with infants and preschoolers (Diamond, 1985; Diamond & Goldman-Rakic, 1989; Espy et al., 1999; Gratch et al., 1974), in which an increment of efficiency (correct responses) and a decrease of perseverative errors, with increasing age, were observed.

Second, with respect to delay, *consecutive correct responses* decreased with the increase in difficulty. As suggested by Espy et al. (1999), this result would indicate that an increased difficulty alters the ability to sustain a search strategy. This tendency coincides with the hypotheses according to which in early stages of executive development available executive abilities can be insufficient when cognitive demands increase (Anderson, 1998; Anderson et al., 2001; Hughes, 2002; Luciana & Nelson, 1998). Furthermore, *perseverative and non-perseverative* errors did not vary with respect to delay. In previous studies it was observed that the most frequent errors were those of the perseverative kind (i.e., *A-not-B*; Diamond, 1985). The conceptual definition of *perseverative errors* used in the present study (Espy et al., 1999), does not consider as such those errors occurring following reversals. Another difference with the results obtained in Anglo-Saxon studies (Butterworth, 1977; Diamond, 1985; Diamond & Goldman-Rakic, 1989; Gratch & Landers, 1971) is that with the delay of <1 second all the children made *perseverative errors*. This could be interpreted: a) as an effect of the cross-sectional nature of the study (practice effects, or unfamiliar condition with the experimenter and testing room) (Diamond, 1985); b) as the alteration of functions of cognitive specific domains, e.g. attention (Anderson, 1998; Klenberg et al., 2001); or c) as a combination of them. More investigation would be needed to refute these hypotheses. Due to the cross-sectional character of this study, and the duration of the delay periods used, we cannot provide a further insight regarding the delay needed to produce perseverative errors.

According to our results the *SBN* group made significantly more *consecutive correct responses* and fewer *perseverative and non-perseverative errors* than the *UBN*. Thus, *SBN* infants performed better on the *A-not-B* task than the *UBN*, which is attributable to an increase in the two types of errors, i.e., perseverative and non-perseverative. The former error has been associated with immaturity concerning object permanence (Piaget, 1954), with impairment of the inhibitory control, and with mechanisms involved in spatial working memory processes (Diamond, 1985, 1990, 2001). *Non-perseverative errors* are more likely to be associated with attention, space codification and search strategies than with inhibitory control (Ahmed & Ruffmann, 1998; Diamond, 1990, 2001; Diamond & Goldman-Rakic, 1989). Present results do not allow to clearly determining whether *perseverative* and *non-perseverative errors* were either mnemic immature, produced by attentional deficits, or by difficulties in inhibitory control or in codifying spatial locations. Regarding development of unsuitable manual search strategies (which also include motor components) results showed that infants were able to reach correctly. It could be argued that *UBN* infants' performance was associated with a combination of alterations in the decodification of spatial cues in the first stages of task contingencies, inhibitory control processes, and its integration with a response module, as proposed by Mareschal, Plunkett and Harris (1999). In terms of the Competing-System approach, it could be argued that *UBN* infants showed an immature balance between response-based and representational systems, thus suggesting immaturity at the level of response control as well as lack of flexibility in representational systems (Zelazo et al., 1998). With respect to the *A trials* necessary to reach criteria of reversals, no differences were observed between groups. This could either imply that this variable was not a predictor of performance as also noted by Markovitz and Zelazo (1999), or that the decodification of task contingencies (spatial representation) was also difficult for *SBN* infants, especially at the high level of difficulty (ten seconds delay).

This study did not apply the indirect method for measurement of establishment of poverty based on income as most Anglo-Saxon studies do (Bradley, 2002; Brooks-Gunn & Duncan, 1997; McLloyd, 1998). This was due to lack of reliability in the information on income, and the need to identify homes whose poverty was structural (less than five years). The application of the *UBN* direct method (Boltvinik, 2000) allowed to characterize two significantly different profiles of poverty: 1) The *UBN* group was characterized by low levels of parental occupation (qualified workers), low quality homes (shanty or tenancy rooms), little physical space in the home and higher levels of overcrowding (more than three people per room). The paternal educational level was also lower in this group although the statistical differences were marginal. 2) The profile of the *SBN* group differed from similar groups of previous studies (Lipina, Vuelta, Martelli, Bisio, & Colombo, 2000). In these cases parental occupational levels were higher (professionals), housing was of better quality and the mean total score in the NES scale was 43.53 (11.84 points more than that of this study).

Concerning the conditions of the obstetric history and prenatal care, the mothers of the *UBN* group consumed more tobacco, had more episodes of hypertension, and more early deliveries, abortions and cesarean. Consumption of tobacco and episodes of hypertension during pregnancy have been considered prenatal risk factors for cerebral development (Mendola et al., 2002; Ornoy, 2003; Wasserman, Liu, Pine, & Graziano, 2001). Yet, since the percentage of mothers that consumed tobacco was 17% (with an average of ten cigarettes per day) and that of episodes of hypertension 18%, it is suggested that the contribution of these factors to the differences observed in cognitive performance would not have been high. The groups did not differ in the other analyzed indicators: obstetric history (previous pregnancy); prenatal care (first examination, obstetric examinations, high temperature episodes, hemorrhages, diabetes mellitus, maternal anemia, urinary infections, exposure to radiological studies); delivery (weeks of pregnancy, APGAR 8, APGAR 10, anesthesia and stress) and neonatal dates (ICU, reanimation and jaundice). Body weight at birth, iron supplementation during the puerperium (94% of cases in the *UBN* group), vaccination program, actual body weight, size and cephalic perimeter at the moment of the cognitive evaluation, was similar in both groups and within normal population parameters (Sociedad Argentina de Pediatria, 1997). Nevertheless, it is not possible to confirm that the intra-uterine cerebral development was not affected, due to lack potential of information on the maternal nutritional history and the potential exposition to environmental toxins.

Between the mechanisms mediating the effects of poverty on children's cognitive development proposed by Guo and Mullan-Harris (2000), that of the inadequate physical environment of the home is the only one that this study can confirm in the UBN group. Cognitive stimulation at home and parenting style have not been evaluated. Regarding these last two factors, in different studies with African-American cases, positive associations were found between levels of poverty and of home stimulation, evaluated with the HOME scale (Bradley, 1989). On the other hand, in the study carried out by CESNI (1995), such associations were found, which suggests the need for more investigation.

The *SBN* and *UBN* functional characteristics herein described are far from representing the general population of these age groups and cultural contexts. To achieve global outcomes, further study including a higher number of cases, and diverse cultural origin, are needed in order to correlate this (working memory and inhibitory control) and other executive functions with ethnicity, home stimulation, type of neighborhood, and other environmental features associated with poverty. Aside from these pending matters, results from the present study allowed to (a) identify a specific executive functioning profile in infants from Unsatisfied Basic Needs homes, (b) the use of an alternative approach for the analysis of intelligence or developmental quotients paradigms in the study of poverty effects on cognitive performance, and (c) the attainment of a Latin-American infant executive performance database, which could be used either in intervention programs, or to test theoretical issues regarding executive components and sub processes.

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APPENDIX A

NES Scale for Measure Poverty

educational background

	Father	Mother	Years of education
Complete University	12	12	18
Incomplete University	10	10	12-18
Complete College	10	10	15
Incomplete College	9	9	12-15
Complete Secondary	9	9	12
Incomplete Secondary	6	6	7-12
Complete Primary	3	3	7
Incomplete Primary	1	1	0-7
No education	0	0	0
Educational Score:			

occupational background

	Father	Mother
CEO	12	12
Professional	11	11
In charge of a small company	10	10
Technical employer	8	8
Administrative employer	7	7
Seller	7	7
Independent manufacturer	6	6
Independent technician	6	6
Qualified worker	4	4
Non qualified worker	2	2
Non permanent worker	1	1
Servant	1	1
Unemployed	0	0
Does not work	0	0
Occupational Score:		

dwelling

Type		Bathroom	
Home	2	Sheared	0
Appartment	2	Toilet	3
Shanty	0	Ceiling	
Tenancy Room	0	Asphalt	3
Hostel	0	Flagstone	3
Shop premises	0	Roof tile	3
Motor home	0	Metal sheet	1
Homeless	0	Plastic sheet	1
Floor		Cardboard sheet	0
Ceramic tile, carpet, wood	3	Canes, wooden boards	0
Cement, fixed brick	1	External walls	
Ground, non-fixed brick	0	bricks, stones, concrete	3
Water		wood	2
Public net	2	Metal sheet	1
Motor bomb	2	Sun-dried clay brick	0
Manual bomb	1	Cardboard sheet, residues	0
Well	0	Home property	
Rain	0	Own	3
Water tank (cistern)	0	Rented	2
River or canal	0	Borrowed	1
		Seized	0
Dwelling Score:			

overcrowding conditions

Number of persons living in the home:
Number of rooms:
Rate (persons per room):
Overcrowding Score:
TOTAL SCORE: