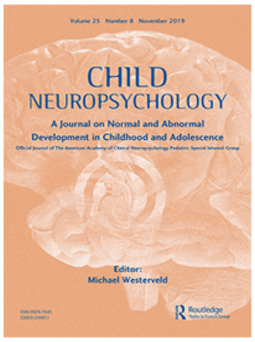

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Parenting and the dysregulation profile predict executive functioning in children with acquired brain injury

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ABSTRACT

Background: Children with acquired brain injury (ABI) present with high rates of psychological disorders commonly accompanied by deficits in hot and cold executive functions (EFs). Impairments in EFs have been reported to precede mental health problems. Moreover, children who are vulnerable to developing mental health problems in adulthood frequently present with a *dysregulation profile* in childhood, characterized by impairments in cognitive, behavioral and emotional regulation. **Objective**: To identify profiles of behaviors associated with impairment in hot and cold EFs and compare injury factors, environmental stressors and dysregulation profile between them. **Methods**: A latent profile analysis was conducted with 77 children with ABI aged between 6 and 12. Injury factors, child IQ, environmental stressors and the dysregulation profile were compared between these behavioral profiles. Logistic regressions were conducted to predict profile membership. **Results**: Two profiles were identified: Profile M, with mild deficits (1–2 SD above the mean) in working memory and social skills, and profile C, presenting clinically significant deficits (2–3 SD above the mean) in shift, initiate, working memory, planning and social skills and mild deficits in inhibit, emotional control and task monitor. Proximal environmental stressors (dysfunctional parenting practices, parental stress, parent's executive dysfunction, anxiety-trait, and depressive symptoms) and dysregulation symptoms predicted profile membership, whereas injury factors, child IQ and distal environmental stressors did not. **Conclusion**: Following ABI, children with profile C are at risk of mental health problems and present with more proximal stressors. The dysregulation profile may be useful as a proxy for risk for later mental health problems in children with ABI.

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Research with healthy children has identified poor self-regulation as an early predictor of a variety of mental health problems in adulthood (Althoff, Verhulst, Rettew, Hudziak, & Van der Ende, 2010). Self-regulation involves emotional, cognitive and behavioral regulation (Althoff et al., 2010). Poor self-regulation in childhood has been associated with anxiety, depression, bipolar disorder, disruptive behavior, drug abuse, self-harm and suicidal ideation in adulthood (Althoff et al., 2010; Biederman et al., 2012; Deutz, Geeraerts, van Baar, Dekovic, & Prinzie, 2016). The dysregulation profile, derived from the Child Behavior Checklist (CBCL: Achenbach & Resco, 2001), provides a conceptualization of self-regulation. It summarizes the propensity towards developing psychopathology and identifies children who could benefit from early intervention to prevent or ameliorate later psychopathology (Ayer et al., 2013; Deutz et al., 2018; Geeraerts et al., 2015). The dysregulation profile consists of elevated ratings CBCL subscales including (a) Attention Problems (b) Anxious/Depressed Behavior and (c) Aggressive Behavior and is used as a proxy for risk of later mental health problems (Althoff et al., 2010).

The dysregulation profile supports the dimensional approach, which considers that mental health symptoms vary along a spectrum of severity (Moller, 2014). For instance, while children with mood instability, irritability, aggression and temper outburst may not fit a specific diagnostic category (e.g., attention deficit and hyperactive disorder or oppositional defiant disorder), they still share features of these domains (Masi, Muratori, Manfredi, Pisano, & Milone, 2015). The dimensional approach overcomes problems such as excessive co-occurrence and heterogeneity of disorders (Widiger & Simonsen, 2005). Using the dimensional approach may allow children with acquired brain injury (ABI) to receive services when their symptoms not fit a strict symptom count for diagnosis (Reynolds & Livingston, 2012). According to Li and Liu (2013), about 50% of children with ABI will have mood and behavioral problems that persist or worsen over time. Children who have sustained an ABI have high rates of novel psychological symptoms (Max, 2014; Max et al., 1998, 2015), commonly accompanied by deficits in executive functions (EFs).

EFs can be divided into cold (attention, processing speed, working memory, and planning) and hot (inhibit, shift, emotional control, and social abilities) domains (Max, 2014; Max et al., 1998, 2015). Cold EFs are more likely to be elicited by decontextualized tasks, including manipulating letters, numbers or abstract concepts (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Hongwanishkul, Happaney, Lee, & Zelazo, 2005), while hot EFs tend to be evoked by contexts that are emotionally and motivationally meaningful (Brock et al., 2009; Hongwanishkul et al., 2005). Hot and cold EFs work together to achieve self-regulation (Zelazo & Carlson, 2012). Impairment of hot and cold EFs seen in daily behaviors, such as time management difficulties or lack of initiative (Gioia, Lsquith, Guy, & Kenworthy, 2000) have been reported to precede mental health problems (Mondragón-Maya, Ramos-Mastache, Román, & Yállez-Téllez, 2017; Willcutt, Sonuga-Barke, Nigg, & Segeant, 2008). Children with ABI are vulnerable to global disruptions of EFs due to damage to underlying neural networks and environmental stressors (Woods, Catroppa, Barnett, & Anderson, 2011). An insult to a developing brain can involve different pathological mechanisms. For example vascular injuries often lead to ischemia; intracranial tumors and arachnoid cysts can cause compression and increased intracranial pressure, whereas traumatic brain injuries often cause diffuse injuries (Allen et al., 2015; Andriessen, Jacobs, & Vos, 2010; Betmouni & Love, 2004). Regardless of the type of injury and its pathological effect on the brain, the development of EFs is often disrupted following ABI (Woods et al., 2011). Because the development of both hot and cold EFs depend on an intact central nervous system and a healthy environment (Ryan et al., 2016; Spencer-Smith & Anderson, 2009). A younger age at injury onset has been associated with more severe damage to neural networks and more impairments in EFs (Anderson, Catroppa, Haritou, Morse, & Rosenfeld, 2005; Crowe, Catroppa, Babl, Rosenfeld, & Anderson, 2012). An elevated risk of mental health problems in children with ABI has been associated with both, brain injury and environmental stressors (Max, 2014; Mulhern, Wasserman, Friedman, & Fairclough, 1989; Shaffer, 1973).

In typically developing children, biopsychosocial theories emphasize that the development of mental health problems is influenced by distal environmental stressors (Samernoff, 2010). Environmental stressors that exacerbate this risk of mental health problems include both, proximal (dysfunctional parenting, parental stress) and distal stressors (lower income, educational achievement, and occupational level, as well as non-intact families) (Mulhern et al., 1989; Wicks-Nelson & Israel, 2016). Children from high-risk environments are more likely to develop behavioral, emotional and cognitive dysregulation (Wicks-Nelson & Israel, 2016). In children with ABI, lower income and single-parent families have been associated with poor self-regulation (Yeates, Taylor, Walz, Stancin, & Wade, 2010).

Proximal factors are also critical for child development, levels of parental discipline (known as behavioral control) and warmth, are particularly important (Prinzie et al., 2003; Prinzie, Stams, Dekovic, Reijntjes, & Belsky, 2009). Adequate levels of behavioral control consist in providing clear expectations for mature behavior in combination with consistent and suitable limit setting (Prinzie et al., 2003, 2009). Warmth refers to parenting that intentionally fosters emotional regulation, characterized by positive affect and acceptance (Prinzie et al., 2003, 2009). Children whose parents present with dysfunctional parenting practices, such as low warmth and lax discipline are at elevated risk of both poor EF, and emergence of a dysregulation profile (Kok et al., 2014; Lucassen et al., 2015). Moreover, efficient EFs are required to engage in warmth parent–child interactions and apply adequate limits (Bridgett, Kanya, Rutherford, & Mayes, 2017). Consequently, parents with executive dysfunction tend to present with reactive and harsh parenting (Bridgett et al., 2017; Crandall, Deater-Deckard, & Riley, 2015; Cuevas et al., 2014). Further, high levels of trait-anxiety and depressive symptoms in parent's increase the child's risk of mental health problems and may hinder the development of EF (Bridgett et al., 2017; Crandall et al., 2015; Cuevas et al., 2014). Interventions aiming to reduced proximal environmental stressors may be helpful for children with ABI (Chavez-Arana et al., 2018).

This study will be the first to apply the dysregulation profile in children with ABI. Using latent profile analysis (LPA) we aimed to (1) identify specific profiles of behaviors associated with EF impairment (hot and cold) and investigate whether (2) distal environmental stressors, (3) proximal environmental stressors, (4) dysregulation profile, and (5) injury factors predict profile membership. We hypothesized that: (1) multiple profiles would be detected based on EFs (hot and cold); (2) distal environmental stressors, (3) proximal environmental stressors, (4) dysregulation profile, and (5) younger age at injury onset and more time since injury would predict profile membership. The presence of more environmental stressors, dysregulation symptoms, younger age at injury onset and more time since injury would be associated with profiles with greater impairment in EF.

Methods

Participants

Parents of 77 children with a diagnosis of ABI participated in this study. Participants were recruited using posters and flyers located in hospitals, clinics, and universities in Mexico City. Families who were interested in participating contacted the researchers via email or phone. Face-to-face interviews were arranged to provide details regarding the study and verify participant eligibility. Children´s age ranged from 6 to 12 years (M = 9.4, SD = 2.1), the age of ABI diagnosis ranged between 0 and 12.5 years (M = 5.9, SD = 3.3), and the age of the primary caregiver ranged from 21 to 48 years (M = 35.7, SD = 6.2). Demographic characteristics are described in Table 1.

Inclusion and exclusion criteria

The following inclusion criteria were required to participate in the study: (1) child aged between 6 and 12 years of age; (2) diagnosis of ABI (defined as damage to the brain that occurs beginning 28 days after birth); (3) the cause or type of ABI was diagnosed and

Table 1. Demographic characteristics of children and their primary caregiver.

	n	%
Sex Male	46	59.7
Type of injury		
• Atrophy unknown origin	2	2.5
• Tumor	24	31.1
• Cyst	21	27.2
• Infection	2	2.5
• TBI	18	23.3
• TBI + cys	5	6.5
• Vascular lesion	5	6.5
Primary caregiver		
• Mother	74	96.10
• Father	3	3.9
Family structure		
• Separated parents with dual custody	15	19.4
• Single parent	8	10.4
• Two parents	54	70.1
Occupation of the primary income earner		
• Semiskilled	27	35
• Skilled	18	23.3
• Unskilled	32	41.5
Education of the primary caregiver		
• Below year 11	27	35
• Completed year 11	30	38.9
• Tertiary	20	25.9
Maternal age at birth N (%)		
• Between 18 and 21	13	16.9
• Less than 18	4	5.2
• Older than 21	60	77.9

TBI: Traumatic Brain Injury

documented in an official report by the treating neurologist or neurosurgeon; (4) injury occurred at least 3 months prior to assessment (three months is considered the minimal time required to recover from the acute phase); (5) parents have an active and current parenting role with the child; (6) parent is over 18 years of age; and (7) parents able to write and read in Spanish. Exclusion criteria: (1) ongoing medical treatment (e.g., chemotherapy, planned neurosurgery); (2) child currently receiving psychological treatment (due to the fact that interventions can improve child and parent outcomes, and, thus, bias the results); (3) child or parent with a history of psychiatric diagnosis not related to ABI, as developmental disorders or onset of disease present prior to ABI (autism, symptoms of psychosis or borderline personality); and (4) uncontrolled seizures in the child. Participants were recruited between March 2016 and May 2017, all cases from this consecutive series that met the study criteria were included.

Approvals

The University of Melbourne Human Research Ethics Sub-Committee approved this study (Ethics ID:1545487). Parents were informed about the research project and signed informed consent was obtained prior to the assessment session.

Setting

The assessments were conducted at a clinic in Mexico City (Iskalti-Condesa).

Measures

All questionnaires were available in Spanish, in all of them higher scores indicated higher dysfunction (Achenbach & Resco, 2001; Abidin, 2012; Arnold, O'Leary, Wolff, & Acker, 1993; Gioia et al., 2000; Prinzie, Onghena, & Hellinckx, 2007; Roberts et al., 2008; Woods, Catroppa, Godfrey, Giallo, & Anderson, 2014). While the questionnaires used did not have norms for a Mexican population, all of them had previously been used with Spanish-speaking populations (Aracena et al., 2016; Dumas, Arriaga, Begle, & Longoria, 2010; Garcia-Fernandez, Gonzalez-Pienda, Rodriguez-Perez, Alvarez-Garcia, & Alvarez-Perez, 2014). These Spanish versions had proven valid and reliable (Aracena et al., 2016; Dumas et al., 2010; Garcia-Fernandez et al., 2014; Rubio-Stipec, Bird, Canino, & Gould, 1990). Assessments were conducted by volunteer-interns who had a minimum of three years of study in Psychology, and had received a 25-h training in the assessment instruments. The assessments were supervised by a neuropsychologist.

Children's hot and cold EFs

Subscales of the Behavior Rating Inventory of Executive Function (BRIEF) parent form (Gioia et al., 2000) Spanish version were used to asses' everyday behaviors associated with impairment in EF. T-scores from the hot EF (inhibition, shift, emotional control) and cold EF (initiate, working memory and task-monitoring) subscales were used for the analysis. Scores ≥ 65 are considered abnormal (Gioia et al., 2000). The Spanish version of BRIEF has proven good internal consistency ($\alpha = 0.98$) and test–retest reliability (Garcia-Fernandez et al., 2014). The social problems subscale from the Child Behavior Checklist (CBCL) Spanish version was used to assess social skills (Achenbach & Resco, 2001). Subscale T-scores were used for analysis (M = 50; SD = 10) with scores ≥63 indicating dysfunction (Achenbach & Resco, 2001). The social skills subscale has proven good internal consistency (α = 0.82) and reliability (Achenbach & Resco, 2001).

Child factors

Intellectual ability

Was measured with five subtests (Similarities, Vocabulary, Arithmetic, Matrix Reasoning, and Coding) of the Spanish version of the Wechsler Intelligence Scale for Children WISC-IV using Mexican norms (Sattler, 2010; Wechsler, 2007). IQ scores (M = 100, SD = 10) were used for analysis.

Injury factors

Parents were asked to bring copies of the official report by the treating neurologist or neurosurgeon with the description of the ABI, age at injury and time since injury. Age at injury and time since injury in years (ordinal variables) were used for analysis. Also, type of injury was used for analysis including seven categories: atrophy unknown origin, tumor, cyst, infection, TBI, TBI + cyst and vascular lesion.

Distal environmental stressors

Social risk

Social risk was measured using a modified Social Risk Score previously used (Roberts et al., 2008), including family structure (0 = family intact, 1 = separated/dual custody or cared for by another intact family member such as grandparents, 2 = single caregiver or foster care), education of the primary caregiver (0 = tertiary, 1 = completed year 11 or 12, 2 = completed below year 11) and occupation of the primary income earner (0 = skilled/professional, 1 = semi-skilled, 2 = unskilled). Each component has three levels, with 0 being lowest risk and 2 being highest risk (Roberts et al., 2008). The total social risk score (ranging from 0 to 6) and the score in each component (raging 0–2) were used for analysis (ordinal variables), with higher scores indicating more social risk (Roberts et al., 2008). Two items from the original version were excluded (employment status and primary language at home), because no participants in the current study had a part-time job or spoke a language different from Spanish at home.

Proximal environmental stressors

Parent stress

Parent Stress Index short form Spanish version measured parental stress, using the Total Stress T-score (Mean = 50; SD = 10). This scale reflects the level of parental stress experienced by the respondent (Abidin, 2012). Scores ≥65 indicate a high level of parental stress (Abidin, 2012). The Spanish version has proven good internal consistency (α = 0.92) and reliability (Aracena et al., 2016).

Dysfunctional parenting practices

The Parenting Scale (PS; Arnold et al., 1993) measured disciplinary practices associated with problematic child behavior. We used the version translated to Spanish conducted by García-Piñeyrúa with permission of the author (Arnold et al., 1993) which has previously used with Spanish-speaking populations (Dumas et al., 2010). The PS has adequate internal consistency (α = 0.84) and test–retest reliability (Arnold et al., 1993) and these has been identified as valid by factor analysis and confirmatory factor analysis (Prinzie et al., 2007). The mean of the total scale raw score was used in analyses. Total scores above 3.2 indicate dysfunctional parenting practices (Arnold et al., 1993; Woods et al., 2014).

Parent's executive dysfunction

The Behaviour Rating Inventory of Executive Function-Adult Self-report (BRIEF-A; Roth, Isquith, & Gioia, 2005) assesses executive dysfunction in daily life. It consists of 75 items scored using a Likert scale. The raw score of the Global Executive Composite was used for the analysis. Higher scores indicate greater executive dysfunction. BRIEF-A has proven a reliable and valid measure (α 0.93–0.96; Roth et al., 2005).

Parent's trait anxiety

The State-Trait Anxiety Inventory (STAI; Diaz-Guerrero, & Spielberg, 1975) is a questionnaire that measures anxiety symptoms in adults using a Likert scale. We used the raw score (ordinal variable) of the trait subscale, which consists of 20 items for analysis. The instruction in this subscale asks one to choose the option that reflects how parents usually feel rather than how they feel at the moment. Higher scores indicate a higher level of trait-anxiety. STAI has proven a reliable and valid measure (α = 0.93; Díaz-Guerrero & Spielberger, 1975).

Parent's depressive symptoms

The raw score (ordinal variable) of the Beck Depression Inventory was used to measure parent depressive symptoms (BDI: Beck, Steer, & Brown, 2006). This inventory has proven to be valid and reliable, and higher scores indicate more depressive symptoms (Beck, Steer, & Brown, 2006).

CBCL dysregulation profile

Child mental health

The dysregulation profile was used to assess vulnerability to mental health disorders (Althoff et al., 2010). This tool is composed of the following CBCL subscales: attention problems, anxious depressed, and aggressive behavior (Achenbach & Resco, 2001). Subscale T-scores from the Spanish version were used for the analysis (M = 50; SD = 10), with ≥63 indicating dysfunction (Achenbach & Resco, 2001). The Spanish version of the CBCL has proven good internal consistency (α = 0.89–0.94; Rubio-Stipec et al., 1990).

Analysis

Latent profile analysis was conducted using Mplus 7.2 with standardized scores from the Inhibition, Shift, Emotional Control, Initiate, Working Memory, Plan, Organization of Materials and Task Monitor subscales from the BRIEF (Gioia et al., 2000) and Social Problems subscale from the CBCL (Achenbach & Resco, 2001). Models were estimated by adding profiles to determine the best fit to the data. To determine the optimal number of profiles within the sample, each model was evaluated using the Akaike Information Criterion (AIC), the sample size-adjusted Bayesian Information Criterion (sBIC), the Lo-Mendell Rubin Adjusted Likelihood Ratio Test (LMRT), the bootstrapped likelihood ratio test (BLRT) and Entropy. AIC and sBIC are parsimony indexes in which lower values suggest improvement in the solution (Collins & Lanza, 2010). The p value generated for the LMRT and BLRT indicate whether moving to more complex models results in a significant improvement in model fit (Collins & Lanza, 2010). Entropy measures how well profiles can be distinguished (Collins & Lanza, 2010). Entropy scores closer to 1 indicate that there is little error associated with assigning individuals to latent profiles (Collins & Lanza, 2010). Table 2 shows the fit indices obtained, the model with two profiles was chosen as best model fit. Participants were allocated to profiles mild impairment (M) or clinically significant impairment (C) by estimating their profile membership using Mplus 7.2. In line with a previous study (Anderson et al., 2005), we considered mild impairment as scores between 1 and 2 SD above the mean in BRIEF, clinically significant impairment for scores between 2 and 3 SD and severe impairment for scores ≥3SD above the mean.

Five logistic regressions were conducted (child factors, injury factors, distal environmental stressors, proximal environmental stressors, and dysregulation profile) in IBM SPSS using the profile membership identified by Mplus 7.2 as a categorical dependent variable. These five logistic regressions were conducted to find the best fitting and

Table 2. Model fit indices.

Number of Profiles	AIC	Sbic	LMRT (p)	BLRT (p)	Entropy
1 Profile	5360.29	5345.73			
2 Profiles	5147.73	5125.09	227.32 (0.01)	232.55 (<0.001)	.90
3 Profiles	5079.56	5048.84	86.18 (0.15)	88.16 (<0.001)	.91
4 Profiles	5059.55	5020.74	39.11 (0.57)	40.01 (<0.001)	.90
5 Profiles	5034.76	4987.87	43.59 (0.45)	44.59 (<0.001)	.92

AIC: Akaike information criterion; sBIC: sample size-adjusted Bayesian information criterion; LMRT: Lo-Mendell-Rubin test. BLRT: Parametric bootstrapped likelihood ratio test.

clinically interpretable model that better predicts the profiles. In the "child factors model," IQ and sex were included as predictors. IQ was included as a predictor as due to higher IQ has been found to be associated with better EFs (Mahone et al., 2002). Sex was included as a predictor considering that previous research described some sex differences in the development of EFs (Kerr & Zelazo, 2003). As a result, deficits in EFs following ABI may also vary. In the "injury factors model" age at injury, time since injury and type of injury were included as predictors. The type of injury was analyzed with seven different categories (atrophy, tumor, cyst, infection, TBI, TBI +cyst, vascular), and was included as a predictor to explore whether certain types of injuries are associated with greater impairment in EFs. In the "distal environmental stressors model," social risk and its components (family structure, occupation, education and maternal age at birth) were included as predictors. Dysfunctional parenting practices, parental stress, parent´s executive dysfunction, anxiety-trait, and depressive symptoms were predictors in the "proximal environmental stressors model." Lastly, in the CBCL dysregulation profile the anxious-depressed, attention problems and aggressive behavior subscales were included as predictors.

The fit of each model was assessed based on Hosmer–Lemeshow test, Cox and Senll R^2, and Nagelkerke R^2. In Hosmer–Lemeshow test $p > 0.05$ suggests good model fit (Hosmer, Lemeshow, & Sturdicant, 2013). Whereas Cox and Senll R^2 and Nagelkerke R^2 can be useful when comparing competing models (Hosmer et al., 2013). The statistical tests of individual predictors within the model were analyzed using regression coefficient, Wald's χ^2, and odds ratio. Finally, to identify specific factors that better predict profiles regardless of the model, *p* values of independent logistic regressions (outside the equation) were analyzed.

Results

A total of 170 participants were interested in participating, 77 participants met the inclusion criteria. Reasons for exclusion were: pre-existing diagnosis (e.g., cerebral palsy, neurofibromatosis) or uncontrolled seizures. All participants in the current study were Mexicans whose primary language was Spanish. As can be seen in Table 1, the type of injuries in the sample was heterogeneous. Participants' age at diagnosis ranged between the perinatal period and late childhood, while the age at the time of the study ranged between 6 and 12 years. Most participants were diagnosed with a brain tumor (31.1%) or brain cyst (27.2%). The mother was the main caregiver (96.1%) in most families. Most families participating in this study (70.1%) were intact families. In most families (41.5%) the primary income earner had an unskilled occupation and had completed year 11 (38.9%). Most mothers (77.9%) were older than 20 when their child with ABI born. Children participating in the current study were attending regular schools. Participants did not require special assistance for motor, visual or hearing impairments. Six participants were diagnosed with comorbid disorders (one with a learning disorder, three with ADHD, one with ADHD and anxiety disorder, one with ADHD and learning disorder). Participants in the current study were part of a previous case study (Chavez-Arana et al., 2017b) and a randomized controlled trial (Chávez et al., 2017a).

Table 2 shows the AIC, sBIC, LMRT, and entropy results for the models with one to five profiles. The decreasing values in the indexes generally favored more profiles rather than fewer results, in other words, values favored more complex results. However, due to the

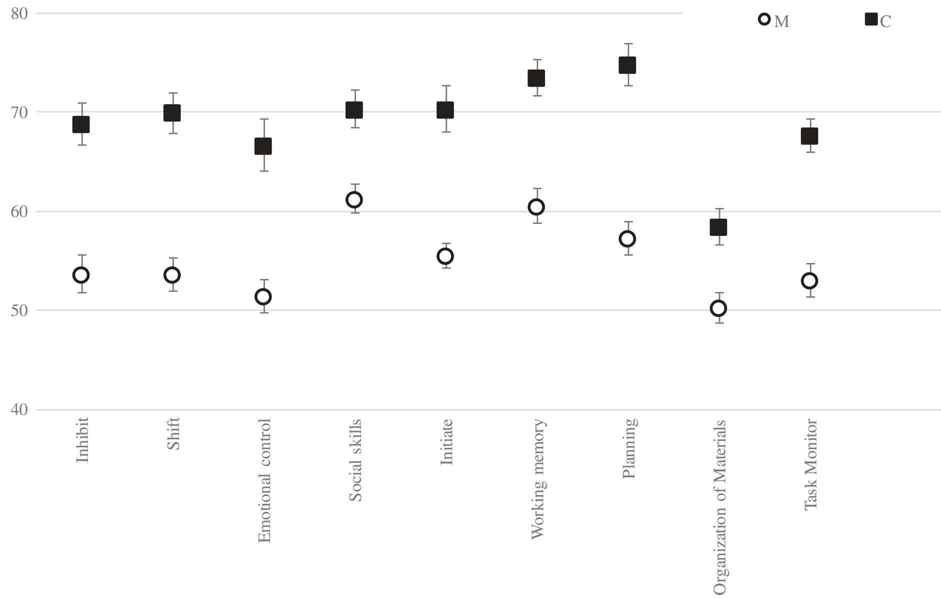

Figure 1. Hot and cold executive functions in profiles M and C.
Mean: 50 SD: 10

sample size (N = 77), there were too few subjects when a three-profile solution is examined (profile 1 N = 12, profile 2 N = 42, profile 3 N = 23). Further, the significant *p* value generated for the LMRT favored the two-profile solution. For these reasons, the model with two profiles was chosen as best model fit.

As can be seen in Figure 1, children with profile M presented with mild deficits (1–2SD < M) in working memory and social skills. In contrast, children with profile C presented with clinically significant deficits (2–3SD < M) in shift, initiate, working memory, planning and social skills and mild deficits in inhibit, emotional control and task monitor.

In the child factors model a Hosmer-Lemeshow $\chi^2(12.352) = 8$, p = .136, Cox and Snell $R^2 = .006$, and Nagelkerke $R^2 = .008$ were obtained. This logistic regression model correctly classified 56.6% of the children. When IQ and sex were entered as predictors in one model, none of these factors made a statistically significant contribution to the model.

In the injury factors model Hosmer-Lemeshow χ^2 (1.721) = 8, p = .988, Cox and Snell $R^2 = .064$, and Nagelkerke $R^2 = .086$ were obtained. This logistic regression model correctly classified 61% of the children. When entered age at injury, time since injury and type of injury as predictors in one model, none these factors made a statistically significant contribution to the model.

For the distal environmental stressors model a Hosmer–Lemeshow a $\chi^2(5.914) = 6$ p = .433, Cox and Snell $R^2 = .041$, and Nagelkerke $R^2 = .055$ were obtained. This logistic regression model correctly classified 62.3% of the children. When all the components of social risk (family structure, occupation of the primary income earner, education of the primary caregiver and maternal age at birth) were entered as predictors in one model none made a statistically significant contribution to the model.

Regarding the proximal environmental stressors model, a Hosmer-Lemeshow of χ^2 (6.984) = 8 p = .538, Cox and Snell R^2 = .301, and Nagelkerke R^2 = .404 were obtained. This logistic regression model correctly classified 80.5% of the children. When the proximal environmental stressors were entered as predictors in one model, only parental stress made a statistically significant contribution to the model (B = .114, Wald = 7.633, p = .006, odds ratio = 1.121).

For the CBCL-dysregulation a Hosmer–Lemeshow a χ^2(12.67) = 8 p = .124, Cox and Snell R^2 = .354, and Nagelkerke R^2 = .476 were obtained. This logistic regression model

Table 3. Descriptive statistics and comparisons between profiles.

	Profile M	Profile C	p value
Participants N (%)	44 (57.1)	33 (42.9)	
CHILD FACTORS			
Sex Male N (%)	27 (58.7)	19 (41.3)	.861
Child Intellectual ability M (SD)	86.6 (18.2)	83.3 (13.4)	.509
INJURY FACTORS			
Age at ABI	6.0 (2.9)	5.2 (3.5)	.260
Time since ABI in months M (SD)	79.6 (18.6)	78.06 (14.2)	.194
Type of injury N (%)			
• Atrophy unknown origin	1 (50)	1 (50)	.795
• Tumor	17 (70.8)	7 (29.2)	.836
• Cyst	10 (47.6)	11 (52.4)	.102
• Infection	1 (50)	1 (50)	.301
• TBI	9 (50)	9 (50)	.836
• TBI + cyst	3 (60)	2 (40)	.484
• Vascular lesion	3 (60)	2 (40)	.894
DISTAL ENVIRONMENTAL STRESSORS			
Family structure N (%)			.351
• Separated parents with dual custody	5 (33.3)	10 (66.7)	
• Single parent	5 (62.5)	3 (37.5)	
• Two parents	34 (63)	20 (37)	
Occupation of the primary income-earner N (%)			.241
• Semiskilled	20 (74.1)	7 (25.9)	
• Skilled	10 (55.6)	8 (44.4)	
• Unskilled	14 (43.8)	18 (56.3)	
Education of the primary caregiver N (%)			.467
• Below year 11	13 (48.1)	14 (51.8)	
• Completed year 11	19 (63.3)	11 (36.6)	
• Tertiary	12 (60)	8 (40)	
Maternal age at birth N (%)			1.000
• Between 18 and 21	8 (61.5)	5 (38.5)	
• Less than 18	2 (50)	2 (50)	
• Older than 21	34 (56.7)	26 (43.3)	
PROXIMAL ENVIRONMENTAL STRESSORS			
Dysfunctional parenting practices M (SD)	3.4 (.49)	3.8 (.44)	.001
Parent stress M (SD)	49.5 (8.1)	60.36 (9.9)	<.001
Parent executive dysfunction M (SD)	52.2 (8.4)	58.2 (10.07)	.022
Parent anxiety-trait symptoms M (SD)	40.5 (6.9)	47.0 (9.8)	.001
Parent depressive symptoms M (SD)	8.0 (6.25)	12.96 (6.6)	.002
CBCL Dysregulation Profile			
DP- Anxious-depressed, M(SD)	57.3 (7.1)	66.8 (8.5)	<.001
DP- Attention problems, M(SD)	60.1 (9.7)	71.3 (8.8)	<.001
DP- Aggressive behavior, M (SD)	64.3 (6.6)	69.8 (8.2)	.002

ABI: Acquired brain injury; BRIEF: Behavior Rating Inventory of Executive Function parent form; CBCL: Child Behavior Checklist; EF: Executive functions; DP: Dysregulation profile; M: Mean; Profile C: with clinically significant (2-3 SD above the mean) deficits in shift, initiate, working memory, planning and social skills and mild deficits (1-2 SD above the mean) in inhibit, emotional control and task monitor; Profile M: Mild deficits in working memory and social skills.

correctly classified 79.2% of the children. Anxious depressed (odds ratio [OR] = 1.122, p = .009) and attention problems model (OR = 1.090, p = .017) made a statistically significant contribution to the model. Whereas the aggressive behavior subscale did not. The proximal environmental stressors and CBCL dysregulation profile models were identified as the best fitting and clinically interpretable models. These models yielded non-significant Hosmer-Lemeshow *p* values and the largest R^2.

Logistic regression analyses outside the model revealed that proximal environmental stressors and the dysregulation profile predicted profile membership (see Table 3). The presence of more proximal environmental stressors and dysregulation symptoms were associated with profile C. In contrast, child factors, injury factors, and distal environmental stressors, did not predict profile membership.

Discussion

Two profiles were identified; profile M (with mild deficits in working memory and social skills) and profile C (with clinically significant deficits in shift, initiate, working memory, planning and social skills and mild deficits in inhibit, emotional control and task monitor). Contrary to our hypothesis, distal environmental stressors and injury factors did not predict profile membership. Supporting our hypothesis, proximal environmental stressors and the dysregulation profile predicted profile membership. As hypothesized, children with profile C are more likely to exhibit dysregulation symptoms associated with risk for mental health problems, their parent's present with more dysfunctional parenting practices, parental stress, anxiety-trait, depressive symptoms, and executive dysfunction.

Profile M

Following ABI, mild deficits in working memory and social skills may be present regardless of environmental stressors. Children with profile M demonstrated mild deficits in working memory and social skills and lower levels of proximal environmental stressors. Certain EFs may be more sensitive to optimal parenting practices (Kok et al., 2014). By studying a non-clinical pediatric population, Kok et al. (2014) found that the presence of warm parent–child interactions at three years of age was associated with better EFs. Similarly, our results suggest that children with ABI whose parents are able to implement optimal parenting practices are less likely to present with behaviors associated with deficits in some EFs (inhibition, shift, planning, emotional control, initiate, and monitor). Moreover, children with profile M, presented with lower scores in the dysregulation profile, suggesting a lower risk for developing mental health problems over time. While further studies are required, it seems that parent's optimal parenting practices and mental health may enhance the development of EFs and protect children from developing mental health problems following ABI.

Profile C

Due to the disruption in neural networks, children with ABI are already prone to present with deficits EFs (Conklin, Salorio, & Slomine, 2008; Konigs et al., 2015), if in addition they are exposed to proximal stressors, such as dysfunctional parenting practices, parent's with high levels of parental stress, anxiety trait, depressive symptoms, and executive dysfunction, these deficits may worsen. Profile C consisted in clinically significant deficits in shift, initiate, working memory, planning and social skills and mild deficits in inhibit, emotional control and task monitor. Consistent with biopsychosocial theories (Samernoff, 2010), the presence of more proximal stressors was associated with profile C. There is evidence describing the influence that parents have on child development following an ABI (Henrichs et al., 2011; Kok et al., 2014; Prinzie et al., 2003; Samernoff, 2010). Parents with high levels of anxiety-trait, parental stress and executive dysfunction model avoidance and intolerance of uncertainty and may unintentionally hinder the development of EFs in their children (Aktar, Nikolic, & Bögels, 2017; Henrichs et al., 2011). Moreover, trait-anxiety has been associated with abnormalities in the functioning of the central nervous system and genetic factors (Aktar et al., 2017; Henrichs et al., 2011; Lewis-Morrarty et al., 2015; Verkhratsky & Parpura, 2014). While further studies are required, another explanation is that profile C and associated proximal stressors (dysfunctional parenting practices, high levels of parental stress, anxiety trait, depressive symptoms, and executive dysfunction), can be a consequence genetic factors, in combination with the injury onset. Although genetic factors were not studied in the current study. It is also crucial to consider that the parent–child relationship is reciprocal (Taylor et al., 2001). Children shape their environment; child behaviors can evoke parenting behaviors. For instance, better child's self-regulation in infancy predicts better parenting practices in childhood (Bates & Pettit, 2014), and the high levels of parental stress and dysfunctional parenting practices can be associated with child behavior. Nonetheless, children with profile C may not fit a specific diagnostic category, still they are at risk of developing mental health problems.

Dysregulation profile

The dysregulation profile can be used as a proxy for risk for later mental health problems in children with ABI. Adults who survived a brain tumor during childhood presented with higher rates of depression, poorer quality of life and a lack of close friends compared to survivors of other types of cancer (Max, 2014; Mulhern et al., 1989; Roddy & Mueller, 2016). In line with adult studies (Roddy & Mueller, 2016), 42.9% of the children participating in this study presented with a risk for mental health problems. This is in consistent with what has been described as the "growing into deficits," when consequences of a brain insult are initially silent and become evident over time (Anderson, Spencer-Smith, & Wood, 2011; Lipska, Jaskiw, & Weinberger, 1994). Studies with animal models also show that early brain injury can lead to a delayed onset of abnormal behaviors (Lipska & Weinberger, 2000). In healthy populations, improvements seen in self-regulation during childhood and adolescence are supported by the integration of neural circuits (Luna, Garver, Urban, Lazar, & Sweeney, 2004), which can be disrupted following ABI. Self-regulation is more reliable at seven years of age (Spencer-Smith & Anderson, 2009). We could expect that the risk for mental health problems may start becoming evident at seven years of age, and, thus, could be identified by using the dysregulation profile. Children with ABI may present with persistent symptoms that do not necessarily fit a diagnosis category. Grounded on previous evidence (Masi, Pisano, Milone, & Muratori, 2015), results suggest that the dysregulation profile is a cost-effective measure that may allow clinicians to monitor, prevent and ameliorate mental health issues following pediatric ABI.

Injury and distal environmental stressors

In the current study injury (age at injury, time since injury, type of injury) and distal stressors did not predict everyday EFs. In contrast with previous studies associating younger age at injury onset with greater cognitive impairments (Anderson et al., 2011), we did not find differences in age at injury and time since injury between children with profiles M and C. This absence of differences could be explained due to the heterogeneity in the sample, we included diverse types of injuries with varying and incomparable degrees of severity. Moreover, this study suggests that social risk does not contribute to the differences between the profiles. Previous studies completed in high-income countries reported an association between social risk and poor outcomes (Max et al., 1998; Willcutt et al., 2008). The current study comprised a Mexican population, and social risk was assessed based on the indicators from high-income countries. Differences in how social risk is displayed between these countries may explain why our hypothesis was not supported. In Latin America, the neighborhood in which the family lives and their economic status have been closely related to the resources families can access following ABI (Arango-Lasprilla et al., 2011; Bonow et al., 2018), and may be considered stronger indicators in this population.

Limitations

This study has a number of limitations. Due to the heterogeneity and size of the sample, we were not able to compare injury factors that have been associated with impairments in EFs, such as injury severity and brain pathology in regions underpinning psychological functions (Colonnelli et al., 2012; Max, 2014; Max et al., 1998; Shaffer, 1973). Further, with a larger sample size, more profiles may have arisen, and the comparison of these may have been informative. In addition, due to the difficulties in recruiting a considerable number of participants for the current study, we included a variety of brain injuries with a minimum time since injury onset of 3 months. This could impact the results because some children may still be in early stages of recovery. However, time since injury was not significantly different between profiles. The lack of standardized instruments available with a Mexican population may also impact the results. Moreover, we do not know if the high level of parental stress, dysfunctional parenting practices, and child EF impairment were present prior to the injury or established following the diagnosis. Lastly, social risk was assessed using measures commonly used in high-income countries, which can be different in a Mexican population.

Future studies

Future studies in children with ABI could incorporate long term follow-up assessments, to study the course of behaviors associated with impairment in EFs and the risk for mental health problems. Future studies using homogeneous samples could compare injury factors associated with the profiles. Different methods to measure social risk could be used to study a Mexican population. Previous research shows that the parent´s report of child EFs on behavioral ratings does not correlate with child´s performance on individually administered measures of EFs (Vriezen & Pigott, 2002). As a result, future studies could investigate whether similar results are found by using performance-based measures.

Conclusions

Two profiles were identified in children with ABI: profile M (with mild deficits in working memory and social skills) and profile C (with clinically significant deficits in shift, initiate, working memory, planning and social skills and mild deficits in inhibit, emotional control and task monitor). Children with profile C presented with dysregulation symptoms associated with risk for mental health problems in adulthood, their parents presented with high levels of parental stress and dysfunctional parenting compared to children in profile M. Child intellectual ability, injury factors and social risk were not different between profiles. The dysregulation profile may be useful to identify children with ABI who are at risk of mental health problems.

Disclosure statement

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