Optimal Scaling for Early Life Stress Measurement

Olena Iakunchykova, Tatiana I Andreeva, Zoreslava Shkiryak-Nizhnyk, Yuri Antipkin, Daniel Hryhorczuk, Alexander Zvinchuk, Natalia Chislovska

BACKGROUND: Early life stress is associated with high risk for both negative psychological and physical health outcomes. However, many of the stressful life events inventories that have been used in epidemiological research have not been validated or checked for reliability or consistency. The aim of our study is to use optimal scaling and correspondence analysis that employ categorical principal components analysis (CATPCA) algorithm to consider the internal structure and the geometry of the space of variables obtained through the questions measuring early life stress. This approach was chosen because it allows quantification of categorical (both nominal and ordinal) scales and reduction of initial number of variables with interval quantification of the resulting dimensions.

METHODS: A questionnaire for measuring early life stress was applied to the participants of the Ukrainian component of European Longitudinal Study of Pregnancy and Childhood at the age of three and seven years. CATPCA algorithm was used to elaborate a tool for estimating related integral quantified characteristics.

RESULTS: Application of quantification and dimension reduction techniques to the categorical variables measuring stress in three- and seven-year-old children resulted in two dimensions.

The first dimension that accounts for a major part of initial variance and is associated with all the collected variables can be interpreted as the overall measure of stress. The second dimension accounts for smaller but still considerable part of variance and can be related to child's attachment to mother and acquiring new experience as the route of development.

CONCLUSIONS: Application of optimal scaling to the empirical data of early life stress measurement resulted in construction of two integral indicators – first measuring overall stress and second contrasting security related to child's attachment to mother and new experiences – consistent across age groups of three and seven-year-old children.

KEYWORDS: psychological stress; questionnaires; mathematical models; algorithms; scaling; statistics; computation; optimal scaling; correspondence analysis.

Оптимальное шкалирование измерений стресса раннего возраста

Olena Iakunchykova, Tatiana I Andreeva, Zoreslava Shkiryak-Nizhnyk, Yuri Antipkin, Daniel Hryhorczuk, Alexander Zvinchuk, Natalia Chislovska

УДК 159.944.4:303.425:311.2

АКТУАЛЬНОСТЬ: Стресс в ранний период жизни связан с высоким риском как психологических, так и физиологических проблем. При этом многие инструменты, используемые для регистрации стрессовых событий в жизни в эпидемиологических исследованиях, не прошли проверку на валидность, надежность и согласованность. Целью нашего исследования было использование оптимального шкалирования и анализа соответствий по методу главных компонент для категориальных признаков с целью рассмотрения внутренней структуры и пространственной геометрии переменных, полученных из вопросника по измерению стресса в ранний период

жизни. Выбор такого подхода был обусловлен тем, что он делает возможным количественное выражение категориальных (номинальных и порядковых) переменных и уменьшение размерности данных с интервальным выражением выявленных размерностей.

МЕТОДЫ: Вопросник по измерению стресса в ранние периоды жизни был предложен участникам украинской компоненты Европейского лонгитюдного исследования беременности и детства, когда их дети достигли 3-х и 7-ми лет. Алгоритм анализа соответствий по методу главных компонент для категориальных величин использовался для оценки соответствующих интегральных характеристик.

РЕЗУЛЬТАТЫ: Применение количественного выражения и сокращения размерностей к категориальным переменным, измеряющим стресс у 3-х и 7-ми-летних детей, позволило выделить две размерности.

Первая размерность, которая учитывает основную часть дисперсии и связана со всеми переменными в исследовании, может быть интерпретирована как общий уровень стресса. Вторая размерность, которая учитывает меньшую, но все же значительную часть дисперсии, сопоставляет привязанность ребенка к матери и получение нового опыта как важные элементы развития.

ВЫВОДЫ: Применение оптимального шкалирования к эмпирическим данным по стрессу в ранний период жизни позволило сконструировать два интегральных индикатора. Первый индикатор служит для измерения общего стресса, а второй – для противопоставления ощущения безопасности, выражаемой в привязанности к матери, и получения нового опыта. Оба индикатора были выявлены как в возрастной группе 3-х-летних, так и 7-ми-летних детей.

КЛЮЧЕВЫЕ СЛОВА: психологический стресс; вопросники; математические модели; алгоритмы; градуировка; шкалирование; статистика; вычисление; оптимальное шкалирование; анализ соответствий.

Оптимальне шкалювання для вимірювання стресу раннього періоду життя

Olena Iakunchykova, Tatiana I Andreeva, Zoreslava Shkiryak-Nizhnyk, Yuri Antipkin, Daniel Hryhorczuk, Alexander Zvinchuk, Natalia Chislovska

АКТУАЛЬНІСТЬ: Стрес у ранній період життя пов'язаний з високим ризиком як психологічних, так і фізіологічних проблем. Однак, інструменти, що використовують для реєстрації стресових подій у житті в епідеміологічних дослідженнях, не пройшли перевірку на валідність, надійність та узгодженість. Метою нашого дослідження було використання оптимального градуювання і аналізу відповідностей за методом головних компонент для категоріальних величин з метою виявлення внутрішньої структури і просторової геометрії змінних, отриманих з опитувальника, що вимірює стрес у ранній період життя. Вибір такого підходу був зумовлений його здатністю квантифікації категоріальних (номінальних і порядкових) шкал і зменшення розмірності даних з їх інтервальним визначенням.

МЕТОДИ: Опитувальник стресу у ранні періоди життя був запропонований учасникам української компоненти Європейського лонгітюдного дослідження вагітності і дитинства, коли їх діти досягли 3-х і 7-ми років. Алгоритм аналізу відповідностей за методом головних компонент для категоріальних величин використовували для оцінки відповідних інтегральних характеристик.

РЕЗУЛЬТАТИ: Використання вирахування і скорочення розмірностей щодо категоріальних змінних, які вимірюють стрес в 3-х і 7-ми-літніх дітей, дозволило виділити дві розмірності.

Перша розмірність, яка враховує основну частину дисперсії і пов'язана з усіма змінними у дослідженні, може бути проінтерпретована як загальний рівень стресу. Друга розмірність, яка враховує меншу, але все ж значну частину дисперсії, співставляє прив'язаність дитини до матері й отримання нового досвіду як елементи процесу розвитку.

ВИСНОВКИ: Використання оптимального градуювання до емпіричних даних зі стресу у ранній період життя дозволило сконструювати два інтегральні індикатори. Перший індикатор служить для вимірювання загального рівня стресу, а другий – для визначення відчуття безпеки, що проявляється через прив'язаність до матері, і отримання нового досвіду. Обидва індикатора були виявлені як у віковій групі 3-х-річних, так і 7-ми-річних дітей.

КЛЮЧОВІ СЛОВА: психологічний стрес; опитувальники; математичні моделі; алгоритми; градуювання; статистика; обчислення; оптимальне градуювання; аналіз відповідностей.

ORIGINAL STUDY

INTRODUCTION

Early life stress (ELS) is a known risk factor for many behavioral and health problems. It has been associated with a range of adverse outcomes in adults, including abnormalities in electrical brain activity (McFarlane et al., 2005), personality dimensions (Roy, 2002), increased vulnerability to substance abuse and depression (Anda et al., 2002; Fuller-Thomson, Filippelli, & Lue-Crisostomo, 2013), and adult health risk behaviors and diseases (Chapman et al., 2013; Enoch, 2011; Felitti et al., 1998). Numerous studies have shown that stressors in childhood influence the risk for adult alcohol and drug dependence regardless of the genetic factors (Anda, et al., 2002; Eaves, Prom, & Silberg, 2010; Verona & Sachs-Ericsson, 2005). Experiencing maltreatment and stressful life events in the first few years of life is associated with the onset of problem drinking in adolescence and alcohol dependence in early adulthood (Dube et al., 2006; Rothman, Edwards, Heeren, & Hingson, 2008; Strine et al., 2012). The degree of risk for adult alcohol use and drug dependence tends to be correlated with the severity of childhood maltreatment and the number of stressful life events while being a child (Enoch, Steer, Newman, Gibson, & Goldman, 2010; Jaffee, Caspi, Moffitt, Polo-Tomas, & Taylor, 2007). Long-term impact of early-life adverse experiences on at-risk behaviors leads to an increased risk of sexually transmitted diseases (STDs) during adulthood (Hillis, Anda, Felitti, Nordenberg, & Marchbanks, 2000).

Childhood traumatic experiences have the same magnitude of risk for negative physical health outcomes as they do for negative psychological outcomes. High-quality studies show consistent positive associations between obesity and childhood domestic and peer violence: obesity and central adiposity may mediate the association between interpersonal violence in childhood and negative physical health outcomes (Midei & Matthews, 2011). There is a correlation between adverse childhood experiences and ischemic heart disease, and psychological factors appear to be more important than traditional risk factors in mediating this association (Dong et al., 2004).

When studies take into account the impact of early life stress, the latter requires proper measuring. The most widely used method for assessing stress in children is the use of checklists of stressors (environmental experiences). Checklists differ in the extent to which they focus on breadth or depth. General checklists include a broad range of stressful life events, whereas specialized checklists assess specific domains of stressful events in children. Unfortunately, basic psychometric data are not available for many of the stressful life events inventories that have been reported in the literature (Grant, Compas, Thurm, McMahon, & Gipson, 2004). A questionnaire for measuring ELS was developed based on the study of stress in obstetric groups (Barnett, Hanna, & Parker, 1983) and applied to the participants of Avon Longitudinal Study of Parents and Children (ALSPAC, October 2012). If a particular event happened, mothers rated the impact of the listed events on the child and specified whether the child was very upset, quite upset, a bit upset, not upset. However, to the best of our knowledge, this questionnaire has not been assessed for its consistency.

In previous studies based on ALSPAC data, total life event scores were calculated by summing the event-specific impact score reported by mothers (Enoch, et al., 2010). If mother rated the impact of the event on the child as very upset, impact score equaled 4, quite upset - 3, a bit upset - 2, not upset - 1. For example, if a child had three events each rated as "very upset", this child received a score of 12 (3 times 4). However, the scale was an ordinal one and there were no grounds to apply it as an interval scale, which in fact was done. No quantification of the ordinal scales was conducted before and correspondence between separate ordinal variables was not taken into account.

The variables resulting from the questionnaire were ordered categorical (i.e., ordinal) variables. In analyzing ordinal variables it should be taken into account that the categories of the variable have a priori a fixed order, but we cannot assume that the distances between the categories are equal (Manisera, Van Der Kooij, & Dusseldorp, 2010).

The present analysis uses data obtained from mothers with the abovementioned questionnaire about stressful events of their 3 and 7 year old children from the Ukrainian component of the European Longitudinal Study of Pregnancy and Childhood (ELSPAC). We aimed to apply optimal scaling to the data collected on ELS.

Optimal scaling and correspondence analysis that employ categorical principal components analysis (CATPCA) algorithm allow quantification of categorical (both nominal and ordinal) scales and reduction of the initial number of variables with interval quantification of the resulting dimensions. Resulting variables – both transformed quantified initial variables and newly acquired object scores –

are normalized interval variables, i.e. those having mean equal to 0 and standard deviation equal to 1.

Integral new variables (object scores) are constructed based on the analysis of relationships between categorical variables deriving from answers to different questions. This gives an opportunity to develop scales that synthesize the responses to several questions that have a common theme. Several categorical variables can be replaced by a single scale which can then be used in subsequent analyses such as regression analysis which require interval-scaled data (Greenacre, 2002).

This approach is very similar to that of principal component analysis and falls into the class of classical multivariate statistical methods of dimension reduction (Greenacre, 2005): the method implies that total variance of the data matrix is defined and then this total is decomposed optimally along so-called "principal axes".

These scale values have been shown to have interesting geometric properties and provide what is called "maps" of the relationships between variables. As relationships of categorical variables are usually represented with cross-tabulations, the correspondence method is to produce a "map" of such tables, where each row and each column is represented by a point.

For mapping purposes, it is usually hoped that a large percentage of total variance is accounted for by the first two principal axes, thereby allowing the table to be visualized in two dimensions. Each row of a table divided by its row total is a vector called a profile that is a set of proportions adding up to 1. Each row profile point is then given a weight which is essentially a measure of importance of the point, called "the mass". The row "mass" is the frequency of the row category divided by the grand total (Greenacre, 2002).

Thus the aim of our study is to consider the internal structure and the geometry of the space of variables obtained through the questions measuring early life stress and to elaborate a tool for estimating related integral quantified characteristics applicable as an exposure measurement in further studies.

METHODS

Study setting and population

The present analysis is based on data from the Ukrainian component of the European Longitudinal Study of Pregnancy and Childhood

Table 1. Stressful life events experienced by children at age 3 (since 18 month old) and age 7 (since 5 years old), according to mother's report

Type of life event		age 3 (n=1316)		age 7 (n=1107)
Child was taken into care by someone else	G1	336 (25.5%)	FG1	138 (12.5%)
Pet died	G2	271 (20.6%)	FG2	359 (32.4%)
Child's family moved	G3	331 (25.2%)	FG3	187 (16.9%)
Child had shock/fright	G4	276 (21.0%)	FG4	130 (11.7%)
Child was beaten by someone	G5	266 (20.2%)	FG5	232 (21.0%)
Child was sexually abused	G6	4 (0.3%)	FG6	3 (0.3%)
Child was separated from the mother	G7	118 (9%)	FG8	40 (3.6%)
Child was separated from the father	G8	259 (19.7%)	FG9	248 (22.4%)
Child acquired a new mother/father	G9	55 (4.2%)	FG10	76 (6.9%)
Child had a new sister/brother	G10	110 (8.4%)	FG11	113 (10.2%)
Child was hospitalized	G11	382 (29%)	FG12	280 (25.3%)
Child was looked after by a new person	G12	208 (15.8%)	FG13	65 (5.9%)
Child was separated from someone	G13	127 (9.7%)	FG14	93 (8.4%)
Child started attending a new kindergarten/school	G14	283 (21.5%)	FG15	154 (13.9%)
Something else happened to child	G15	67 (5.1%)	FG18	12 (1.1%)
A family member died*	NA	NA	FG7	273 (24.7%)
The child started to visit school*	NA	NA	FG16	918 (82.9%)
The child has lost the best friend*	NA	NA	FG17	62 (5.6%)

NA – not applicable
G1-G15 – Names of the variables at age 3 on the variable map (see Figure 1)
FG1-FG2 - Names of the variables at age 7 on the variable map (see Figure 2)

ORIGINAL STUDY

(ELSPAC). The details of this study have been described previously (Hryhorczuk et al., 2009). Briefly, it is a prospective cohort study of women and their children aimed at identifying features of the environment that affect the health and development of children (Golding, Pembrey, & Jones, 2001). Of all the pregnant women in Dniprodzerzhynsk, a city which is in Dnipropetrovsk province in south-central Ukraine, we invited those who visited antenatal clinics, planned to continue their pregnancy, and were permanent residents of the city between 1992 and 1994 (Little, Monaghan, Gladen, Shkyryak-Nyzhnyk, & Wilcox, 1999). Of 4398 women who met study eligibility criteria, 2148 (49%) women agreed to participate; 1316 and 1107 mothers completed stressful life events inventory at 3 and 7 years follow-up respectively. Out of 1316 mothers, 1057 (86%) were married, 189 (19%) had secondary education, 522 (52%) had secondary education with professional specialization, 289 (29%) had higher education.

Being a birth-cohort based, the study aimed to attain not the nationally-representative estimates of any of the measured parameters but rather information on risk factors of health and developmental problems typical for the children born in a particular time span after Ukraine became an independent country, considered in their life-course perspective.

Data collection

Data were obtained through self-completed questionnaires distributed by medical staff from local primary health care facilities. Mothers completed questionnaires about their children's exposure to and impact from stressful life events at ages 3 and 7: Mothers reported on the study questionnaire whether their children had ever experienced (yes or no) any of 15-18 different stressful life events (for questions, see Table 1). If mothers had marked only some events, we assumed that those events had happened to their kids, and that the others did not take place. The surrogate recall period was the past 1.5 years for 3-year-old children and the past 2 years for 7-year-old

Table 2. Quantification of variables corresponding to each type of life event, component loadings, and Cronbach's alpha for the factorial solution at age 3

		Initial categories					Component loadings for two dimensions	
		Yes, very upset	Yes, upset	Yes, little upset	Yes, not upset	Did not happen	1	2
Child was taken into care by someone else	G1	-3.968	-1.794	-0.468	0.213	0.392	0.347	-0.105
Pet died	G2	-4.040	-1.621	-1.224	-1.092	0.456	0.254	-0.174
Child's family moved	G3	-8.076	-5.768	-2.062	-0.178	0.308	0.436	0.439
Child had shock/fright	G4	-4.171	-1.237	-0.064	0.327	0.327	0.416	-0.307
Child was beaten by someone	G5	-5.509	-3.705	-0.945	0.122	0.348	0.335	-0.292
Child was sexually abused	G6	NA	-18.111	-18.111	-18.111	0.055	0.229	0.404
Child was separated from the mother	G7	-6.652	-2.801	-0.916	-0.288	0.242	0.638	-0.317
Child was separated from the father	G8	-4.825	-2.863	-2.051	-0.532	0.404	0.670	0.044
Child acquired a new mother/father	G9	-16.366	-12.751	-6.384	-1.740	0.151	0.296	0.535
Child had a new sister/brother	G10	-13.674	0.003	0.056	0.074	0.074	0.206	-0.310
Child was hospitalized	G11	-3.656	-2.305	-0.280	0.395	0.395	0.438	-0.364
Child was looked after by a new person	G12	-10.266	-5.351	-1.902	-0.723	0.275	0.488	0.077
Child was separated from someone	G13	-5.886	-4.335	-2.008	-1.233	0.282	0.621	0.190
Child started attending a new kindergarten/school	G14	-2.553	-2.553	-2.220	-1.219	0.503	0.206	0.216
Something else happened to child	G15	-7.653	-1.299	-1.054	-0.322	0.166	0.227	0.263
Cronbach's Alpha							0.660	0.279
Variance explained							2.61	1.35

G1-G15 – Names of the variables at age 3 on the variable map (see Figure 1)

children. The mothers also rated the impact of the event on the child as follows: very upset, quite upset, a bit upset, not upset. Some of the mothers who marked that an event happened have not marked to which extent the child was upset. In this case, the authors coded responses as quite upset.

Analysis

We used the CATegorical Principal Components Analysis (CATPCA algorithm) developed by the Faculty of Social and Behavioral Sciences, Leiden University, The Netherlands, implemented in SPSS, version 15.0, which is an implementation of the optimal scaling approach to Nonlinear Principal Components Analysis (NLPCA)

(Manisera, et al., 2010). It allows quantification of categorical (both nominal and ordinal) scales and reduction of initial number of variables with interval quantification of the resulting dimensions. Resulting variables – both transformed quantified initial variables and newly acquired object scores – are normalized interval variables, i.e. those having mean equal to 0 and standard deviation equal to 1. These two types of calculation algorithm output are shown in the tables and can be further applied for quantitative measurement of either each stressful event or integrative measures of stress.

Data for 3 year old and 7 year old measurements were analyzed separately. With initial scales being or-

dinal, optimal scaling analysis allows two options: spline ordinal variables and just ordinal. As both solutions obtained gave quite similar results, spline ordinal option was further kept as the default one.

RESULTS

The listed stressful life events were experienced by less than one percent to one third of study participants, except for starting to visit school, which was experienced by 918 (82.9%) children. (Table 1).

At the age of three, quantification of each variable value is shown in Table 2 along with the factorial solution with two dimensions which is also shown in Figure 1. Cronbach's alpha for the first dimension
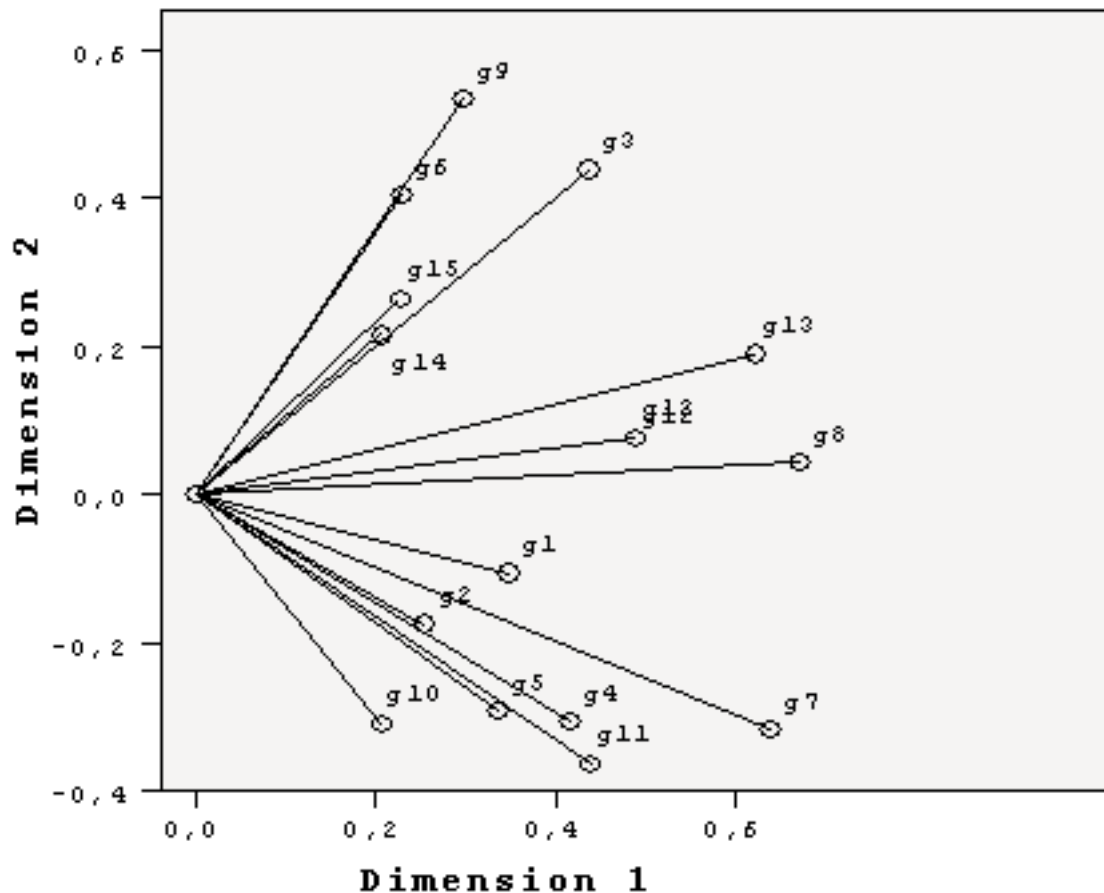

Figure 1. Variable map at the age of 3 years old.

constituted 0.66 and 0.28 for the second one. Thus the first dimension accounts for larger portion of variance and most initial variables have high correspondence with it.

The variable map (Figure 1) is a useful graphical representation of factorial solution. Along with the component loadings (Table 2) it reveals three groups of variables.

The first group consisted of three variables which had positive loadings with dimension 1 and loadings with dimension 2 close to zero. These are G8 (Child was separated from the father), G13 (Child was separated from someone) and G12

(Child was looked after by a new person) thus related to separation from father or any other person but not from mother.

The second group included seven variables with positive loadings with dimension 1 and negative loadings with dimension 2. These are in descending order of variable input G7 (Child was separated from the mother), G11 (Child was hospitalized), G4 (Child had shock/fright), G5 (Child was beaten by someone), G10 (Child had a new sister/brother), G1 (Child was taken into care by someone else), G2 (Pet died). Thus most of these variables reflect loss

of linkage to the mother which for a child of age below three is associated with physical safety.

The third group consisting of five variables has positive loadings both for the first and second dimensions. These are G3 (Child's family moved); G9 (Child acquired a new mother/father); G6 (Child was sexually abused); G15 (Something else happened to child); G14 (Child started attending a new kindergarten/school) thus all associated with having new experience.

At the age of 7, the factorial solution has also consisted of two dimensions. The component loadings

Table 3. Quantification of variables corresponding to each type of life event, component loadings, and Cronbach's alpha for the factorial solution at age 7

		Initial categories					Component loadings for two dimensions	
		Yes, very upset	Yes, upset	Yes, little upset	Yes, not upset	Did not happen	1	2
Child was taken into care by someone else	FG1	-6.419	-2.229	-1.547	-0.412	0.269	0.522	-0.149
Pet died	FG2	-2.464	-1.063	0.065	0.441	0.561	0.260	-0.332
Child's family moved	FG3	-7.754	-4.625	-2.547	-0.611	0.322	0.241	-0.228
Child had shock/fright	FG4	-5.031	-1.189	-0.985	-0.587	0.283	0.328	-0.459
Child was beaten by someone	FG5	-4.724	-1.985	-0.518	-0.029	0.373	0.336	-0.424
Child was sexually abused	FG6	NA	-23.105	-21.175	-11.045	0.050	0.079	-0.103
Child was separated from the mother	FG8	-7.831	-2.839	-2.339	-0.840	0.159	0.407	-0.384
Child was separated from the father	FG9	-5.150	-1.542	-0.744	-0.021	0.322	0.469	-0.153
Child acquired a new mother/father	FG10	-23.427	-0.262	-0.262	-0.262	0.064	0.461	0.572
Child had a new sister/brother	FG11	-23.181	-1.635	-0.791	-0.172	0.081	0.481	0.607
Child was hospitalized	FG12	-4.556	-0.251	-0.023	0.180	0.276	0.324	-0.085
Child was looked after by a new person	FG13	-13.159	-1.985	-1.264	-0.610	0.124	0.649	0.142
Child was separated from someone	FG14	-6.496	-1.952	-0.616	-0.171	0.209	0.582	-0.092
Child started attending a new kindergarten/school	FG15	-8.965	-2.372	-0.588	0.007	0.154	0.481	0.026
Something else happened to child	FG18	-14.846	0.067	0.067	0.067	0.067	0.326	0.456
A family member died*	FG7	-3.522	-0.889	-0.069	0.308	0.386	0.238	-0.315
The child started to visit school*	FG16	-6.624	-2.072	-0.350	0.224	0.224	0.473	0.174
The child has lost the best friend*	FG17	-8.566	-4.402	-1.252	-0.202	0.171	0.503	0.027
Cronbach's Alpha							0.727	0.479
Variance explained							3.19	1.83

FG1-FG2 - Names of the variables at age 7 on the variable map (see Figure 2)

are shown in Table 3 and Figure 2. Variable quantification is presented in Table 3. The values of Cronbach's Alpha for both dimensions at this age were higher than at age 3 years old and equaled 0.73 and 0.48 respectively. This reflects higher correspondence between variables used for measurement of stress experienced by children at age 7 than at age 3.

Initial variables have also clustered into three groups.

First group included FG13 (Child was looked after by a new person), FG14 (Child was separated from someone), FG1 (Child was taken into care by someone else), FG9 (Child was separated from the father), FG15 (Child started attending a new kindergarten/school), FG16 (The child started to visit school), FG17 (The child has lost the best friend). So this group is similar to the first group at age 3 with high correlates with dimen-

sion 1 which thus gets interpreted as separation from different people excluding mother.

Second group includes FG8 (Child was separated from the mother), FG5 (Child was beaten by someone), FG4 (Child had shock/fright), thus is quite similar to the second group of variables in the factorial solution acquired for three-year-old kids.

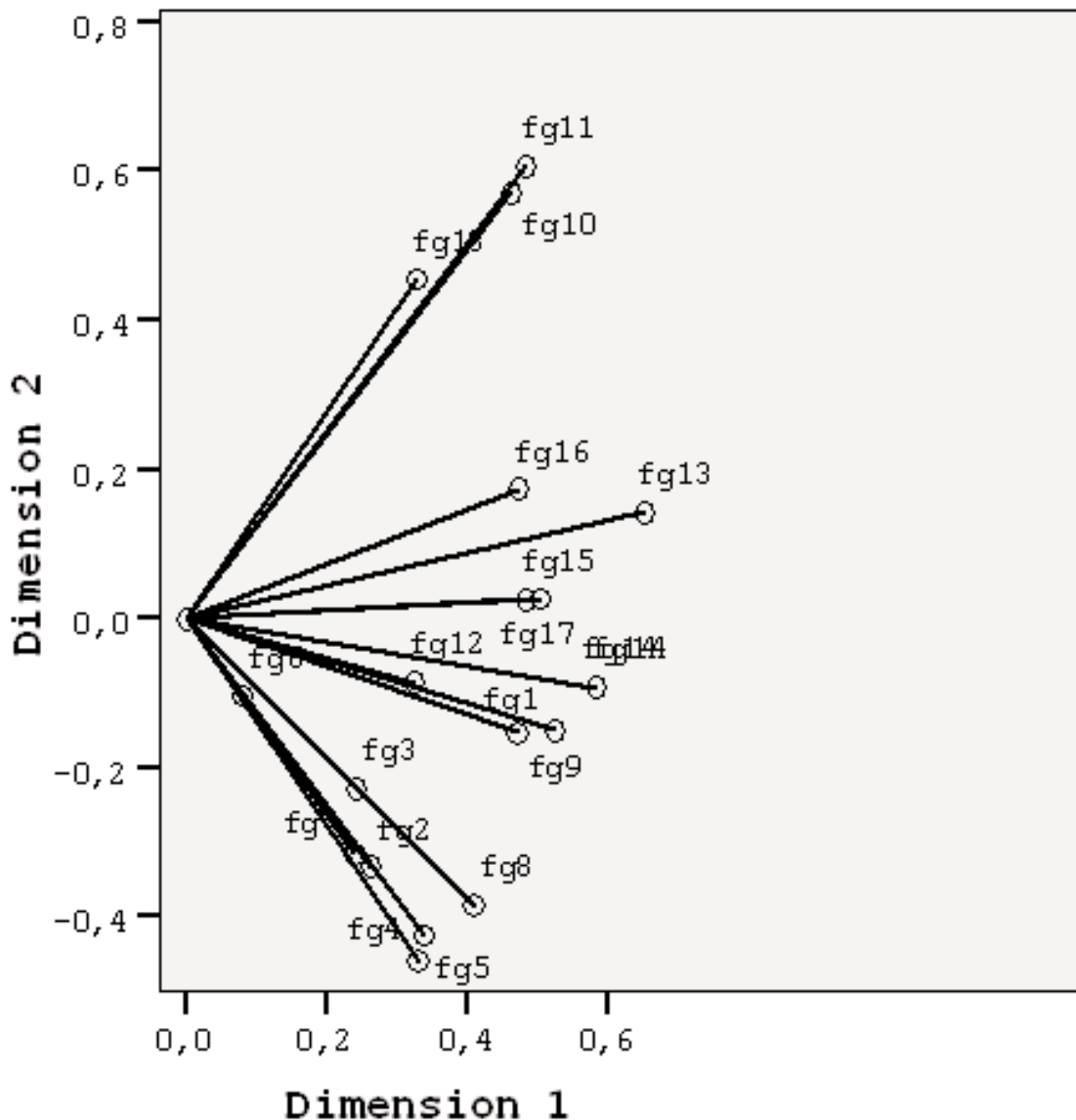Third group of variables was associated with high values at dimen-

Figure 2. Variable map for the component solution for the age of 7.

sions 1 and 2 and includes variables FG11 (Child had a new sister/brother), FG10 (Child acquired a new mother/father) and FG18 (Something else happened to child).

Thus both factorial solutions were quite similar for ages 3 and 7 which make them more reliable measures.

DISCUSSION

Application of quantification and dimension reduction techniques to the categorical variables measuring stress in three- and seven-year-old children resulted in quite similar reduced dimensions and variable geometry.

The first dimension, which accounts for a major part of initial variance and is associated with all the collected variables, can be interpreted as the overall value of stress. The advantage of this new measure of stress compared to those used in earlier ELSPAC studies based on early life stress measurement (Enoch, et al., 2010) is that it takes into account how different variables are related to each other and how they correspond within the overall space of indicators used.

Besides the first one, the second dimension was revealed, which accounts for smaller but still considerable part of variance and remains consistent across two considered age groups – children aged 3 and 7 years. Interpretation of this measure can be related to other important dimension of childhood development. One edge of the new variable is related to child's safety and the other – to acquiring new experience as the route of development. Both traumatic and developing experiences are important within the developmental psychol-

ogy, and secure attachment to mother is a platform for processing future experiences (Kerns, 1996).

Although the authors' interpretations of these dimensions may be subjective and somewhat arbitrary, these interpretations are based on the revealed factorial solution.

Getting similarly interpretable integral characteristics for both age groups of study children is a positive sign and may testify a potential strength of the study. Were component structure much different, two potential explanations could be applicable: either different events are able to cause stress in kids aged three and seven or the combined integral measures created within our analysis are not reliable.

Many studies measured early life stress from adverse childhood experiences (ACE), including severe stressors such as: emotional, physical, and sexual abuse; interparental violence; parental divorce; and presence of a substance-abusing, mentally ill, or incarcerated household member (Anda, et al., 2002; Dube et al., 2003). Our study exposure measure included a range of stressors, involving such mild ones as death of a pet, entering kindergarten/ school, moving of the family, and birth of a brother/ sister.

Most stressor checklists are consistent with an objective conceptualization of environmental stress, so that they only account for the type of stressful life events experienced by child. On the contrary, the early life stress questionnaire which was employed in our study encompassed not only the wide range of stressors, but also attempted to gather information about perceived impact of particular event on child's emotional state.

Still the study is not free from certain limitations. First, stress measurement has almost never been

truly theory driven (Lazarus, 1990). This limitation applies to our study, which is fully empirical. However, there are several empirical limitations as well. Some mothers have marked only those events which happened to their kids. So we assumed that others did not take place; however, we in fact do not know whether other events have not been marked because they did not happen, or mothers were doubtful, or they did not mark the event because it was too stressful. Thus, the possibility of recall bias is not excluded. Some of the mothers who marked that an event happened have not marked to which extent the child was upset. The implications of relying on proxy reports by mothers as opposed to self-reports are not clear, but it seems to be the only option for 3-year-old children. According to survey theory, proxy responses are less accurate and rely more on generic than episodic information in recalling facts. Several authors have suggested that the effect of proxy interviewing varies with the type of questions, and there is no general consensus on how seriously proxy interviewing affects the data quality (Thomsen, 2011). Moreover, how mothers described stress suffered by their kids could be a projection of their own emotions. It is also known that children can be 'taught' how to perceive potentially stressful life events by parents (Schwarz & Perry, 1994).

Further research is related to using the constructed integral object scores as measures of exposure and analyzing what health outcomes in study children are associated to suffering higher childhood stress.

CONCLUSIONS

Application of optimal scaling to the empirical data of early life stress measurement resulted in con-

struction of two integral indicators – first measuring overall stress and second contrasting security related to child's attachment to mother and new experiences – consistent across age groups of three and seven-years-aged children.

ABOUT THE AUTHORS

Olena Iakunchykova[1], MPH, Tatiana I Andreeva[1], MD, PhD, Zoreslava Shkiryak-Nizhnyk[2], MD, PhD, Yuri Antipkin[2] MD, PhD, Daniel Hryhorczuk[3], MD, MPH, Alexander Zvinchuk[2], Natalia Chislovska[2], MD, PhD.

1. School of Public Health, National University of "Kyiv-Mohyla Academy", Kyiv, Ukraine.

2. Institute of Pediatrics, Obstetrics, and Gynecology, Kyiv, Ukraine

3. Center for Global Health, University of Illinois College of Medicine.

Corresponding author: Olena Iakunchykova, olenauak@ukr.net

REFERENCES

ALSPAC. (October 2012). Avon Longitudinal Study of Parents and Children. Questionnaires. Retrieved October, 2012, from http://www.bristol.ac.uk/alspac/researchers/resources-available/data-details/questionnaires

Anda, R. F., Whitfield, C. L., Felitti, V. J., Chapman, D., Edwards, V. J., Dube, S. R., et al. (2002). Adverse childhood experiences, alcoholic parents, and later risk of alcoholism and depression. *Psychiatr Serv*, 53(8), 1001-1009.

Barnett, B. E. W., Hanna, B., & Parker, G. (1983). Life event scales for obstetric groups. Journal of *Psychosomatic Research*, 27(4), 313-320.

Chapman, D. P., Liu, Y., Presley-Cantrell, L. R., Edwards, V. J., Wheaton, A. G., Perry, G. S., et al. (2013). Adverse childhood experiences and frequent insufficient sleep in 5 U.S. States, 2009: a retrospective cohort study. *BMC Public Health*, 13, 3.

Dong, M., Giles, W. H., Felitti, V. J., Dube, S. R., Williams, J. E., Chapman, D. P., et al. (2004). Insights into causal pathways for ischemic heart disease: adverse childhood experiences study. *Circulation*, 110(13), 1761-1766.

Dube, S. R., Felitti, V. J., Dong, M., Chapman, D. P., Giles, W. H., & Anda, R. F. (2003). Childhood abuse, neglect, and household dysfunction and the risk of illicit drug use: the adverse childhood experiences study. *Pediatrics*, 111(3), 564-572.

Dube, S. R., Miller, J. W., Brown, D. W., Giles, W. H., Felitti, V. J., Dong, M., et al. (2006). Adverse childhood experiences and the association with ever using alcohol and initiating alcohol use during adolescence. *J Adolesc Health*, 38(4), 444 e441-410.

Eaves, L. J., Prom, E. C., & Silberg, J. L. (2010). The mediating effect of parental neglect on adolescent and young adult anti-sociality: a longitudinal study of twins and their parents. *Behav Genet*, 40(4), 425-437.

Enoch, M. A. (2011). The role of early life stress as a predictor for alcohol and drug dependence. *Psychopharmacology (Berl)*, 214(1), 17-31.

Enoch, M. A., Steer, C. D., Newman, T. K., Gibson, N., & Goldman, D. (2010). Early life stress, MAOA, and gene-environment interactions predict behavioral disinhibition in children. *Genes Brain Behav*, 9(1), 65-74.

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., et al. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. *Am J Prev Med*, 14(4), 245-258.

Fuller-Thomson, E., Filippelli, J., & Lue-Crisostomo, C. A. (2013). Gender-specific association between childhood adversities and smoking in adulthood: findings from a population-based study. *Public Health*. DOI 10.1016/j.puhe.2013.01.006

Golding, J., Pembrey, M., & Jones, R. (2001). ALSPAC--the Avon Longitudinal Study of Parents and Children. I. Study methodology. *Paediatric and Perinatal Epidemiology*, 15(1), 74-87.

Grant, K. E., Compas, B. E., Thurm, A. E., McMahon, S. D., & Gipson, P. Y. (2004). Stressors and child and adolescent psychopathology: measurement issues and prospective effects. *J Clin Child Adolesc Psychol*, 33(2), 412-425.

Greenacre, M. (2002). [Correspondence analysis of the Spanish National Health Survey]. *Gac Sanit*, 16(2), 160-170.

Greenacre, M. (2005). Correspondence Analysis Encyclopedia of Statistics in Behavioral Science: John Wiley & Sons, Ltd.

Hillis, S. D., Anda, R. F., Felitti, V. J., Nordenberg, D., & Marchbanks, P. A. (2000). Adverse childhood experiences and sexually transmitted diseases in men and women: a retrospective study. *Pediatrics*, 106(1), E11.

Hryhorczuk, D., Dardynskaia, I., Lukyanova, E., Matwyshyn-Fuoco, M., Friedman, L., Shkiryak-Nizhnyk, Z., et al. (2009). Risk factors for wheezing in Ukrainian children: Ukraine European Longitudinal Study of Pregnancy and Childhood Group. *Paediatric and Perinatal Epidemiology*, 23(4), 346-351.

Jaffee, S. R., Caspi, A., Moffitt, T. E., Polo-Tomas, M., & Taylor, A. (2007). Individual, family, and neighborhood factors distinguish resilient from non-resilient maltreated children: a cumulative stressors model. *Child Abuse Negl*, 31(3), 231-253.

Kerns, K. A. (1996). Individual differences in friendship quality: Links to child-mother attachment The company they keep: Friendship in childhood and adolescence (pp. 137-157). Cambridge, UK: Cambridge University Press

Lazarus, R. S. (1990). Theory-based stress measurement. *Psychological Inquiry*, 1(1), 3-13.

Little, R. E., Monaghan, S. C., Gladen, B. C., Shkyryak-Nyzhnyk, Z. A., & Wilcox, A. J. (1999). Outcomes of 17,137 pregnancies in 2 urban areas of Ukraine. *American Journal of Public Health*, 89(12), 1832-1836.

Manisera, M., Van Der Kooij, A., & Dusseldorp, E. (2010). Identifying the component structure of satisfaction scales by nonlinear principal components analysis. *Quality Technology & Quantitative Mangement*, 7(2), 97-115.

McFarlane, A., Clark, C. R., Bryant, R. A., Williams, L. M., Niaura, R., Paul, R. H., et al. (2005). The impact of early life stress on psychophysiological, personality and behavioral measures in 740 non-clinical subjects. *J Integr Neurosci*, 4(1), 27-40.

Midei, A. J., & Matthews, K. A. (2011). Interpersonal violence in childhood as a risk factor for obesity: a systematic review of the literature and proposed pathways. *Obes Rev*, 12(5), e159-172.

Rothman, E. F., Edwards, E. M., Heeren, T., & Hingson, R. W. (2008). Adverse childhood experiences predict earlier age of drinking onset: results from a representative US sample of current or former drinkers. *Pediatrics*, 122(2), e298-304.

Roy, A. (2002). Childhood trauma and neuroticism as an adult: possible implication for the development of the common psychiatric disorders and suicidal behaviour. *Psychol Med*, 32(8), 1471-1474.

Schwarz, E., & Perry, B. (1994). The post-traumatic response in children and adolescents. *The Psychiatric clinics of North America*, 17(2), 311.

Strine, T. W., Dube, S. R., Edwards, V. J., Prehn, A. W., Rasmussen, S., Wagenfeld, M., et al. (2012). Associations between adverse childhood experiences, psychological distress, and adult alcohol problems. *Am J Health Behav*, 36(3), 408-423.

Thomsen, I., Villund, O. (2011). Using Register Data to Evaluate the Effects of Proxy Interviews in the Norwegian Labour Force Survey. *Journal of Official Statistics*, Vol. 27(No. 1), pp. 87–98.

Verona, E., & Sachs-Ericsson, N. (2005). The intergenerational transmission of externalizing behaviors in adult participants: the mediating role of childhood abuse. *J Consult Clin Psychol*, 73(6), 1135-1145.