TESTING MEASUREMENT INVARIANCE ACROSS SES GROUPS: APPLICATION IN THE BANDUNG FAMILY RELATION TEST

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Abstract: Adolescents from families of 3 different SES groups (Low, Medium and High) have scored their Mother and Father using the format of the Bandung Family Relations Test (BFRT). The sample consisted of 349 pupils from primary and secondary schools in Bandung (Indonesia) selected by a stratified cluster design. In order to find out whether the model of the test was invariant across SES groups, a multi group confirmatory factor analysis, by means of Structural Equation Modelling (SEM) has been conducted. We found with regard to the scoring of the relationship with Mother that only one dimension (Affection) had a significant difference across SES in the comparison of Low and High SES groups. With regard to Father there were two Dimensions significantly different: Vulnerability in the comparison of Medium and High SES groups, while the Dimension of Justice gave very significant differences in all

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three pairs. We finish with a description of the items involved in the significant different comparisons and the interpretation of the consequences of the different scoring of these items.

Keywords: Bandung family relations test (BFRT); social economic strata (SES); multi-group CFA; measurement invariance.

2010 AMS Subject Classification: 93A30.

1. INTRODUCTION

Padjadjaran University, Bandung (Indonesia) and Radboud University, Nijmegen (the Netherlands) to repeat the research and construct The Bandung Family Relation Test (BFRT). This test is designed to obtain information on how both children and parents experience their relations in the family [1]. The validation research is limited to children from 9-12 years old. [2]. We used the stratified cluster sample as developed by [3] in order to give every child in Bandung the chance to take part in the research.

In developing the BFRT we used the same theoretical background as we did developing the NGT. The NGT Dimensions described the relations in the family in their different aspects. The Dutch authors followed the ideas of Ivan Boszormenyi-Nagy who is the author of the paradigm changing book "Invisible Loyalties (1984)" and Stierlin's concept of Binding, that he explained in "Delegation and Family (1978)". For Binding, we operationalised two dimensions: Restrictiveness and Affection. Inspired by Boszormenyi-Nagy's Loyalty concept, we created four Dimensions: Vulnerability, Justice, Acknowledgment and Trust [2], [4], [5].

Indonesian society is, as any society, socio-economically layered. Compared with European societies the differences in socio economic strata (SES) in Indonesia are much larger than for example in the Netherlands where the original test has been constructed [4]. For the research in Indonesia we discerned a high class with a consumption culture typical for the globalized world. Then there is an extensive medium class which is still growing and a low class partly living on the edge of poverty. Representatives of all these layers are in our sample. In the research, we interviewed separate from each other, the parents. We obtained information from them

among other subjects about their education and profession. With the help of these indicator we constructed the three classes of SES. To understand the differences between the three Classes as related to the six Dimensions, we decided to use Multi-Group Analysis by means of Confirmatory Factor Analysis (CFA) [6]–[9]. With this method, we could check our principal research question: whether the model for each of the six Dimensions mentioned above, is invariant across the three SES groups. The research question we divided in four objectives:

(1) to know whether the six Dimensions as rated by the children about mother and about father have a factorial invariance across SES groups;

(2) after we know that some Dimensions are non-invariant across SES, we have to find out in which pair of SES groups (Low-Medium, Low-High and Medium-High) the significant difference(s) exist(s);

(3) we have to discern those items that cause differences within each of the Dimensions and pairs of groups involved;

(4) knowing those Dimensions, the pairs of groups and the items that show non-invariance we try to formulate the psychological differences between the classes in the children's experiences of their fathers and mothers. Here we want to remark here that the results from a test taken with a child gives information on how to start possible therapeutic treatment. The statistical overview helps to understand the interpretation of the test results

2. METHODS

Confirmatory factor analysis is one of the multivariate analysis methods that can be used to test or confirm a hypothesized model [10]–[12] The hypothesized model consists of one or more latent variables, which are measured by one or more latent variables [6], [7]. The terminology of the confirmatory factor analysis can be explained in the equation below [13]–[17]

$$x_1 = \lambda_{11}\xi_1 + \delta_1$$
$$x_2 = \lambda_{21}\xi_1 + \delta_2$$

$$\vdots$$

$$x_p = \lambda_{pm}\xi_1 + \delta_p$$

(1)

Equation 1 can be written as follows:

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_p \end{bmatrix} = \begin{bmatrix} \lambda_{11} & \lambda_{12} & \cdots & \lambda_{1m} \\ \lambda_{21} & \lambda_{22} & \cdots & \lambda_{2m} \\ \vdots & \vdots & \cdots & \vdots \\ \lambda_{p1} & \lambda_{p2} & \cdots & \lambda_{pm} \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \vdots \\ \xi_m \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \vdots \\ \delta_p \end{bmatrix}$$

(2)

λ_{ij} is a loading factor of the i-th indicator and the factor j-th, ξ_j is a vector for the j-th latent variables, δ_i vector for error measurement for i-indicator and $i = 1, \dots, p$ and $j = 1, \dots, m$. At the same time, p shows the number of indicators and m number of latent factors or latent variables. So that when a confirmatory factor analysis model is expressed in the form of a matrix it is possible to obtain the following equation:

$$x = \Lambda_x\xi + \delta$$

(3)

x is a vector for variable indicator sizes $p \times 1$. Λ_x represents as matrix for loading factors λ with size $p \times m$ which is the coefficient that shows the relationship x and ξ. While ξ is a vector for latent-sized variables $m \times 1$ and δ vector for size measurement error $p \times 1$. The loading factor value is obtained from the indicator expectations x_j with latent variables ξ which can be explained as follows :

$$E(x_j\xi) = E[(\lambda_j\xi + \delta_j)\xi]$$

$$E(x_j\xi) = \lambda_j E(\xi^2) + E(\xi\delta_j)$$

$$E(x_j\xi) = \lambda_j$$

(4)

After get the loading factor value, then the biggest loading factor value will be observed to find out which indicator has the biggest contribution in forming latent variables [18]; [19]; [20]. To measure the accuracy of the model in producing observable covariance matrices can use the

Goodnes Fit Index (GIF) [21], [22]

$$GFI = 1 - \frac{tr\left[(\widehat{\boldsymbol{\Sigma}}^{-1}\boldsymbol{S} - \boldsymbol{I})^2\right]}{tr\left[(\widehat{\boldsymbol{\Sigma}}^{-1}\boldsymbol{S})^2\right]}$$

Also, $\widehat{\boldsymbol{\Sigma}}$ represents model covariance matrix, $\boldsymbol{S}$ covariance matrix of observed data, and $\boldsymbol{I}$ identity matrix. However, GFI values have a range of values ranging from 0 (poor fit) to 1 (perfect fit). GFI value $\geq$ 0.90 indicates the model has a good match [23]–[27].

Dimensions

The test comprehends 6 Dimensions, two Dimensions belong, as said before, to the Binding concept: Restrictiveness (R) and Affection (AB); and four Dimensions belong to the Loyalty concept: Vulnerability (VU), Justice (JU), Acknowledgement (AC) and Trust (TR).

Below a description of those Dimensions:

Restrictiveness (11 items):

Restrictiveness expresses the degree to which the child experiences its father and mother as normative. High scores indicate that the child sees the parent as a person with much authority: the child might not feel free. An example of the items belonging to this Dimension is: "*I feel uncertain with this person*"(This person can be father or mother or even another relevant person in the child's life.)

Affection (11 items):

The child indicates to what level the parent and child have an intimate relationship and/or the need to have such a relationship. Bodily closeness is the primary way to develop intimacy. A high score means that the child and the parent experience this way of relating with satisfaction. A low score means that there is a distant, non-bodily relationship. Example: "*I like it when I can cosily sit near this person.*"

Vulnerability (9 items):

Vulnerability is the recognition of and expression of empathy with the feelings of pain, loneliness and sorrow between the family members. High scores on this Dimension implies that the child has much compassion with father or mother or other family members and vice versa.

Example: "*I am eager to solve this person's problems.*"

Justice (12 items):

Justice measures the experience of the child of the balance or imbalance between give and take in relation with father and mother. A high score refers to the opinion of the child that the parent does much for him or her and that he or she likes to do something in return. Example: "*This person remains unsatisfied with me no matter what I do.*"

Acknowledgement (12 items):

On this Dimension the child expresses whether it experiences that the parent values its presence and behaviour. With a high score the child says that he or she feels that his or her way of doing has been explicitly affirmed by the parent. A low score indicates the child's feeling of not to be really important in the relationship with the parent. Example: "*This person feels happy because of me.*"

Trust (12 items):

Trust measures to what extent the child sees the parent as reliable, to which degree the experiences of the child and the parents are similar, how much support the child expects from the parents and whether the child experiences much togetherness with the parents. Example: "*When I worry about something I will go to this person*".

3. DATA

The sampling design used in the research for the construction of the BFRT was a stratified cluster sample of pupils. We took the sampling design dealt with in detail in the Progress in International Reading Literacy Study (PIRLS) by Foy and Joncas (2000). The BFRT is constructed for children aged 9-12. Most of these children go to school and belong to grades 5 or 6 of primary school (Sekolah Dasar, SD;(Bahasa Indonesia: BI.) or grade 1 of junior high school (Sekolah Menengah Pertama, SMP, BI). This being the designated age-group, it was decided to collect the data from these three grades in the two school types mentioned.

It should be kept in mind, however, that some difference exists between the target population (all children in Bandung aged 9-12) and the sampled population in the two school types. Typically, some of the children in the target population are in fact not going to school, because they are busy earning a living for themselves and their family, while some stay at home because their parents cannot afford the extra costs of going to school, and others again would simply be

characterized as street children. Comparing the total number of pupils according the figures in [28] the difference between the target and the sample population is about 20% [2]. Our sample consisted of 349 pupils (the Low SES group has 77 pupils, the Medium SES group has 209 pupils and the High SES group has 63 pupils). The BFRT material consists of two sets of 67 items, each written on 67 cards, one set is for the relationship with father, the other with mother. The number of items was partly based on the time the test takes and the potential loss of concentration of the children. The items have the same content in relation to father and mother. There are two boxes with each five drawers, in which the children have to put the cards with the items. The drawers are named in Bahasa Indonesia: *"ya-ya" ("yes-yes"), "ya" ("yes"), "0", "tidak" ("no"), "tidak-tidak" ("no-no").* Regarding all reliability measurements, the 67 items test has moderate to high reliability. Justice has moderate reliability and especially Affection and Acknowledgement have high reliability.

4. ANALYSIS

Confirmatory Factor Analysis (CFA) is one of the most widely used methods to test for measurement invariance. CFA is a model testing technique in which a theoretical model is compared with the observed data structure in a sample [29] ; [30]. In CFA, especially in Structural Equation Modeling (SEM), latent variables are represented with circles and measured variables are represented with squares. Lines with an arrow in one direction show a hypothesized direct relationship between two variables. It should originate at the causal variable and point to the variable that is caused. Absence of a line indicates there is no causal relationship between the variables. Lines with an arrow in both directions should be curved and this demonstrates a bidirectional relationship (i.e., a covariance). Covariance arrows should only be allowed for exogenous variables. For every endogenous variable, a residual term should be added to the model. In research of comparing samples whether there they have measurement invariance, one can use Multi-Group Confirmatory Factor Analysis (MGCFA). Using MGCFA, the theoretical model is compared with the observed structure of two or more samples. The idea of [30]; [27] about the assessment of comparability of factor structures is typical for the test measurement invariance. Nested models that are organized in a hierarchical ordering with decreasing numbers of parameters or increasing degrees of freedom, entail adding parameter constraint on at a time.
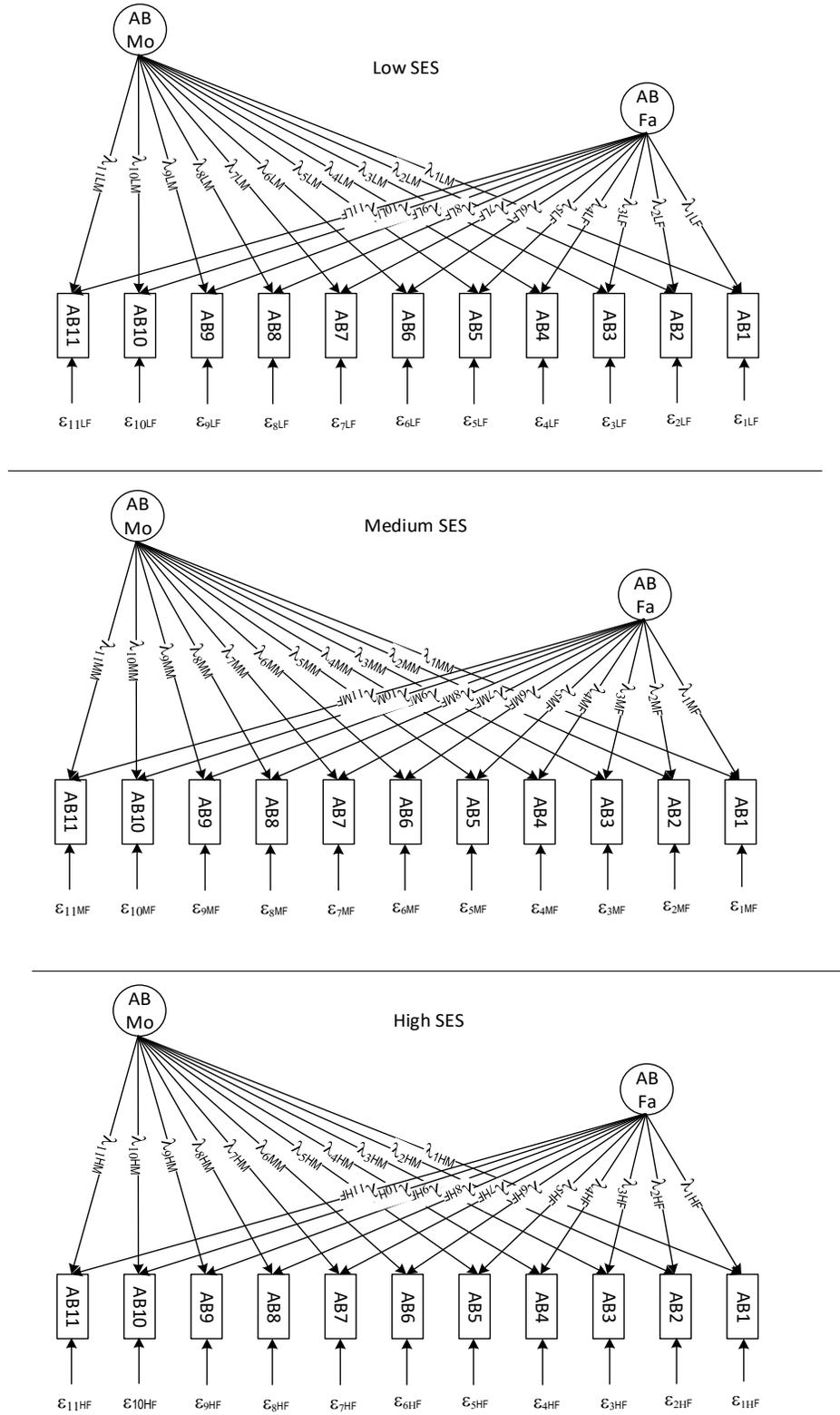
Figure 1. Path Diagram of Affection for the three SES Groups (AB= Affection; Mo=Mother; Fa=Father; λ=loading factor; ε=residual)

Figure 1 shows the example of three path diagrams of the Dimension Affection, with the 11 items that we compare. The comparisons we do is whether Affection as rated by the children across the three SES groups is variant or invariant. We have to find out in which pair of the SES groups we have to look for the items which cause differences. Using the Fit Model technic we have to know the Likelihood-Ratio (LR) test, also known as the chi-square difference test [22], [31], [32]. The chi-square difference ($\Delta\chi^2$) is calculated where χ_c^2 is the value for the constrained model and χ_{uc}^2 is the value for the unconstrained (or less constrained) respectively [33]. Significance is evaluated with Δdf degrees of freedom. The LR test, like the usual chi-square test, is a null-hypothesis significance test for a difference between the two groups. If there is no difference in fit, that is, $\Delta\chi^2 = 0$.

4. RESULTS

As we noted above, Indonesian society has gone through rapid changes. The traditional society of the 50's and 60's of the last century is now, especially in the cities not present anymore. The population of Bandung was 511.000 in 1950, 902.000 in 1960 and 3.409.000 in 2000. Economy has been booming, especially for the middle and high classes. Doing our research about families and SES we have to look at the differences between the several classes and also for the impact on the family relations: between mother and child, father and child. BFRT gives a very clear picture of the relations within the family. With the MGCFA technique we can see whether some aspects of the family relationships are significant different between the classes. In the report on the results we follow our four objectives:

Objective 1:

We see in **Table 1** that the relationship between mother and the children is very significantly different concerning Affection. Then with regard to father, we see that two dimensions are significantly different: Vulnerability and Justice. It means, that the relationship between child and mother in Affection and between child and father in Vulnerability and Justice have significant differences between two, or between the three SES classes.

Table 1. Testing differences between 6 dimensions

No	Dimension	Mother			Father		
		$\Delta\chi^2$	Δdf	P-Value	$\Delta\chi^2$	Δdf	P-Value
1	Restrictiveness	16,75	22	0,7770	14,23	22	0,8931
2	Affection	56,89	22	0,0001	20,58	22	0,5468
3	Vulnerability	13,1	18	0,7856	28,75	18	0,0257
4	Justice	23,31	24	0,5016	457,26	24	0,0000
5	Acknowledgement	29,07	24	0,2175	22,47	24	0,5512
6	Trust	27,16	24	0,2971	17,82	24	0,8117

Looking at the results of Table 1, we have to explore, where precisely the differences are. Starting with Affection (concerning mother), we like to see whether the differences are between Low and Medium SES, Medium and High SES or Low and High SES. For Vulnerability and Justice (concerning father), we have the same question.

Objective 2:

Table 2 shows that the only significant difference relating to mother is between Low and High SES Classes in the scoring of the dimension Affection. Regarding the data about father we see that concerning Vulnerability the significant difference is between the Medium and High class. In the scoring of Justice, all comparisons between the SES Classes are very significant.

Table 2. Testing differences between SES Groups

No	Sub SES	$\Delta\chi^2$	Δdf	P-Value
	Affection (Mother)			
1	Low – High	20,8	11	0,0355
2	Low - Medium	14,54	11	0,2045
3	Medium - High	18,95	11	0,0620
	Vulnerability (Father)			
1	Low – High	6,28	9	0,7116
2	Low - Medium	12,85	9	0,1695
3	Medium - High	17,94	9	0,0217
	Justice (Father)			
1	Low – High	85,48	12	0,0000
2	Low - Medium	152,41	12	0,0000
3	Medium - High	145,61	12	0,0000

Objective 3:

Table 3 shows that only three items in the dimension of Affection are not significantly discriminating between Low and High SES groups. We possibly find an explanation for this in the statistical characteristics of the items and/or in the content of the items. The scores concerning mother by the children of the High SES group have a much higher mean on the other eight items. Regarding item AB_28 (*Usually I wait (impatiently) until this person comes home*), the mean of Low and High SES group is almost the same. Item AB_52 (*I think that this person likes it when I kiss him/her*) is not discriminating: maybe because it has a very unusual habit in Indonesia.Item AB_79 (*When this person has to leave, I do not feel at ease*) has probably a multi-interpretable content: the Indonesian words "*tidak tenang*" that mean something as "not at ease" seem not to be definite enough to be discriminating. Table 4 shows that children of the Medium and High SES groups only differ in scoring item VU_05. Their experiences of "being in trouble and then feeling the sympathizing attitude of father" is different. Medium class fathers have less empathy according to the experience of their children, at least on this item.

Table 3. Testing Differences between Low and High SES in the scoring of Affection Related to Mother at the level of items.

No	Item	$\Delta\chi^2$	Δdf	*P-Value*
1	AB_15	20,26	10	0,0269
2	AB_16	20,67	10	0,0235
3	AB_27	20,68	10	0,0234
4	AB_28	15,82	10	0,1049
5	AB_40	20,91	10	0,0217
6	AB_51	18,55	10	0,0464
7	AB_52	17,02	10	0,0739
8	AB_67	20,63	10	0,0238
9	AB_68	20,05	10	0,0288
10	AB_79	16,01	10	0,0993
11	AB_80	18,38	10	0,0489

Table 4. Testing Differences between Medium and High SES in the scoring of Vulnerability related to Father at the level of items.

No	Item	$\Delta\chi^2$	Δdf	P-Value
1	VU_05	17,94	8	0,0217
2	VU_06	9,82	8	0,2779
3	VU_17	7,05	8	0,5312
4	VU_18	13,03	8	0,1108
5	VU_29	13,25	8	0,1035
6	VU_30	13,44	8	0,0976
7	VU_41	7,28	8	0,5067
8	VU_62	13,09	8	0,1088
9	VU_81	9,97	8	0,2671

Table 5. Testing differences between SES in Justice related to Father at the level of items.

No	Item	Low & High SES			Medium & High SES			Low &Medium SES		
		$\Delta\chi^2$	Δdf	Sign	$\Delta\chi^2$	Δdf	Sign	$\Delta\chi^2$	Δdf	Sign
1	JU_11	69,3	11	0,000	50,46	11	0,000	39,45	11	0,000
2	JU_23	44,25	11	0,000	51,79	11	0,000	42,23	11	0,000
3	JU_24	66,55	11	0,000	34,37	11	0,000	48,12	11	0,000
4	JU_35	43,78	11	0,000	51,79	11	0,000	6,99	11	0,799
5	JU_36	79,53	11	0,000	46,71	11	0,000	4,37	11	0,958
6	JU_47	81,03	11	0,000	51,17	11	0,000	37,59	11	0,000
7	JU_59	79,07	11	0,000	49,8	11	0,000	44,97	11	0,000
8	JU_61	82,99	11	0,000	48,17	11	0,000	4,68	11	0,946
9	JU_76	82,02	11	0,000	51,69	11	0,000	42,31	11	0,000
10	JU_82	76,92	11	0,000	43,93	11	0,000	48,57	11	0,000
11	JU_87	45,98	11	0,000	49,39	11	0,000	10,62	11	0,476
12	JU_94	83,78	11	0,000	51,55	11	0,000	47,28	11	0,000

Table 5, as we can see here: all items regarding Justice are significantly different. These significant differences apply to all comparisons of the SES groups. The way children of these three groups (Low, Medium and High SES) experience the "Justice behaviour" of their fathers in Bandung, Indonesia very differently. All three groups of children have a various "Justice concept" in their

mind while judging the behaviour of their fathers. Comparing Low and Medium SES groups, four items are not significantly different and eight items are significant. It would be interesting to know why these four items give no significant differences. When we look at the content and the wording of these four items we think that for children of the Low and Medium SES groups, the items have the same appealing value.

Objective 4:

The MGCFA about the child-mother relation (as seen by the child) learn us that there is one dimension, "Affection", which gives differences between two classes Low and High SES. From the 12 items there are 3 which are invariant. For the child father relation, we find two dimensions: Vulnerablity and Justice with respectively 1 and 12 items that creates the differences. It is typical that in the relation with mother, there are differences on the dimension Affection, after this relation starts with the close-bodily-affective contact.

Vulnerability and Justice are experienced different by the children in the relation with father. Concerning Vulnerability, it happens in 1 item between Medium and High SES. We repeat: fathers in the medium class are experienced a having less empathy than fathers in the High SES. Around Justice the differences are huge, as if every class has his own ideas about Justice. The differences between Low and High SES are maximum, all 12 items are significantly different. The same happens between Medium and High SES. In the comparison between Low and Medium SES, 4 items do not differ significantly. For the interpretation at the psychological level we state: Justice is a complex phenomenon for the children in Bandung. There is apparently no clear interpretation (see discussion).

5. GENERAL DISCUSSION

Since the result above we have to realize that there is a big difference between the attitude of the children toward father and mother. Interesting and practical for the psychologist who "works" with father and mother or with the family or just with one child, we checked the correlation of the responses toward father and mother for the 6 dimensions in the three SES classes. In the Low SES, Restricttiveness, Affection, Vulnerability and a bit less Trust ahow high correlation between father

and mother. All this correlation are higher even sometime much higher than the correlation between father and mother in the medium and in the high SES. Remarkable that Vulnerability has rather constant high correlation for all three classes.

6. CONCLUSION AND LIMITATION

Concerning the first objective, we found that there is only one dimension (Affection) which has a significant difference across SES in regard to the scoring of mother. There are two dimensions (Vulnerability and Justice) which have a significant difference across SES in regard to Father. However, Concerning the second objective, we found that only in the comparison of Low and High SES regarding Affection a significant difference relating to the scoring of mother. In the context of father the Vulnerability dimension appears to be significantly different only in the comparison of Medium and High SES groups.

But for Justice we found that all the pairs we compared gave very significant differences. Concerning the third objective we make a more general statement: the children's experience of their mothers is on Affection dimension significantly different on 8 items (comparing Low and High SES). The children's experience of their father is strikingly different on all Justice items (comparing both Low and High SES groups and Medium and High SES groups). On eight items we compared the Low and Medium groups with the same result.   The same applies to the item of Vulnerability (while comparing Medium and High SES groups).Lastly, Concerning the fourth objective, we conclude that the responses about the mother in general are invariants, its only Affection which shows non-invariant. The responses about the father are more complex at the dimension of Justice. All 12 items are nearly in all the three comparisons are significant different. There are jobs that are difficult to score. For insantance when they only answer : official or government official. For cases like this the following rule was determined. In principle we use the rank of educational level of mother or father , unless it is proven that the job belongs to a higher level as shown by the two sub indicators. If those activities indicate a lower level, the educational level will be considered as (still) the primary indicator. In cases where both mother and fatherhave no job, each of them will be scored in accordance to each of their educational levels. Every family

have two sets of data in terms of education and occupancy which is from the mather and from the father. There are families who has only one data set which is from the mather or the father. When there are two set of data, the rule to determine the family SES is as follows: the sum of the two scores should be devided by two to get the average. If the average value is between two absolute values, an absolute value has to be determined based on the principle of rounding off upward or downward. Further research should performing HSEM [24], [34], [35].

DATA AVAILABILITY STATEMENT

The analysis codes used in this paper available from the corresponding author upon reasonable request.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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