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Modelling verbal aggression, physical aggression, and inappropriate sexual behaviour after acquired brain injury

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Abstract

Understanding the underpinnings of behavioural disturbances following brain injury is of considerable importance, but little at present is known about the relationships between different types of behavioural disturbances. Here we take a novel approach to this issue by using confirmatory factor analysis to elucidate the architecture of verbal aggression, physical aggression, and inappropriate sexual behaviour using systematic records made across an 8 week observation period for a large sample (n = 301) of individuals with a range of brain injuries. This approach offers a powerful test of the architecture of these behavioural disturbances by testing the fit between observed behaviours and different theoretical models. We chose models that reflected alternative theoretical perspectives based on generalised disinhibition (Model 1), a difference between aggression and inappropriate sexual behaviour (Model 2), or on the idea that verbal aggression, physical aggression, and inappropriate sexual behaviour reflect broadly distinct but correlated clinical phenomena (Model 3). Model 3 provided the best fit to the data indicating that these behaviours can be viewed as broadly distinct, but with some overlap. These data are important both for developing models concerning the architecture of behaviour as well as for clinical management in individuals with brain injury.

Keywords:

Aggression, inappropriate sexual behaviour, brain injury, confirmatory factor analysis

Introduction

Acts of aggression are of clear social concern, with significant costs existing at both the economic (e.g. legal and prison costs) and the personal (e.g. psychological scarring) level. Accordingly, understanding the underpinnings of aggression is of considerable importance, yet little is known about the relationship between different forms of aggressive and inappropriate behaviours, especially in neuropsychological contexts. Here we take a novel approach to this issue by exploring the architecture of behavioural disturbances in a sample of individuals with brain injury through confirmatory factor analysis. This approach provides a powerful window into the origins of aggression for a number of reasons. First, acts of aggression in this population are often significant in magnitude and frequency, moving our analyses beyond the more commonly reported student or normal population studies of aggression. Second, we were able to utilise a systematic and detailed database of aggressive behaviours recorded as they occurred over an 8 week observation period. Third, we investigated instances of inappropriate sexual behaviours alongside verbal and physical aggression in order to assess their links.

Disorders of behavioural regulation, including verbal aggression, physical aggression, and inappropriate sexual behaviour, are problematic and relatively common sequelae of severe acquired brain injury (1-7). While there have been a number of studies investigating the nature and clinical correlates of aggressive behaviours following brain injury (3, 8-13), only a handful have looked at inappropriate sexual behaviours (7, 9, 16-20). Fewer still have

addressed both aggressive and inappropriate sexual behaviours within the same sample of patients, with mixed results to date concerning the co-occurrence of these behaviours (7, 19, 20). Moreover, our previously reported sample of 152 patients with brain injury (14) documented the only known multivariate analysis of co-occurrence between aggression and inappropriate sexual behaviour. In this study we found statistical distinctions between verbal aggression, physical aggression, and inappropriate sexual behaviour based on principal component analysis.

The limited work to date addressing the architecture of behavioural disturbances following brain injury, alongside the broader benefits that insights into the aetiology of aggression and inappropriate sexual behaviour can bring to theory development, motivated the current study. To this end we sought to examine an independent and larger sample of individuals with brain injury in order to provide a more powerful test of the behavioural structure through confirmatory factor analysis. This approach offers a rigorous and hypothesis-driven examination of the relative merits of a given model of observed behaviour compared to its competitor models, as well as an absolute test of how well the model can explain observed data (15).

The three models we tested were chosen to closely reflect key theoretical perspectives in the field. First, we fitted a model based on the widely used neuropsychological concepts of disinhibition (16) or dysexecutive syndrome (17). According to this perspective, the reason why most of us do not usually show aggressive or inappropriate sexual behaviours in our daily lives is that we are able to exercise a substantial degree of inhibitory control. Brain injury (and especially frontal lobe damage) reduces the degree of

inhibitory control, or makes inhibition more effortful. Based on this line of reasoning instances of verbal aggression, physical aggression, and sexually inappropriate behaviour should covary, as they all reflect a common loss of inhibitory control. Such a model, in its simplest form, would be represented by a single common latent factor loading on each of the indicators of aggression or sexual inappropriateness (see Figure 1a).

Our second model (see Figure 1b) was based on the common sense distinction (evident in the words themselves) of a difference between aggression and inappropriate sexual behaviour. From this perspective, verbal and physical aggression should covary (both are instances of 'aggression', even if one considers that physical aggression is the more severe) but they will be broadly unrelated to inappropriate sexual behaviours (except perhaps where these also involve aggression). Whilst we therefore separated these factors in our second model, we also allowed them to correlate to some degree, in line with work suggesting that they are likely to be at least modestly correlated (14).

Our third theoretical model (see Figure 1c) was derived from these earlier results (14) with principal component analysis of data from a smaller and independent sample of 152 participants, in which we noted distinctions between verbal aggression, physical aggression, and inappropriate sexual behaviour following acquired brain injury that were interpreted to reflect broadly distinct but correlated clinical phenomena.

The Current Study

To test these competing models we were fortunate to be able to draw on a large database of systematically recorded instances of verbal aggression, physical aggression, and inappropriate sexual behaviour exhibited by 301 participants with severe acquired brain injury. The participants had been admitted consecutively to a number of specialist neurobehavioural rehabilitation centres across the UK. All incidents of these behaviours over an 8-week assessment period were recorded as they occurred by trained rehabilitation staff via specifically-designed psychometric observational scales. This approach is a substantial advance over many other studies investigating such behavioural disorders after brain injury, which are typically forced to rely on judgments by health professionals (11, 18) and/or patients' families (3, 10, 13) that are often made some time after the incidents in question. This introduces potential unwanted error arising from memory biases and distortions and therefore represents a major limitation to such studies. Frequency of occurrence and co-occurrence of different behaviours may be underestimated, overestimated or missed altogether without a contemporaneous method of recording (19). Systematic contemporaneous recordings of the type we were able to use therefore constitute a gold standard for this type of study.

The participants we studied had a number of different types of precipitating brain injuries, and had been referred for residential assessment for a variety of reasons that all centred on the likelihood of significant neuropsychological sequelae. They can therefore be considered to represent the full range of types of impairment that might affect behavioural regulation. Using the systematic records of observed behaviour, we sought to test which

of these three major competing theoretical models detailed above best fitted the patterns of disordered behaviour that were observed. In line with previous work indicating that aggression contains both distinct and overlapping components we predicted that a model characterised by such features (i.e. Model 3) would provide the best fit to the data.

----- Insert Figure 1 about here -----

Method

Participants

Three hundred and one participants were recruited from a total pool of admissions to seven organisational residential rehabilitation programmes across the UK during the period January 2010 to June 2012. Two of the programmes specialised in challenging behaviour while the remaining five were classed as community re-integration (although one programme within a local hospital ward was also considered sub-acute rather than post-acute). Participants were included if they had completed at least 9 weeks of residential neurobehavioural assessment, which included continuous behavioural observation and recording.

Two hundred and thirty-five (78%) of the participants were male and 66 female. Age at admission, which was normally distributed, ranged from 16 to 76 years, with mean of 42.7 years and standard deviation of 14.6 years. Years of formal education ranged from 6 to 18, which was positively skewed

and leptokurtic, with a median value of 10 years. The majority of the sample (93%) was identified as predominantly right-handed prior to their injury/illness.

Data regarding severity of injury were incomplete but indicative of predominantly severe injuries. This is consistent with previous clinical research (20, 21) in similar post-acute brain injury rehabilitation programmes and with our previously reported sample (14). The most common diagnosis was traumatic brain injury (56%), followed by cerebro-vascular accidents (22%) and cerebral anoxia (11%). Other types of injuries or illnesses made up 11% of the sample and included infectious diseases (n = 16), cerebral tumour (n = 6) and alcohol-related brain damage (n = 4).

The age at which the participants acquired their brain injuries or illnesses ranged from 1 to 75 years and was normally distributed, with mean age 39.7 years and standard deviation 16.8 years. The time between injury/illness and admission to the rehabilitation programme ranged from 1 month to 636 months. These post-injury admission intervals were not normally distributed, being positively skewed and leptokurtic with a median chronicity of 5.9 months.

Measures

Data were recorded across a continuous 9-week observation period used as part of the assessment of each patient in the hospital rehabilitation setting. To allow participants time to establish some kind of routine, data from the first week of observation were not analysed, leaving records across an 8-week period for each of 301 participants. During this time, all instances of physical aggression, verbal aggression, and inappropriate sexual

inappropriate behaviours were recorded by trained staff immediately after they were observed.

Aggressive behaviour was coded according to the Brain Injury Rehabilitation Trust (BIRT) Aggression Rating Scale (BARS), which has demonstrated good inter-rater reliability (22). The BARS codes aggression into six categories reflecting the nature (verbal or physical) and severity (1, 2, or 3) of each episode. Incidents of verbal aggression are scored as V1 for non-directed, V2 for directed at another person or V3 for verbal threats. Similarly, incidents of physical aggression are scored as P1 for non-directed, P2 for damage to property and P3 for violence towards another person or one's self.

Episodes of inappropriate sexual behaviour were recorded by staff with the St Andrews Sexual Behaviour Assessment – SASBA (23). This scale consists of four categories of behaviour (Verbal Comments, VC; Non-Contact, NC; Exposure, E; and Touching Others, TO) with four severity levels within each category. This produces a matrix of 16 specific behaviour codes for inappropriate sexual behaviour. Examples of behaviours categorised using this system include: comments made directly to another person about their genitals (VC3), beginning to masturbate in own bedroom without exposing genitals when staff are present (NC3), intentionally exposing genitals to another person (E3), touching another person's buttocks (TO3)

Participants' behaviours were observed for the eight weeks of assessment in order to obtain a baseline from which later clinical decisions could be taken. For each participant, total frequencies of recorded incidents across the assessment period were obtained for each of these 22 raw

behavioural variables, 6 of which came from the BARS (verbal aggression V1, V2, V3; physical aggression P1, P2, P3) and 16 from the SASBA (verbal comments VC1, VC2, VC3, VC4; non-contact NC1, NC2, NC3, NC4; exposure E1, E2, E3, E4; touching others TO1, TO2, TO3, TO4). However, as in our previous study (James & Young, 2013), each behavioural variable had a highly non-normal distribution with an excess of zero counts. This was particularly the case for most of the SASBA codes. In consequence, we summed the SASBA data into the four categorical codes of verbal comments (VC), non-contact (NC), exposure (E), and touching others (TO).

Analysis

All confirmatory factor models were fitted in R 3.1.2 (24) using mirt 1.8 (25). We used the Metropolis-Hastings Robbins-Monro hybrid algorithm for estimation (26). To assess model fit we used the Baysian Information Criterion – (BIC: (27), where lower values indicate more parsimonious fit in model comparisons), the root mean squared error of approximation (RMSEA: excellent fit < .05) and the comparative fit index (CFI: excellent fit > .95).

Results

Ranges for all measures are available in Table 1. In brief, we observed substantial variability across each of the measures, but with many scores at zero or slightly above (median/mode = 0) for all variables.

----- Insert Table 1 about here -----

Model Fitting

As detailed above, we tested a series of competing models (see Figures 1 and 2). Model 1 was a common factor model with a single latent factor loading on all of the indicators. Model 2 contained two correlated common factors: the first for physical and verbal aggression and the second for inappropriate sexual behaviour items. Model 3, our hypothesized model, contained three correlated latent factors, with these factors loading on the verbal aggression, physical aggression, and inappropriate sexual behaviour indicators, respectively.

Due to the non-normality of the data we adopted a categorical approach based on multidimensional item response theory (28) to fit our theoretical models. The data were extremely right-skewed and each item of the coding system had disproportionately many zero values. Although alternative possibilities were considered (see Discussion), this categorical approach has at least two key advantages: (1) categorisation makes it possible to deal with both zero-inflated and right-skewed data; (2) categorising and then analysing the data based on polychoric correlations neither assumes that the categories are equidistant nor that the indicators are linearly related (29), which allows for a better representation of data in the model. As such, the data were re-coded into four categories: 0 instances of aggression/inappropriate sexual behaviour over the 8 weeks = 0; 1 = 1; 2 to 4 = 2; 5 and above = 3. This coding scheme was deemed appropriate since it ensured for all recoded variables at least 10 responses per category (only for item 8 this was not possible).

Model output is detailed in Table 2. Model 3 was the best fitting model among the competing models and also provided an excellent absolute fit to the data. All paths and inter-factor correlations were significant (< .01). The final model (Model 3) is presented in Figure 2.

----- Insert Tables 2 and 3 about here -----

----- Insert Figure 2 about here -----

To facilitate clinical interpretation we conducted a complementary analysis assessing the probability of displaying a given behaviour based on another one having been reported. These results are detailed in Table 3. In short these observations further illustrate how strong is the differentiation in our sample between participants that show behavioural disturbance and those that do not. As soon as any aggressive or sexually inappropriate behaviour is recorded for a given patient, there is a probability of between .40 and .64 that any other aggressive or sexually inappropriate behaviour will be observed as well. Columns four to six of table 3 provide information on the predictive power of the individual behaviours. Participants showing physical aggression and inappropriate sexual behaviour are very likely to also show verbal aggression (all P(verb+|1) > .50). The probabilities for the other two are markedly lower; inappropriate sexual behaviour is particularly difficult to predict from verbal and physical aggression.

Discussion

The current study sought to test the factor structure of aggressive and inappropriate sexual behaviours in a clinical sample. A model based on considering physical aggressiveness, verbal aggressiveness and sexually inappropriate behaviours as reflecting broadly distinct but correlated clinical phenomena (Model 3) offered the best comparative fit to the data. Moreover, this model also provided a good absolute fit to the data. These results, then, indicate that these behaviours can be considered as distinct clinical phenomena, although fairly substantial overlap is also apparent as demonstrated by the sizeable inter-factor correlations. These findings suggest that concepts of overall disinhibition or dysexecutive deficits may still be appropriate, although it is clear that they are unable alone to provide a full explanation of the covariation across these forms of aggressive and sexually-inappropriate behaviour.

Importantly, this model was derived from our earlier results with principal component analysis of a smaller independent sample of 152 brain-injured participants (14). The confirmatory factor analysis of a larger sample of 301 participants presented here therefore offers strong convergent evidence of the model's validity. In addition, the present study was able to draw on a more sophisticated measure of sexually inappropriate behaviours (the SASBA) than had been available in the prior study (20).

Some discussion is required with regards to our analytical approach in light of the highly non-normal distribution of the data. We opted to use a categorical analysis approach; however, we also considered alternative approaches, including applying different transformations of the original count data (logarithm, square-root) or the exclusion of outliers (based on

Mahalanobis distances; (30)). While results differed in detail across these transformations of the data, overall three factors always fitted the data better than two-factor solutions. In contrast to our categorical analysis, however, none of these approaches produced a satisfying level of absolute fit for any of our theoretical models. The purpose of these transformations was to try to accommodate the severe non-normality of the data, but it turned out that even transformations of this kind were insufficient to normalise the data. As a consequence, absolute fit indices – which are heavily dependent on normality and linearity of the observed variables – will be negatively impacted, even when an appropriate model is examined. As such this further confirms the value of the categorical approach adopted here, which is free of these assumptions (29).

As well as their implications for modelling and understanding what are usually considered challenging behaviours, the findings have two substantial clinical implications. First, these results provide support for assessing and formulating these behaviours separately within the context of behavioural management in individuals with acquired brain injury. This is consistent with previously reported analyses (7, 31) showing differing maintaining factors and environmental triggers for aggression and inappropriate sexual behaviour after brain injury. A recent intervention case study (32) also documented the specificity of treatment effects for inappropriate sexual behaviour in a young man following severe traumatic brain injury.

Second, the results of our complementary analyses presented in Table 3 provide information concerning the relative risk of individuals demonstrating other forms of behavioural disturbance when some disturbance has already

been observed. This will be of considerable use to clinicians undertaking risk assessments for admission of individuals with challenging behaviour into residential facilities. For example, individuals demonstrating verbal aggression have a relatively low likelihood of also exhibiting physical aggression or inappropriate sexual behaviour. Conversely, individuals demonstrating physical aggression are likely to also exhibit verbal aggression but not inappropriate sexual behaviour. For those individuals displaying inappropriate sexual behaviour, there is also a relatively high risk of exhibiting verbal aggression. The risk of also exhibiting physical aggression is lower, although it becomes higher with the more severe forms of observed inappropriate sexual behaviour. Specifically, the risk of any physical aggression with the lowest level of inappropriate sexual behaviour (through verbal comments) is relatively low (0.29) but steadily increases with the severity of inappropriate sexual behaviour, so that physical aggression in the context of sexually inappropriately touching others becomes more likely than not (0.52).

In summary, here we find evidence for dissociable yet correlated components of verbal aggression, physical aggression, and inappropriate sexual behaviours using systematic records made across an 8 week observation period for a large clinical sample of adults with severe brain injuries. Complementary analyses demonstrated that, when a particular behaviour had been observed, the probability of another form of aggressive or inappropriate sexual behaviour occurring was high (between .40 & .64).

Ethics. Ethics approval for this study was granted by the University of York and The Disabilities Trust. As this was an archival study of routine clinical data, participants were not required to provide informed consent.

Data accessibility. Raw and categorised behavioural data can be found here…

Competing interests. We have no competing interests.

Authors' contributions. AJ conceived of the study, collected the behavioural data; JB conducted the statistical analyses; AY coordinated the study; GL participated in the statistical analyses. All authors helped draft the manuscript and gave final approval for publication.

Table 1. Descriptive statistics from the sample for indices of aggression from BARS (verbal aggression V1, V2, V3; physical aggression P1, P2, P3) and sexually inappropriate behaviours from SASBA (verbal comments VC; non-contact NC; exposure E; touching others TO).

Measure	Range	Mean
V1	0-1042	8.91
V2	0-348	7.73
V3	0-1036	9.95
P1	0-268	3.59
P2	0-147	.92
P3	0-1219	12.26
VC	0-780	6.67
NC	0-227	1.81
E	0-118	.62
TO	0-467	3.06

Note. For all variables: Median = Mode = 0

Table 2. Fit statistics for theoretical models

Model	Log-Likelihood	n(P)	BIC	RMSEA	TLI	CFI
1	-1873	40	3973	.112	.815	.889
2	-1813	41	3861	.045	.970	.983
3	**-1804**	**43**	**3853**	**.00**	**1.0**	**1.0**

Note. Bold = best fitting model; CFI = comparative fit index; TLI = Tucker-Lewis index; n(P) = number of parameters; RMSEA = root mean squared error of approximation.

Table 3. Probability of observing aggression or inappropriate sexual inappropriate behaviour in the absence/presence of other forms of aggression or inappropriate sexual behaviour.

Variable	P(+|0)	P(+|1)	P(VA+|1)	P(PA+|1)	P(ISB+|1)
V1	0.09	0.40	--	0.23	0.16
V2	0.07	0.41	--	0.21	0.22
V3	0.13	0.49	--	0.31	0.21
P1	0.14	0.53	0.74	--	0.19
P2	0.22	0.63	0.77	--	0.27
P3	0.14	0.51	0.67	--	0.25
VC	0.16	0.49	0.56	0.29	--
NC	0.21	0.62	0.70	0.42	--
E	0.25	0.64	0.81	0.48	--
TO	0.19	0.60	0.78	0.52	--

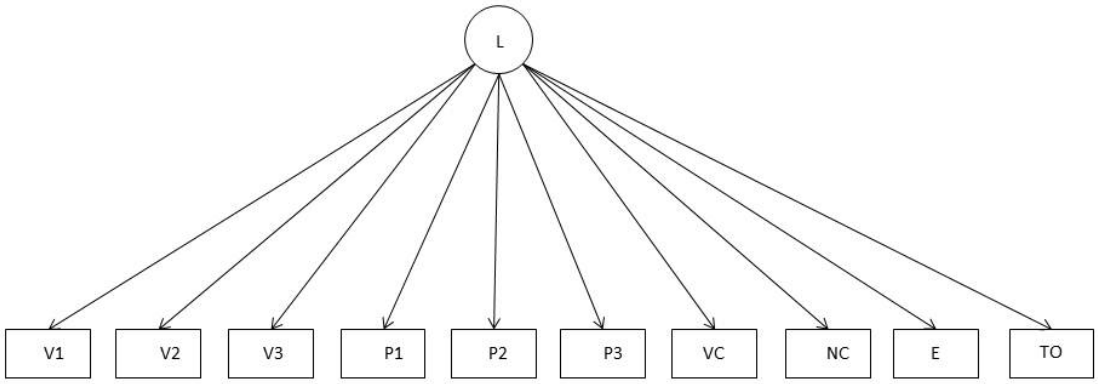
Note. P(+|0) = the probability of at least one incident of aggressive or sexually inappropriate behaviour if no incidents are reported for the variable in question; P(+|1) = the probability of at least one incident of aggressive or sexually inappropriate behaviour if one or more incidents are reported for the

variable in question; P(VA+|1) = the probability of at least one incident of verbal aggressive behaviour if one or more incidents are reported for the variable in question; P(PA+|1) = the probability of at least one incident of physical aggressive behaviour if one or more incidents are reported for the variable in question; P(ISB+|1) = the probability of at least one incident of sexually inappropriate behaviour if one or more incidents are reported for the variable in question.

Figure 1. Graphical representation of Models 1, 2, and 3

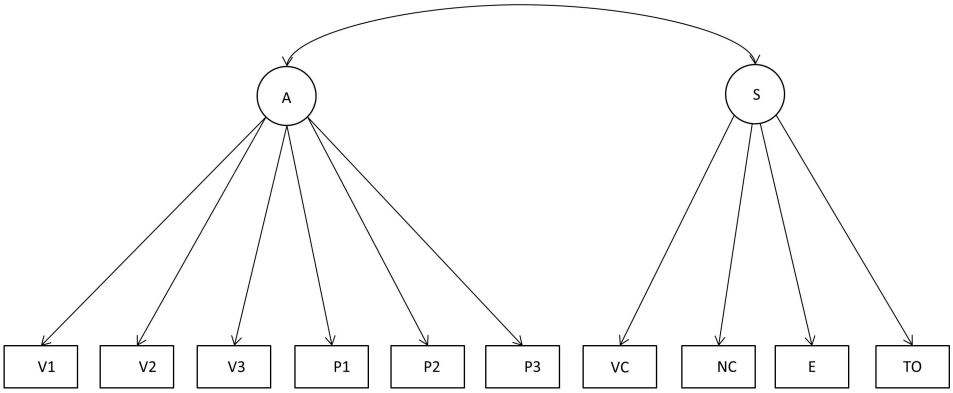
a)

Model 1. Single common factor model in which indices of verbal aggression (V1, V2, V3) physical aggression (P1, P2, P3) and inappropriate sexual behaviours (verbal comments VC, non-contact NC, exposure E, touching others TO) are all related to a common latent variable (L), as might be expected from concepts such as disinhibition or dysexecutive syndrome.



b)

Model 2. Two distinct but correlated factors model based on an aggression (A) factor (verbal aggression V1, V2, V3; physical aggression P1, P2, P3) and a second inappropriate sexual behaviour (S) factor (verbal comments VC, non-contact NC, exposure E, touching others TO).


A
S
V1
V2
V3
P1
P2
P3
VC
NC
E
TO

c)

Model 3. Three distinct but correlated factors model based on a verbal aggression (V) factor (V1, V2, V3), a physical aggression (P) factor (P1, P2, P3), and an inappropriate sexual behaviour (S) factor (verbal comments VC, non-contact NC, exposure E, touching others TO).

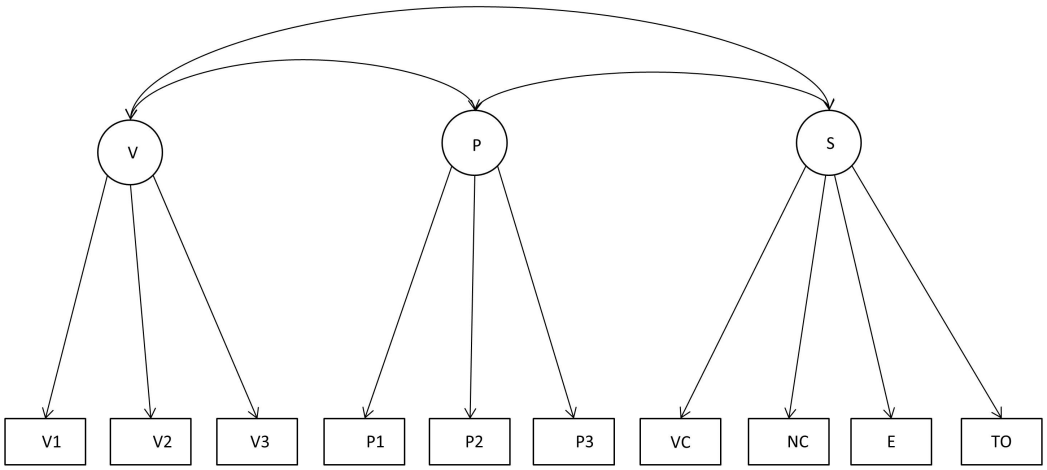
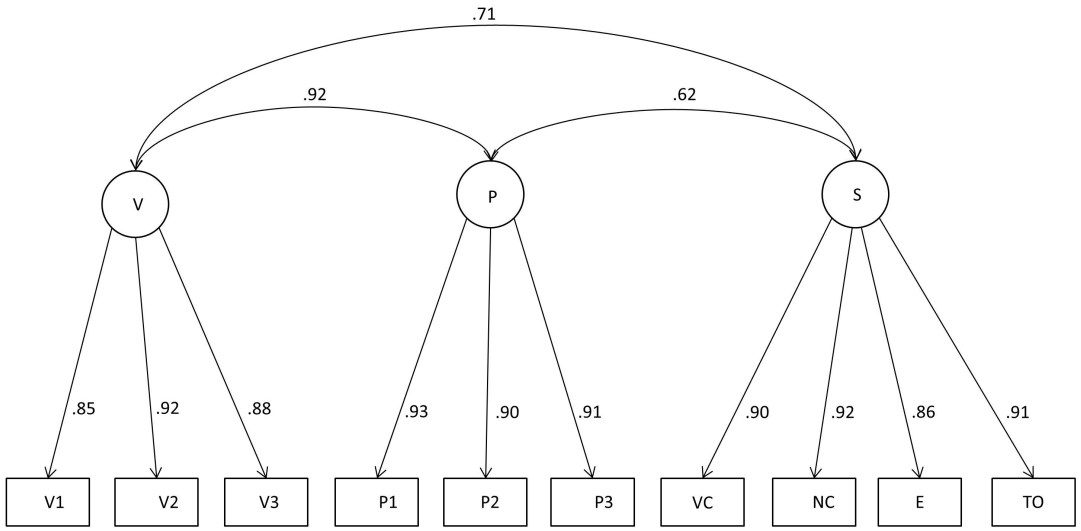


Figure 2. Final best fitting model (Model 3) based on an inter-correlated verbal aggression (V) factor (V1, V2, V3), a physical aggression (P) factor (P1, P2, P3), and an inappropriate sexual behaviour (S) factor (verbal comments VC, non-contact NC, exposure E, touching others TO).



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