Abstract

Background

Risk factors for poor school functioning rarely occur in isolation, but instead are likely to cluster together. As they accumulate, cumulative risk theory (CRT) predicts that the likelihood of negative outcomes increases, often disproportionately.

Aims

We build upon and extend previous research by (i) examining two critical aspects of school functioning (reading attainment and behavioural difficulties); (ii) utilising a large number of candidate risk factors across multiple ecological domains; (iii) testing the two core assumptions of CRT and, (iv) formally examining the functional form of the risk-outcome relationships.

Sample

Participants were N=3084 children aged 6-7 attending 77 mainstream primary schools in England.

Methods

16 candidate risk factors (e.g. familial poverty) were modelled using data from the National Pupil Database. Reading attainment and behavioural difficulties data were generated via teachers' reading assessment scores and the Teacher Observation of Children's Adaptation Checklist (disruptive behaviour subscale) respectively. A cumulative risk score was generated for each pupil. Multi-level modelling was utilised for analysis.

Results

Six risk factors were identified for behaviour, and seven for reading attainment. A cumulative risk effect was found for both outcomes, and the two core assumptions of CRT were supported. Quadratic relationships were found for both aspects of school functioning, indicative of a threshold effect.

Conclusions

As the number of risk factors increases, difficulties in school functioning increase disproportionately. Consistent with CRT, our results suggest that the number of risks is more important than their nature. This has implications for future risk research and the implementation of school-based interventions.

More than the sum of its parts: Cumulative risk effects on school functioning in middle childhood

School functioning refers to a "wide range of factors including school attendance, academic achievement and social relationships" (Dick & Riddell, 2010, p. 238). This definition has been expanded to include behavioural factors such as focused attention on the teacher (Meijer, Habekothe, & Van Den Wittenboer, 2000) and the absence of frequent discipline problems (Attar-Schwartz, 2009). In the current study, two important aspects of school functioning are considered: academic attainment (specifically reading attainment) and disruptive behaviour. More specifically, the research reported herein uses cumulative risk theory (CRT; Rutter, 1979) to advance knowledge and understanding of the factors and processes that underpin poor outcomes in these two domains.

Factors that predict negative outcomes in a given developmental domain are referred to as "risk factors". A range of risk factors for poor school functioning in academic and behavioural domains have been identified at individual, family and community levels, including being male, experiencing poor relationships with peers, family and/or teachers, exposure to poverty, parental mental health difficulties and low education level, and high neighbourhood deprivation (Deater-Deckard, Dodge, Bates, & Pettit, 1998). Although less research has been conducted on school-level risk factors, children attending larger schools, situated in urban areas, with low average socio-economic status have been found to be significantly more likely to experience academic and behavioural difficulties (Huffman, Mehlinger, & Kerivan, 2000).

While much risk research has explored these factors individually, in reality they rarely occur in isolation; instead, they cluster together and are not independent of one another (Flouri & Kallis, 2007). Researching the effects of individual risk factors does not account for the complex and interactional relationships between them (Gerard & Buehler, 1999), meaning that the importance of a single variable can be over-estimated (Sameroff, Gutman, & Peck, 2003). For example, children growing up in poor communities are much more likely to be exposed to multiple, overlapping stressors (Morales & Guerra, 2006). Those in low SES households often also live in sub-standard housing in high-crime neighbourhoods, and attend larger, less well-prepared schools with more inexperienced teachers (Evans, Li, & Whipple, 2013). This argument aligns with Ecological Systems

Theory (Bronfenbrenner, 1986), in that risk factors are theorised to reside in various ecological domains, and that all aspects of a child's environment interact to influence development, both directly and indirectly. In light of this, much recent research on risk factors has turned to focus on the effects of exposure to *multiple* risks (Evans et al., 2013).

Rutter's CRT (1979) provides a powerful explanatory framework through which the erosive effects of multiple risk exposure can be better understood. The basic premise of CRT is that children's developmental outcomes are better predicted by combinations of risk factors rather than single risk factors alone (Greenberg, Lengua, Coie, & Pinderhughes, 1999). Furthermore, it is proposed that it is the *number* of risk factors experienced, as opposed to their specific *nature*, that is most important in the risk-outcome relationship (Evans et al., 2013). In his seminal Isle of Wight study, Rutter (1979) found that while no individual variable predicted disorder in children, when any two stressors occurred together, the risk increased by fourfold; when three and four stressors occurred, the risk increased by tenfold. Thus, he argued that it was not any single factor, but the *accumulation* of stressors that led to psychiatric disorders, with higher cumulative risk leading to greater adjustment difficulties (Appleyard, Egeland, van Dulmen, & Sroufe, 2005; Rutter, 1979). While the cumulative risk effect has been demonstrated in multiple studies (e.g. Appleyard et al., 2005; Flouri & Kallis, 2007; Gerard & Buehler, 2004a, 2004b; Hebron, Oldfield, & Humphrey, 2016; Oldfield, Humphrey, & Hebron, 2015), few of these have focused on academic outcomes. Furthermore, the majority of studies only measure the cumulative effect of risk factors in a single ecological domain, utilise a relatively small number of risk factors, and rarely focus on school-level factors (Evans et al., 2013; Lima, Caughy, Nettles, & O'Campo, 2010).

CRT has two main underlying assumptions. First, it predicts that the greater the number of risk factors, the greater the prevalence of problems (Appleyard et al., 2005; Oldfield et al., 2015). Secondly, it is the accumulation of risk factors, rather than the presence or absence of particular risk factors or combinations of them, that impacts upon developmental outcomes. These tenets are based on the principle of equifinality; that is, there are multiple routes to the same outcome (Dodge & Pettit, 2003). However, not all studies measure both assumptions of CRT. "Multiple risk" is often used interchangeably with "cumulative risk" (e.g. Appleyard et al., 2005), and thus the theorised superior

predictive power of cumulative risk (after accounting for the nature of the individual risk factors) is neglected.

Some studies have explored the functional form of the risk-relationship between cumulative risk exposure and outcomes, focusing on whether it is linear or non-linear (quadratic). The *additive* model assumes there are no statistical interactions between risk factors; suggesting a linear relationship (e.g. Sameroff et al., 1987, 1993, 2003; Appleyard et al., 2005). In contrast, the *quadratic* model proposes that risk factors potentiate each other, creating a 'mass accumulation' effect in which the whole of the influence cumulative risk exerts on children's outcomes is greater than the sum of its individual parts (Evans et al., 2013; Oldfield et al., 2015). Two models of quadratic risk-outcome relationships are proposed, although these are not mutually exclusive. *Threshold effects* are evident when exposure to a specific number of risk factors leads to an exponential increase in difficulties (Appleyard et al., 2005). Alternatively, *saturation* or *sensitisation effects* are observed when there is a levelling off or plateauing of outcomes after exposure to a specific number of risk factors, and thus the addition of extra risk factors has no further detrimental effects (Gerard & Buehler, 2004b). Evans and colleagues' (2013) review established that an approximately equal number of studies found linear and non-linear relationships between cumulative risk and children's developmental outcomes. However, few had conducted formal tests to rigorously ascertain the nature of the functional form. Accordingly, these authors argued that this aspect of CRT warrants more attention in future research.

The Current Study

There are several important gaps in the literature that the current study aims to address, by (i) examining the cumulative risk effect on both behavioural *and* reading attainment outcomes; (ii) utilising a relatively large number of risk factors spanning multiple ecological domains; (iii) testing both assumptions of CRT (e.g. to determine not just whether cumulative risk exposure increases the likelihood of negative outcomes, but also whether cumulative risk exposure is a superior predictor of outcomes, relative to the effects of the individual risk factors); and (iv) conducting formal tests of the risk-outcome relationships for disruptive behaviour and reading attainment.

Method

Design

The current study employs secondary analysis of baseline data drawn from a large randomised controlled trial of a universal school-based behaviour management intervention (Authors, in press). Data were analysed in two stages: first, predictor variables significantly associated with the outcomes of interest were established; second, these significant risk factors were summed to generate a cumulative risk score in order to assess the cumulative risk effect.

Participants

Participants were N=3084 children aged 6-7 attending 77 mainstream primary schools across three regions in England. The composition of participating schools mirrored that of primary schools in England in relation to size and the proportion of students speaking English as an Additional Language (EAL), but contained significantly larger proportions of children with special educational needs and disabilities (SEND) and eligible for free school meals (FSM), in addition to lower rates of absence and attainment (DfE, 2015).

Materials

Disruptive behaviour. The disruptive behaviour subscale of the Teacher Observation of Children's Adaptation Checklist (TOCA-C; Koth, Bradshaw, & Leaf, 2009) comprises 9 items in which statements about a child (e.g. "gets angry when provoked by other children") are read and endorsed using a 6-point scale (Never/Rarely/Sometimes/Often/Very Often/Almost Always). Item scores are summed, with higher total scores indicating more disruptive behaviour (Kourkounasiou & Skordilis, 2014). The TOCA-C has sound psychometric properties (Bradshaw, Waasdorp, & Leaf, 2015; Koth et al., 2009).

Reading attainment. End of Key Stage 1 (KS1) teacher assessments (specifically KS1 National Curriculum reading point score: the KS1_READPOINTS variable) were utilised. These data are collected across England when children reach the end of Year 2 (age 6-7), and were extracted from the National Pupil Database (NPD) by the authors. Higher scores are indicative of greater reading attainment. KS1 scores are highly predictive of future academic performance, both in terms of KS2 assessment scores (when children are 10-11; Authors, 2015) and independent standardised test scores (Authors, in press).

Risk factors. All candidate risk factors (see Table 1) were drawn from the NPD and Edubase performance tables [1], with the exception of school-level behaviour, which was generated by aggregating pupils' scores on the conduct problems subscale of the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997), utilised as part of the main study noted above. Teachers were provided with a password to access an online version of the SDQ, which they completed for every pupil in their class participating in the main study. Each pupil was allocated a unique code to match NPD and teacher data.

Procedure

Data generation. Ethical approval was granted by the authors' institutional research ethics committee (reference: 15126). Opt-out consent was obtained from parents, and assent from pupils. The TOCA-C was completed about each child by a member of teaching staff who knew them well. As noted above, reading attainment data was obtained from the NPD. Data generation for the candidate risk factors is outlined in Table 1. Where a direct measure was not possible, a proxy variable was utilised. For example, FSM eligibility was utilised as a measure of familial deprivation. As is consistent with risk research, a high and low risk group must be identifiable in order for a variable to be defined as a risk factor (Kraemer, 1997). Thus, the variables were considered to be potential risk factors when they were present in the child's environment.

Composition of the cumulative risk score. Pupil- and school-level variables identified as significant predictors of disruptive behaviour or reading attainment in the first stage of analysis were summed, creating a cumulative risk score for each child that represented the number of risk factors to which they were exposed. Prior to this, risk factors were dichotomised by being coded as either "0" for absent or "1" for present. For continuous variables, risk was coded as "1" if the scores fell at or above the 75th percentile (Gerard & Buehler, 2004b; Hebron et al., 2016), while all other scores were coded as "0" (Oldfield et al., 2015).

Analysis. Multi-level modelling (MLM) was used in order to account for the clustered and hierarchical nature of the data (Twisk, 2006). Prior to analysis, disruptive behaviour and reading point scores were standardised by converting them to z scores, in order to facilitate interpretation within and

[1] 'Edubase' is a national database containing data on schools across England.

across models. To establish the risk factors associated with pupils' school functioning, all candidate variables were first fitted into two MLMs (one each for disruptive behaviour and reading). Cumulative risk scores were then generated and fitted in new MLMs to test the first assumption of CRT. To test the functional form of the risk-outcome relationship, cumulative risk scores were squared and mean-centred before being added to these models. Finally, the appropriate cumulative risk scores (i.e. cumulative risk or cumulative risk squared) were fitted to new models alongside the significant risk factors in order to test the second assumption of CRT.

Results

16 candidate risk factors at school- and pupil-levels were fitted as predictor variables. Tables 2 and 3 show the results for behaviour and reading attainment respectively. For disruptive behaviour, two school-level (higher proportions of pupils with behaviour difficulties and speaking EAL) and four pupil-level (being a child looked-after (CLA status), male, eligible for FSM and having SEND) variables were identified as significant risk factors. For reading attainment, one school-level (higher proportion of pupils speaking EAL) and six pupil-level (being male, eligible for FSM, having SEND, being summer-born, White EAL, and living in a deprived neighbourhood) variables emerged as significant risk factors.

Table 4 shows the total number of pupils at each of the risk levels across the two models. The majority of pupils were exposed to 1 or 2 risk factors. As the number of risks increased, the proportion of participants reduced. Hence, the proportion of pupils at the highest levels of risk exposure was extremely small. Accordingly, higher risk levels of risk exposure were combined to maximise power, as is established practice in cumulative risk research (e.g. Oldfield et al., 2015). Pupils exposed to four or more risk factors were collapsed into a new "4+ risks" category.

To test the first assumption of CRT, pupils' cumulative risk scores were fitted in new MLMs as explanatory variables. Tables 5 and 6 show the results for these models. Cumulative risk scores were significant predictors of both disruptive behaviour ($\beta 0ij = 0.384, p<.001$) and reading attainment ($\beta 0ij = -0.397, p<.001$). As the outcome variables were standardised prior to analysis, the co-efficients represent the number of standard deviations above or below the sample mean a particular score is. Thus, each additional risk was associated with an average increase in pupils' disruptive

behaviour scores of 0.384 of a standard deviation, and a decrease in pupils' reading point scores of 0.397 of a standard deviation.

To test the functional form of the risk-outcome relationships, the squared terms of the cumulative risk scores (i.e. the quadratic term) were added to the two models alongside the original cumulative risk scores (i.e. the linear term). If this squared term accounts for additional variance beyond the linear cumulative risk score, then a disproportionate relationship is present, indicating a non-linear relationship. However, prior to this analysis, the cumulative risk score is mean-centred before being squared to avoid multicollinearity issues (Oldfield et al., 2015). Tables 5 and 6 show the results for these models. The squared terms were significant predictors of disruptive behaviour ($\beta 0j = 0.028, p < .05$) and reading attainment ($\beta 0j = -0.021, p < .05$), explaining additional variance after accounting for the linear cumulative risk score. This suggests that the relationship between cumulative risk score and both disruptive behaviour and reading attainment was non-linear.

Figures 1 and 2 provide a visual representation of the relationships between cumulative risk exposure and the two outcome variables. Both are indicative of threshold effects, and additionally there is evidence of a saturation effect for disruptive behaviour. In particular, there are two distinct elbow points for disruptive behaviour (Figure 1), at exposure to one (threshold effect) and three (saturation effect) risk factors respectively. Although the relationship between cumulative risk and reading attainment is closer to a linear trend, there is still evidence of a threshold effect at exposure to two risk factors.

To test the second assumption of CRT, the squared terms of the cumulative risk scores were fitted in new MLMs as explanatory variables, along with the dichotomised forms of the variables found to be significant risk factors in the first stage of the analysis. Tables 5 and 6 show the results for these models. The squared terms of the cumulative risk scores were significant predictors of pupils' disruptive behaviour ($\beta 0j = 0.024, p < .05$) and pupils' reading point ($\beta 0j = 0.020, p < .05$) scores, even after accounting for the variance explained by the individual risk factors.

Discussion

Of the pupil-level risk factors that are well established in the extant literature (e.g. SEND status, FSM eligibility), the current study confirmed their associations with disruptive behaviour

and/or reading attainment in the English primary school context. However, several candidate risk factors have previously produced inconsistent findings, or have not been formally tested. For instance, school-level factors, such as the proportion of pupils speaking EAL, have not been widely investigated (Cho, 2012), and so our findings here contribute new evidence. Furthermore, the study utilised a relatively large number of candidate risk factors spanning multiple developmental contexts, and thus the confounding effects of other proxy variables are taken into account. For example, studies examining pupils' CLA status typically fail to address the higher levels of SEND diagnoses that are prevalent in this group (DfE, 2017), while familial (FSM eligibility) and neighbourhood (income deprivation affecting children index (IDACI) score) deprivation are frequently conflated in risk research (McCulloch, 2006). The current study found that neighbourhood and familial deprivation both contribute unique variance when explaining pupils' reading attainment, highlighting the importance of investigating both.

Pupils' cumulative risk scores were significantly positively associated with disruptive behaviour scores and negatively associated with reading attainment, supporting the first assumption of CRT: the greater the number of risk factors, the greater the prevalence of problems. Previous research conducted in this area, utilising a variety of samples and outcome measures, has found similar effects for externalising behaviour problems (e.g. Appleyard et al., 2005; Deater-Deckard et al., 1998; Gerard & Buehler, 2004a, 2004b). By contrast, risk factors for poor academic attainment have been relatively neglected, and so our findings contribute new evidence in this area. Results were consistent with CRT in that risk factors operated in a cumulative manner; exposure to each additional risk factor resulted in an increase in negative outcomes, irrespective of the nature of the individual risks (Oldfield et al., 2015).

Our analyses indicated that a quadratic risk-outcome relationship was present for both disruptive behaviour and reading attainment. This means that there was a disproportionate change in outcomes as the level of risk increased, indicative of a mass accumulation effect. This is consistent with Rutter's original work (1979), which found that the combination of stressors had much more than a simple additive effect on children's psychiatric outcomes. Instead, there was an interactive effect whereby the risk associated with several concurrent stressors was more than the sum of the

individual effects. Rutter (1979) posited that this was due to the presence of one stressor potentiating the damage caused by another. Indeed, quadratic relationships are thought to provide evidence that risk factors not only cluster and commonly co-occur, but also interact with each other in a multiplicative manner, both within and across ecological domains (Gerard & Buehler, 2004b; Lanza, Rhoades, Nix, & Greenberg, 2010; Oldfield et al., 2015; Whipple, Evans, Barry, & Maxwell, 2010). Thus, examination of singular risk factors likely does not accurately describe their effects and so they should not be investigated in isolation (Flouri & Kallis, 2007). Instead, risk research needs to acknowledge the clustering of risk factors that occurs when considering pupils' outcomes (Whipple et al., 2010).

Regarding the specific nature of the risk relationship with disruptive behaviour, there appeared to be a threshold effect after exposure to *one* risk factor, whereby risk was related to outcomes through an accelerative function, resulting in an exponential increase in difficulties. A similar effect was also present in the reading model after exposure to *two* risk factors. This threshold effect supports previous research that suggests that there is a critical point after which children's coping strategies become overwhelmed, resulting in a sudden increase in problems (Flouri & Kallis, 2007).

In the behaviour model only, this initial dramatic increase in behavioural problems was followed by a plateauing after exposure to three risk factors, meaning that both threshold and saturation effects were identified in this model. This saturation effect implies that the addition of risk factors did not compound the influence of other stressors to any great extent, likely due to the already highly compromised development of the child (Gerard & Buehler, 2004b). Interestingly, this is consistent with several other studies that also noted an effect at around three or four risks (Biederman et al., 1995; Jones, Forehand, Brody, & Armistead, 2002; Rutter, 1979). However, whilst they typically note a *threshold* effect, there was evidence of a *saturation* effect in the present study. Whilst it is theorised that both threshold and saturation effects result in protective factors and other coping mechanisms becoming overwhelmed and subsequently exhausted (Flouri & Kallis, 2007), there is little research into the specific processes through which this phenomenon occurs, and hence how it can be addressed through preventive intervention efforts.

The model of allostatic load, whereby more frequent exposure to stressors accelerates wear and tear on the body by engaging multiple physiological systems, provides one possible explanation for the superior predictive power of cumulative risk identified in the current study (Evans et al., 2013). This theory suggests that it is not simply the summation of the individual risk factors that is having a negative effect on children, but the interactions between them that are placing additional stress on children's bodily response systems. This explains why the cumulative risk scores in the models still accounted for additional variance, even after controlling for the effects of the individual risk factors (Evans, Kim, Ting, Tesher, & Shannis, 2007). However, research into this phenomenon, particularly focusing on non-biological outcomes, is lacking, and so the validity of this explanation, and the exact mechanisms through which children's response systems are affected, are unknown. With further research in this area, more could be done to counteract the disproportionately negative effects of cumulative risk exposure on children.

As noted above, cumulative risk score was a significant predictor of both disruptive behaviour and reading attainment, even after accounting for the variance explained by the individual risk factors. Thus, the second assumption of CRT was supported: the accumulation of risk is more important than the presence or absence of individual risk factors. By utilising cumulative risk methodology, the natural co-variation of risk factors can be accounted for (Flouri & Kallis, 2007), meaning that this approach has superior power to explain more variance in outcomes. This counters previous criticisms of cumulative risk research that discuss the loss of potentially important information on risk factor intensity (Evans et al., 2013; MacCallum, Zhang, Preacher, & Rucker, 2002). Instead, these findings are consistent with the argument that no one risk factor is more important than another. Indeed, it is the confluence of risk factors, rather than any singular risk, regardless of context, that leads to dysfunction (Flouri & Kallis, 2007). As Flouri and Kallis (2007) suggested, only investigating exposure to one extreme risk factor when assessing the prevalence of high-risk youths can bias estimates, and results in those pupils at higher risk due to exposure to multiple medium-level risks being neglected. However, the risk factors that are most likely to occur in conjunction are unknown, as are the ways in which they interact with each other. Indeed, it is likely that severely negative outcomes will have multiple causal chains (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001).

Therefore, future research may benefit from exploring the risk factors that frequently co-occur, and examining the multiple underlying interactions taking place between them.

Implications. In addition to highlighting the need for future research to shift its focus to multiple risk and the underlying mechanisms through which cumulative risk exposure impacts children's outcomes, our findings may also have potential implications for the types of interventions that are utilised in schools. Interventions that target multiple risk factors across various domains are favourable (Oldfield et al., 2015). Based on the findings from the current study, it seems that it may not be the specific risk factors that these interventions target that is important; instead, in order to lower a pupil's risk level, they could aim to reduce the effects of all the risk factors that they can. One solution to this may be to utilise universal interventions that have a strong logic model and theory of change (Authors, 2016) targeting a range of both proximal and distal factors associated with the outcome variable of interest.

Additionally, schools may need to provide targeted interventions for pupils at the highest levels of risk, for whom universal interventions may not provide the required level of intensity. Checklists of risk factors across multiple domains could be used to help identify high-risk pupils (e.g. Shepler, 2009). Schools could then implement more tailored interventions with these pupils in an attempt to reduce their risk level. Furthermore, an increased awareness of the risk factors could aid earlier identification of the pupils more likely to experience negative outcomes; this means that they could be targeted before problems develop, as opposed to conducting the more difficult task of addressing them once the issues are already evident (Greenberg, Domitrovich, Graczyk, & Zins, 2005).

Schools' intervention efforts could also focus on developing promotive and protective factors (e.g. high self-esteem, strong relationships, experiencing success; Masten & Coatsworth, 1998). These enhance resilience, and subsequently buffer the effects of exposure to adversity (Powers, 2010; Stouthamer-Loeber, Loeber, Wei, Farrington, & Wikströrm, 2002). The findings from the current study support the proposition that after exposure to a certain number of risk factors, pupils' coping strategies become overwhelmed and subsequently exhausted, resulting in an exponential increase in difficulties (Evans, 2003; Gerard & Buehler, 2004b; Oldfield et al., 2015). Enhancing resilience by

increasing promotive and protective factor exposure may mitigate the effects of risk by improving pupils' coping abilities. Indeed, Morales and Guerra (2006) emphasise the importance of being able to incorporate training in coping strategies into interventions for pupils, particularly those at the highest levels of risk. A variety of strategies exist regarding the ways in which schools can enhance resilience, such as through the provision of a safe and nurturing school environment, stability, supportive relationships with teachers and peers, high expectations of pupils, and opportunities for pupils to engage in positive activities (Alvord & Grados, 2005; Corcoran & Nichols-Casebolt, 2004; DfE, 2016).

However, in order to do this effectively, more research needs to be conducted into the promotive and protective factors, particularly those that can be developed in and through schools. The mechanisms through which these factors interact with risk at various levels could also be further examined (Oldfield et al., 2015). It is possible that promotive factors operate in the same way as risk factors, in that they are unlikely to occur in isolation and can interact with one another (Stoddard et al., 2013; Ostaszewski & Zimmerman, 2006). Indeed, Ostaszewski and Zimmerman (2006) suggested that enhancing individual promotive factors may not be sufficient to achieve a successful outcome when facing certain constellations of risk; thus, further research is required to identify if there is a cumulative promotion effect in order to utilise this successfully when targeting at-risk pupils. Furthermore, as interventions and the promotion of coping mechanisms were not tested in the current study, the suggested benefits of these for pupils at high levels of cumulative risk exposure are speculative. Further research could test the effects of these different strategies in order to identify which are the more favourable.

Limitations. The majority of the schools participating in the wider trial from which our data were drawn were situated in a densely populated region in the UK known for its ethnic diversity and socio-economic issues (CLES, 2012; Jivraj, 2013). Indeed, the schools were discernibly different from the national average on a variety of socio-demographic indicators. Furthermore, as schools were self-selecting, there is also a potential selection bias evident. The schools interested in this study were likely those where there was a greater perceived need for an intervention targeting behaviour. As such, they may not have been representative of the wider UK population.

Data regarding risk factors were only collected from a single time point following a cross-sectional design. Specific risk factors can influence outcomes at different ages, and sustained exposure to risk factors can have an additional deleterious effect (Stouthamer-Loeber et al., 2002); however, this was not accounted for in the present study. Furthermore, it is important that established risk factors not examined in the current study including biological influences (e.g. testosterone levels, genetic risk), parental and familial issues (e.g. maternal mental health and parenting style), and the influence of maladaptive peer groups (Deater-Deckard et al., 1998; Lösel & Farrington, 2012) are acknowledged. In addition, the limited sample size means that some of the risk groups had only a small number of participants, thus potentially skewing the results.

Finally, criticisms of CRT include the loss of potentially important information regarding risk factors due to the binary treatment of the variables (Evans et al., 2013). The use of the 75th percentile as a cut-off for high-risk status for continuous variables means that pupils were only deemed to be at-risk relative to the rest of the sample, and it is unknown whether the scores in the sample were representative of the wider population. There is also a loss of information on the intensity of the risk factors due to the dichotomisation of continuous variables. Information about the degree of risk exposure is lost, resulting in weaker predictive power and less sensitive estimates of covariation. This also means that the severity of the risk cannot be taken into account when determining whether the number of RFs is more important than their nature. Further criticisms of CRT include the lack of attention to temporal parameters such as pupils' age at exposure and the duration of exposure; these parameters can influence the likelihood of the presence of other risk factors, and the impact of these factors on pupils' outcomes (Evans et al., 2013).

Conclusion. The current study extends the knowledge base regarding CRT, finding a cumulative risk effect for both reading and behavioural outcomes. We provide distinct contributions in terms of the incorporation of a large number of risk factors spanning multiple ecological domains, examining both core assumptions of CRT, and formally testing the functional-form of the risk-outcome relationship. Our analyses provide support for both assumptions of CRT, and identify a quadratic relationship for disruptive behaviour and reading attainment. These findings have important

389 implications for future risk research, and for schools seeking to improve outcomes for pupils at-risk of
390 poor school functioning.

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Table 1

Pupil- and school-level candidate risk factors

Variable	Risk group	Description
Gender	Male	Binary: male or female
Relative age (season of birth)	Summer-born	Binary: s*ummer born* (June – August) or *non-summer born* (September – May)
CLA status	Identified as having child looked-after (CLA) status	Binary: Looked-after child or not looked after
SEND status	Identified as having a special educational need or disability (SEND)	Binary: SEND or non-SEND
Familial deprivation (FSM eligibility)	Eligible for free school meals (FSM; income <60% of national median)	Binary: eligible or not eligible
Ethnic Group	Minority ethnic group	Binary: White British or other
First language	speaking English as an additional language (EAL)	Binary: EAL or English as first language
Neighbourhood deprivation (IDACI score)	High income deprivation affecting children index (IDACI) score	Continuous: the IDACI score for the child's neighbourhood; higher scores indicate higher neighbourhood deprivation (*0-1*)
Achievement	Low average achievement	Continuous: proportion of pupils achieving the national curriculum expected standard in English and Maths; higher rates indicate higher average achievement (*0-100%*)

SEND	High % of pupils with an SEND	Continuous: proportion of pupils identified as having an SEND; higher rates indicate higher numbers of pupils with an SEND (*0-100%)*
EAL	High % of EAL pupils	Continuous: proportion of pupils classified as EAL; higher rates indicate more EAL pupils (*0-100%*)
Attendance	High % average pupil absence	Continuous: the average pupil absence at the school; higher rates indicate more instances of absence (*0-100%)*
Behaviour	High % behaviour problems	Continuous: proportion of pupils scoring in the borderline/abnormal range for conduct problems on the SDQ at baseline; higher rates indicate higher levels of behaviour problems (*0-100%*)
Size	Large school size	Continuous: number of pupils enrolled at the school; higher numbers indicate larger schools
Urbanicity	Urban school	Binary: school is located in *urban* or *rural* area
Deprivation (FSM)	High % pupils eligible for FSM	Continuous: proportion of pupils receiving FSM; higher rates indicate greater numbers of pupils with a low SES (*0-100%*)

Table 2

Risk factors for disruptive behaviour

β0ij = -0.257(0.326)

-2*log likelihood = 7142.054

Level		Coefficient	Standard error	p value
School (ICC =4.2%)		0.034	0.009	<.001**
	School size	-0.000	0.000	-
	School urbanicity (if urban)	-0.047	0.159	.383
	Proportion FSM eligibility	0.001	0.003	.371
	Proportion EAL	0.004	0.001	<.001**
	Proportion absence	-0.076	0.040	.031*
	Proportion SEND	-0.008	0.005	.057
	Proportion Level 4 English and Maths	-0.001	0.003	.371
	Proportion borderline/abnormal conduct problems	0.029	0.003	<.001**
Pupil (ICC = 95.8%)		0.767	0.021	<.001**
	Gender (if male)	0.394	0.034	<.001**
	Relative age (if summer born)	-0.102	0.038	.005**
	FSM eligibility (if eligible)	0.216	0.041	<.001**
	Ethnicity & EAL category:			
	White & non-EAL	◊	◊	◊
	White EAL	-0.020	0.088	.409
	Ethnic minority & non-EAL	-0.093	0.060	.063

Ethnic minority & EAL	-0.344	0.062	<.001**
SEND (if yes)	0.505	0.045	<.001**
CLA (if yes)	0.732	0.205	<.001**
IDACI score	0.158	0.152	.298

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Table 3

Risk factors for reading attainment

β0ij = 0.819(0.268)

-2*log likelihood = 6765.381

Level		Coefficient	Standard error	p value
School		0.020	0.006	<.001**
	School size	0.000	0.000	-
	School urbanicity (if urban)	0.186	0.134	.084
	Proportion FSM eligibility	-0.000	0.002	.5
	Proportion EAL	-0.002	0.001	.025*
	Proportion absence	-0.037	0.033	.133
	Proportion SEND	-0.003	0.004	.4228
	Proportion Level 4 English and Maths	-0.002	0.002	.16
	Proportion borderline/abnormal conduct problems	0.003	0.002	.069
Pupil		0.640	0.017	<.001**
	Gender (if male)	-0.204	0.031	<.001**
	Relative age (if summer born)	-0.265	0.033	<.001**
	FSM eligibility (if eligible)	-0.178	0.037	<.001**
	Ethnicity & EAL category:			
	White & non-EAL	◊	◊	◊
	White EAL	-0.456	0.079	<.001**
	Ethnic minority & non-EAL	0.100	0.054	.034*
	Ethnic minority & EAL	0.033	0.056	.279
	SEND (if yes)	-1.178	0.041	<.001**
	CLA (if yes)	-0.004	0.174	.492
	IDACI score	-0.469	0.136	.0005**

Table 4

Number (N) and percentage (%) of participants per risk level

Risk level	Behaviour		Reading	
	N	%	N	%
0	599	19.4%	406	13.2%
1	1081	35.1%	873	28.3%
2	818	26.5%	837	27.1%
3	410	13.3%	499	16.2%
4	112	3.6%	190	6.2%
5	17	0.6%	46	1.5%
6	0	0%	1	0.0%
7	-	-	0	0%
Missing	47	1.5%	232	7.5%
Total	3084	100%	3084	100%

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Table 5

Cumulative risk models for disruptive behaviour

Cumulative risk assumption 1: Behaviour β0ij = -0.521(0.049)				Quadratic risk: Behaviour β0ij = -0.539(0.050)				Cumulative risk assumption 2: Behaviour β0ij = -0.506(0.049)			
	Coefficient	Standard error	p value		Coefficient	Standard error	p value		Coefficient	Standard error	p value
School level	0.107	0.021	<.001**	School level	0.109	0.021	<.001**	School level	0.077	0.016	<.001**
Pupil level	0.768	0.020	<.001**	Pupil level	0.767	0.020	<.001**	Pupil level	0.761	0.020	<.001**
Cumulative risk score	0.384	0.019	<.001**	Cumulative risk score	0.373	0.019	<.001**	School EAL	-0.077	0.095	.213
				Cumulative risk score squared	0.028	0.013	.015*	School behaviour	0.552	0.082	<.001**

		Gender	0.399	0.033	<.001**
		FSM eligibility	0.222	0.040	<.001**
		SEND	0.481	0.044	<.001**
		CLA	0.660	0.190	<.001**
		Cumulative risk score squared	0.024	0.013	.038*
-2*log likelihood = 7701.906	-2*log likelihood = 7697.134	-2*log likelihood = 7652.987			

Table 6

Cumulative risk models for reading attainment

Cumulative risk assumption 1: Attainment β0ij = 0.697(0.039)				Quadratic risk: Attainment β0ij = 0.714(0.040)				Cumulative risk assumption 2: Attainment β0ij = 0.537(0.036)			
	Coefficient	Standard error	p value		Coefficient	Standard error	p value		Coefficient	Standard error	p value
School level	0.037	0.010	<.001**	School level	0.037	0.009	<.001**	School level	0.025	0.007	<.001**
Pupil level	0.752	0.020	<.001**	Pupil level	0.752	0.020	<.001**	Pupil level	0.641	0.017	<.001**
Cumulative risk score	-0.397	0.016	<.001**	Cumulative risk score	-0.391	0.016	<.001**	School EAL	-0.186	0.062	.002**
				Cumulative risk score squared	-0.021	0.011	.03*	Gender	-0.196	0.031	<.001**

				Relative age	-0.262	0.034	<.001**
				FSM eligibility	-0.214	0.037	<.001**
				White EAL	-0.505	0.078	<.001**
				SEND	-1.201	0.041	<.001**
				IDACI	-0.073	0.040	.036*
				Cumulative risk score squared	0.020	0.011	.038*
-2*log likelihood = 7315.919		-2*log likelihood = 7312.580		-2*log likelihood = 6850.891			

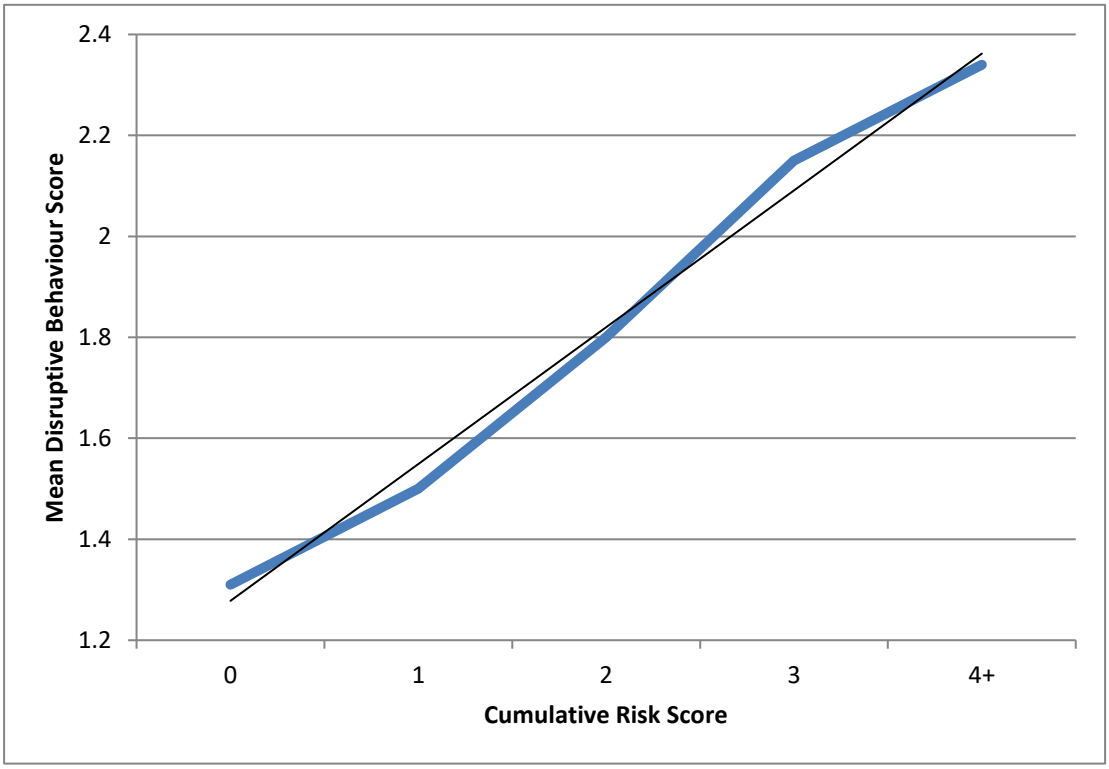

Figure 1. Functional form of risk-outcome relationship for disruptive behaviour

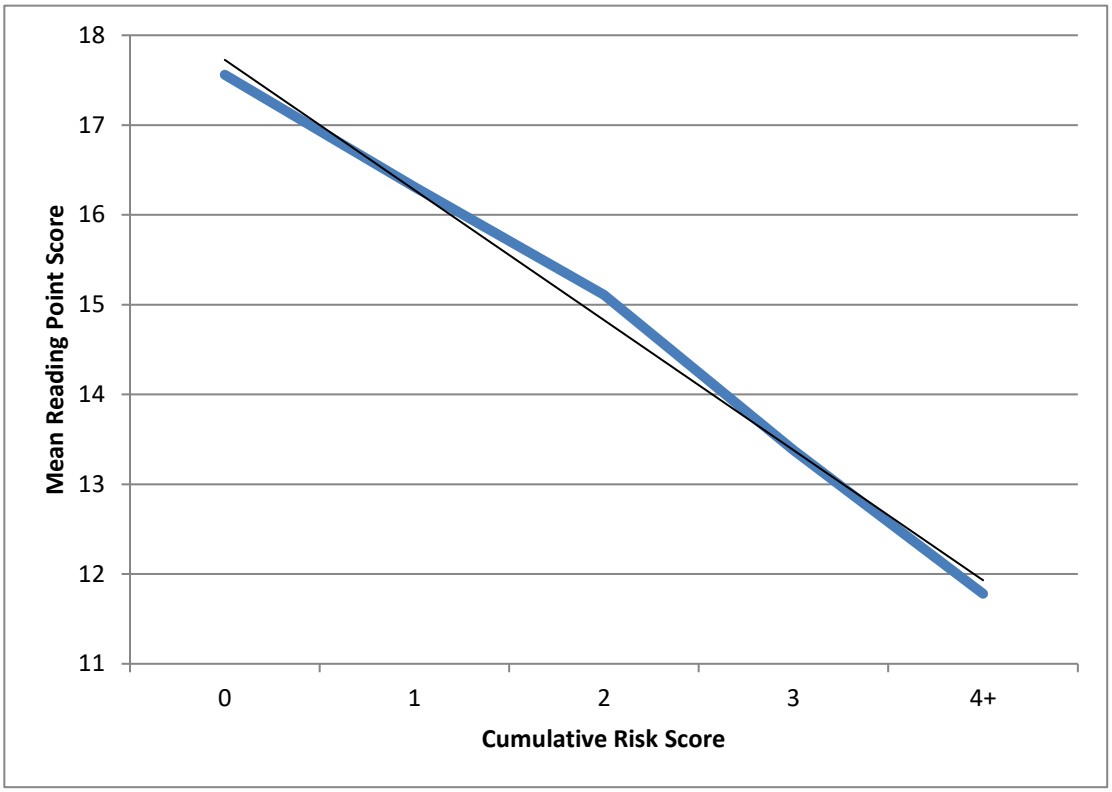

Figure 2. Functional form of risk-outcome relationship for reading attainment