Annual International Scientific Conference Early Childhood Care and Education, ECCE 2016, 12-14 May 2016, Moscow, Russia

A twin study of the relationship between inhibitory control and behavior problems

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Abstract

Inhibitory control is an important part of successfully functioning in society. Low inhibitory control is related to behavior problems in adolescents. However the etiology of this relationship is unclear. In this study we use a genetically informative twin sample to disentangle the genetic and environmental effects that influence this association. We conclude that there is a significant genetic component in the relationship between inhibitory control and externalizing problems, but not internalizing problems.

Keywords: Inhibitory control; behavior problems; twin study.

1. Introduction

Temperament traits have been consistently linked to behavior problems. However the etiology of this relationship hasn’t been well researched and this is especially true for regulatory temperament dimensions, such as inhibitory control.

Inhibition in general is a necessary part of successfully functioning in society: behavior that is considered polite and indeed legal is a result of inhibition. We routinely inhibit negative thoughts about other people and ourselves, fears and desires. Inhibition is the basis of complex behavior, such as planning. Even toddlers and

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primates have the ability to inhibit an immediate response if it leads to a greater reward later on. For adolescents difficulties with inhibition can lead to adaptation problems, which adversely affect their development [1].

Inhibitory control refers to the ability to suppress undesirable thoughts or behavior [2]. In personality and developmental psychology inhibitory control is a temperament dimension linked to the system of effortful control. Effortful control includes inhibitory control, attention control and activation control. A broader construct, effortful control has been more popular in behavior genetics research, and the only study of the etiology of the association between control and behavior problems has been done on effortful control. In this study K. Lemery-Chalfant et al.[3] concluded that the association between effortful control and behavior problems was influenced by genetic factors. The amount of shared variance explained by genetic factors in this association was lower for internalizing than externalizing problems.

Recent studies argue that inhibitory control is not a singular construct. Munakata et al. [4] propose that there are two separate neurological processes underlying inhibition: direct and indirect inhibition. Direct global inhibition allows for coping with stressors, inhibiting responses and suppressing memory retrieval. Indirect competitive inhibition is related to attention and selection, it facilitates a process by which one response becomes dominant, while competing responses are suppressed. These two types of inhibitory control are also reflected in an earlier work by M. R. Rueda et al.[5], although the description they give is in behavioral terms.

The distinction between types of control is important because it hints at a complex relationship between inhibitory control and behavior problems. Even though evidence is so far scarce, it is becoming clear that this relationship is not homogenous for different types of problems. N. Eisenberg et al. [6] showed that the relationship between control and externalizing problems is direct, while the relationship between control and internalizing problems is mediated by resiliency.

Twin studies can improve our understanding of the link between inhibitory control and behavior problems by disentangling environmental and biological influences on this relationship. For example, if a high amount of shared variance between inhibitory control and behavior problems can be attributed to genetic effects, it means that the same genes influence both, prompting more targeted genetic studies. Furthermore, it would discourage a search for environmental mediators of this relationship.

In this study we examined the amount of influence genetic and environmental factors have on the relationship between inhibitory control and behavior problems.

2. Method

Twins can be viewed as an invaluable natural experiment. Monozygotic (MZ) twins develop from the same cell and are therefore genetic copies of each other. Dizygotic (DZ) twins develop from two different cells fertilized at the same time; they share on average half of their unique genetic information. Since these two types of twins share environmental influences to the same extent, this allows us to calculate how much of their differences are influenced by genes.

The twin method compares phenotypic differences between groups of MZ and DZ twins in order to split the variance of any behavioral phenotype into several components. Additive genetic effects (A) represent the combination of all genetic variations that influence the phenotype. Common environmental effects (C) represent the environmental influences that both twins share, such as living in the same house and having the same parents. Finally, unique environmental effects (E) represent all influences on the phenotype that the twins don’t share, such as unique experiences or even different impact of the same events.

This approach works not only for singular behavioral phenotypes, but also groups of phenotypes and relationships between them. In this study we use a bivariate correlated factors twin model to examine the association between inhibitory control and behavior problems. Previous research already informs us that higher levels of inhibitory control are related to lower levels of behavior problems, and the purpose of our bivariate model is to find out how much of this relationship is determined by genetic factors [3].
The A, C and E variance components are approximated using structural equation modeling. Accurate results are ensured by several steps of model fit testing. First, the full ACE model is compared to a saturated model, which is the same model with no constraints. Without constraints the saturated model has perfect fit to the data, so if the differences in the likelihood of the two models are non-significant, it means that the ACE model fits the data well enough. Next, all the variance components are individually tested for significance. This is done by excluding components one by one and comparing the fit of the full ACE model to that of the resulting sub-models. Since the sub-models are nested, they can be directly compared to the full model via likelihood as well. If the likelihood of any of the sub-models does not significantly differ from the likelihood of the baseline model, this means that the respective excluded variance component was insignificant to the baseline model. In other words, if the smaller model fits the data just as well, the excluded component was not needed in the first place.

A full explanation of the twin study methodology, including all possible variance components, different types of models, model assumptions and the rules of likelihood testing falls beyond the scope of this paper. An in-depth explanation can be found in many contemporary papers [7].

A total of 371 twin pairs participated in our study (165 MZ, 117 same sex DZ, 89 opposite sex DZ). 46% of the participants were female. All twins in our study were adolescents from 10 to 15 years old (mean age 12.2 years). Twins came from 4 big Russian cities, their primary language was Russian.

Twins in our study filled out several questionnaires that provided data about their temperament traits, behavior and emotional problems and the type of zygosity of the twin pair.

We measured inhibitory control using the Early Adolescent Temperament Questionnaire – Revised (EATQ-R; [8]). It is a popular temperament questionnaire developed by M. K. Rothbart. Only one scale of the questionnaire was required for this study – the inhibitory control scale. Behavioral problems were measured with the Youth Self Report (YSR; [9]). It is a widely used questionnaire developed by T. Achenbach.

Both questionnaires were developed with adolescents in mind in terms of question wording and factor structures, which makes them well suited for studies such as ours.

3. Results and discussion

We observed moderate negative correlations between inhibitory control and all problem scales. The correlation between inhibitory control and internalizing problems was the smallest (r=-0.16, p<0.01). The correlations were larger with externalizing problems (r=-0.36, p<0.00) and total problems (r=-0.3, p<0.00).

We studied the factors underlying the relationships between inhibitory control and behavior and emotional problems using three bivariate correlated factors twin models. Model parameters converged normally in all cases. In the case of the inhibitory control – externalizing problems relationship, the AE model had the best fit. The relationship between inhibitory control and total problems was best explained by a full ACE model. However, the same model for the relationship between inhibitory control and internalizing problems fit the data poorly. The variance components for all models are displayed in Table 1.

We found that the relationship between inhibitory control and externalizing problems is influenced mostly by genetic factors (A=0.73). Externalizing problems include serious antisocial behaviors, such as stealing, fighting, joining gangs, destroying property, but also milder behaviors, such as swearing and shouting, bragging, showing off and demanding attention. The respective YSR syndrome scales also include emotional indicators, for example mood swings, bad temper and jealousy. All these indicators describe behaviors that are distinctly aimed outwards, and it is not at all surprising that there is a strong connection between them and the ability to inhibit undesirable behavior. This result falls in line with the findings of K. Lemery-Chalfant et al.[3].

We did not find any genetic influences on the relationship between inhibitory control and internalizing problems. Internalizing problems are characterized by fears, paranoia, low self-esteem, guilt, thoughts of self-harm and suicide. It was unexpected that inhibitory control was so weakly related to internalizing problems in our sample, but the low amount of their shared variance is likely what stopped us from discovering genetic or
environmental influences on their relationship. This relationship is possibly indirect, so further investigation will be required, perhaps including measures such as resilience.

Table 1. Estimates of phenotypic correlations between pairs of constructs under investigation, with standardized variance components, 95% confidence intervals given in square brackets

<table>
<thead>
<tr>
<th>Pair of constructs</th>
<th>Phenotypic correlation</th>
<th>Best fitting model</th>
<th>A</th>
<th>C</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhibitory control – externalizing problems</td>
<td>-0.36 [-0.43,-0.28]</td>
<td>AE</td>
<td>0.73 [ 0.50, 0.95]</td>
<td>--</td>
<td>0.27 [ 0.05, 0.50]</td>
</tr>
<tr>
<td>Inhibitory control – internalizing problems</td>
<td>-0.16 [-0.25,-0.08]</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Inhibitory control – total problems</td>
<td>-0.3 [-0.38,-0.22]</td>
<td>ACE</td>
<td>0.53 [ 0.00, 0.90]</td>
<td>0.09 [ 0.00, 0.65]</td>
<td>0.37 [ 0.07, 0.70]</td>
</tr>
</tbody>
</table>

We know that up to 42% of the variance of both internalizing and externalizing problems is determined by genetic factors [10]. Control dimensions are highly heritable as well, up to 79% [3]. Our results indicate that inhibitory control and externalizing problems may be influenced by some of the same genes, or otherwise a set of genetic factors that commonly appear together. However, even though both inhibitory control and internalizing problems are genetically determined to some extent, there does not seem to be much overlap in these genetic influences.

The total problems scale is an amalgamation of all problem scales in the YSR. The results of the bivariate model with this scale are not as valuable, because the problems measured by it are very broad, including internalizing and externalizing problems and also social, attention and thought problems. As an amalgamation of all behavior and emotional problems, its relationship with inhibitory control lies somewhere between externalizing and internalizing in terms of genetic and environmental influences. In this case the genetic component was smaller, but still significant (A=0.53).

A drawback of our study was our low sample size, which stretched the confidence intervals of some of our model parameters. However, the results for the inhibitory control – externalizing problems model were still highly significant.

4. Conclusion

In this study we examined the genetic and environmental influences on the relationship between inhibitory control and behavior problems. The relationship between inhibitory control and externalizing problems was mostly determined by genetic factors. In contrast, the relationship with internalizing problems was weaker and did not have any significant genetic influences. Our results point towards the possibility that the same set of genes influences some aspects of inhibitory control and the development of externalizing behavior problems.

Acknowledgements

This study was supported by RFH grant 15-06-10724.

References


