

Do executive functions predict change in forms of aggression in middle childhood?

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Abstract

This study investigated concurrent and 2-year longitudinal relations between three executive functions (inhibition, working memory, and shifting) and forms of aggression in children. The Instrument of Proactive and Reactive Aggression (IRPA) was considered for applicability for measuring forms of aggression in middle childhood. The mean age of the sample ($n = 844$) was 6.7 years at first assessment and 8.8 years at the final assessment. Neuropsychological test scores of executive functions and teacher report of aggression were obtained at both time points. The IRPA was examined through exploratory (EFA) and confirmatory factor analysis (CFA), growth of forms of aggression were regressed on executive functions. Unlike in the original study (Polman, de Castro, Thomaes, & van Aken, 2009) CFA was not able to distinguish physical, verbal and covert forms, but a significant 2-factor solution consisting of physical and covert aggression was identified through revision of the instrument. Regression analysis revealed modest significant concurrent associations between the executive component working memory with physical aggression at first assessment, and with physical and covert aggression at the second assessment. Executive functions, however, did not predict change in any form of aggression.

Do executive functions predict change in forms of aggression in middle childhood?

Childhood onset aggression is associated with numerous adverse outcomes, including substance dependence, psychopathic traits, financial and work problems, mental-health problems, and drug-related and violent crime (Huesmann, Eron, Lefkowitz, & Walder, 1984; Moffitt, Caspi, Harrington, & Milne, 2002). Early interventions are recommended to prevent this maladaptation (Moffitt et al., 2002). Therefore, to inform the improvement of such interventions, it is important to strive to understand what causes early emerging aggression. However, as repeatedly shown, different forms of aggression, such as physical or covert aggression, may have different impact on maladjustment. Physical aggression is for example associated with externalizing problems, while covert aggression is associated with internalizing problems (Card, Stucky, Sawalani, & Little, 2008; Murray-Close & Ostrov, 2009). Hence, as suggested by Card et al. (2008) and Murray-Close and Ostrov (2009), different forms of aggression may have different precursors, i.e., direct physical aggression may have an etiology that differs from indirect and verbal aggression. Intervention efforts towards direct physical aggression may therefore profit from targeting other factors than interventions directed towards indirect verbal aggression. As it turns out, there is a lacuna of research addressing the possibility that the predictors of different forms of aggression may be different – a gap of knowledge that will be addressed in the current research.

Aggression is complex human behavior, and there is agreement that many factors probably interact in an intricate fashion. These factors can be environmental (Kimonis et al., 2006; Tremblay et al., 2004), psychological (Giancola, Mezzich, & Tarter, 1998; Kimonis et al., 2006), and biological (Raine, 2002), including genetic (Craig & Halton, 2009; Johansson et al., 2012).

Forms of aggression

Historically research on aggression has focused mainly on direct physical forms, whereas indirect aggression was introduced later as the manner in which girls expressed aggressive urges (Björkqvist, 1994). Indeed girls seem to be less physically aggressive than boys, while boys and girls both display similar amounts of relational aggression (Card et al., 2008). The use of verbal and covert forms are suggested to replace physical forms when social and verbal skills improve, and girls are suggested to precede boys in these skills and will therefore use these alternative forms earlier than boys (Björkqvist, 1994). The distinct gender distribution supports the validity of discrete aggressive forms. Forms of aggression also show stability over time (Murray-Close & Ostrov, 2009; Vaillancourt, Brendgen, Boivin, & Tremblay, 2003) which further support their discreteness.

Forms of aggression are usually divided into two factors. Although their names vary, they mainly refer to the same construct; a direct, physical form which also include overt verbal attacks, and an indirect covert and relational form (Card et al., 2008). Alternatively, aggression can also be divided into a physical, verbal and covert form (Björkqvist, 1994; Polman et al., 2009). Contradictive to dividing aggression into forms is the substantial intercorrelation between the forms. Average correlation is high ($\bar{r} = .76$), but there is considerable heterogeneity among effect sizes (Card et al., 2008).

However, moderately high to high correlations do not disprove the usefulness of different forms of aggression, e.g. different components of intelligences are highly correlated, still it is meaningful to discern verbal intelligence from e.g. perceptual reasoning (WISC-IV; Wechsler, 2003). In a similar fashion the division between forms of aggression is nevertheless argued to be relevant because of the statistical separateness of factors, the stability of the forms, and because the distinct forms are associated with unique properties and patterns of behavior (Card et al., 2008). As illustrated by the finding that children who exhibit different forms of aggression differ in regard to social dominance and gender (Murray-Close & Ostrov, 2009). In a similar vein, a meta-analysis by Card et al. (2008) revealed a different pattern of maladjustment associated with the different forms of aggression. Specifically, direct aggression was related to externalizing problems, poor peer relations, and low prosocial behavior, whereas indirect aggression was related to internalizing problems and higher prosocial behavior. Thus, existing evidence concerning the outcome of direct versus indirect aggression supports the validity of the distinction.

A substantial limitation is that most of the research on aggressive forms has been conducted with concurrent data, which means that we know little about causality (Card et al., 2008). Nevertheless it is plausible that the different forms of aggression have different antecedents (Ostrov, Murray-Close, Godleski, & Hart, 2013).

Executive functions and aggression

Executive functions (EFs) refer to a group of top-down mental processes, which enable people to reach goals and solve problems, when automatic processes are insufficient. The different EFs combined constitute a regulation-system (Diamond, 2013; Zhou, Chen, & Main, 2012). There is general agreement that there are three core EFs: inhibition, working memory and set shifting; and that they show stability across time (e.g., Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000). These EFs are also the ones considered here. Numerous authors have hypothesized that deficits in EFs are important correlates or risk factors for aggression. Different EFs may be differentially important for controlling

aggressive impulses and for directing attention towards relevant stimuli that helps activate constructive feelings and behavior, and away from stimuli that activate uncomfortable aggressive impulses (Liew, 2012; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). Furthermore, it has been suggested that aggression peak in adolescence because EFs and prefrontal brain development at this age are lagging behind environmental demands, and make the adolescent incapable of regulating powerful emotions, such as aggression (Raine, 2002). It has also been hypothesized that individual differences in aggression during the life course might partly be explained by variance in executive functioning, which interact with differences in environmental demands and social support (Raine, 2002). Unfortunately, there is little research considering longitudinal relationships between aggression and EFs in middle childhood. (Riggs, Blair, & Greenberg, 2004; Séguin, Pihl, Harden, Tremblay, & Boulerice, 1995).

Several researchers have discovered concurrent associations between laboratory measures of EFs and aggression (e.g., Raaijmakers et al., 2008; Sprague, Verona, Kalkhoff, & Kilmer, 2011) – nevertheless, the results have varied, and there have also been examples of studies where no such associations were reported (Riccio, Hewitt, & Blake, 2011). There are no meta-analytic reviews considering the literature on aggression and EFs. However, reviews have been conducted on the relation between EFs and antisocial behavior (Morgan & Lilienfeld, 2000; Ogilvie, Stewart, Chan, & Shum, 2011), and aggression is often present in such antisocial behavior (American Psychiatric Association, 2013). In these reviews moderate effect sizes (i.e. $d = .44$ to $d = .62$) were identified. This might indicate a connection between EFs and more grave types of aggression.

The use of indirect aggression involves some level of theory of mind, which is the ability to consider other people's mental states. Theory of mind is associated with executive functioning (Hughes, 1998). It can therefore be assumed that indirect aggression demands a higher level of EF than physical aggression. Direct aggression is often triggered by an external cause, for instance being hit or insulted. This is not necessarily the case with indirect aggression (Card et al., 2008). Thus, withholding direct aggressive urges when provoked may demand greater impulse regulation skills than when indirect aggression is at play (Baumeister & Heatherton, 1996). Indeed, physical aggression is more related to emotional dysregulation and ADHD-symptoms than indirect aggression (Card et al., 2008), which again are related to EFs (Barkley, 1997; Liew, 2012). Therefore it is reasonable to hypothesize that limited executive functioning, especially impulse regulation, might be associated with physical aggression, and more so than with indirect aggression.

It has been found that EFs influence aggression differently by gender (Giancola, Roth, & Parrott, 2006). Since forms of aggression are characterized by different patterns of gender distributions, these findings might support the notion that EFs have unique impact on the separate forms of aggression. Additionally, because aggressive forms have shown to be stable over time (Murray-Close & Ostrov, 2009; Vaillancourt et al., 2003), they might be associated with stable properties such as executive functions.

Despite substantial research on the connection between aggression and EFs, there is yet to be established a clear relationship between the two. Different aspects of EFs seem to vary in being the key component associated with aggression (Ellis, Weiss, & Lochman, 2009; Kimonis et al., 2006; Raaijmakers et al., 2008; Riggs et al., 2004; Seguin, Boulerice, Harden, Tremblay, & Pihl, 1999). This may be caused by the measurements chosen, or the properties of the subjects; but it may also be partly due to aggression being a general description of behavior that does not separate between the manifestations of such behavior. Separating the forms of aggression might therefore reveal clearer connections with executive functions. There has been no study that has investigated the relations between EF, let alone various EFs, and forms of aggression.

Measuring forms of aggression in children

When investigating which aspects of human functioning that are related to the forms of aggression it is crucial to have developed valid assessment-tools. There are several methods for assessing forms of aggression (Card et al., 2008). When choosing a measure, it is argued that instruments that separate the forms of aggression from motives or functions of aggression should be preferred because they avoid confounding variables (Little, Henrich, Jones, & Hawley, 2003; Murray-Close & Ostrov, 2009; Polman, de Castro, Koops, van Boxtel, & Merk, 2007). Unfortunately, none of the measures that consider both forms and functions of aggression are adapted for use in middle childhood. The most widely used measure is a self-report for older children (Fite, Stauffacher, Ostrov, & Colder, 2008; Fite, Stoppelbein, Greening, & Gaertner, 2009; Little et al., 2003). In the current study I investigate 1st and 3rd graders. Because children may have difficulties providing valid and reliable information concerning their own aggression at those ages, it may be better to use proxy report (Broidy et al., 2003; Lochman & Dodge, 1998). Thus by using teacher-report, as I have done here, problems with self-reporting are avoided. Teachers are arguably not biased in the same way as parents (Kunda, 1987), they have a solid frame of reference, and observe children over time and across situations, including in interactions with peers.

The Instrument for Reactive and Proactive Aggression (IRPA) identifies, through teacher report, three forms of aggression: physical, verbal, and covert (Polman et al., 2009). The IRPA was originally designed as a questionnaire for late childhood and early adolescence (10-13 years old). The instrument consists of seven behavioral items, which teachers rate by frequency the last 30 days. The instrument have evidenced good construct validity and reliability (Polman et al., 2009).

To the best of my knowledge the structure of the IRPA has not been investigated for replication. Such replications are essential if the IRPA, and the inherent distinction between different forms of aggression, should have a wider use (Koole & Lakens, 2012; Makel, Plucker, & Hegarty, 2012; Schmidt, 2009). This paper investigates whether the original factor structure can be replicated in a community sample of Norwegian 1st and 3rd graders. Note that the original analyses were performed on Dutch 5th and 6th graders, and that factor structure may vary in different samples, and also between ages and cultures.

Replications are crucial for the validation of assessment tools. Results that are replicated across situations and by different researchers, show a robustness and ensure a wider applicability (Rosnow & Rosenthal, 1989; Schmidt, 2009). Thus if the IRPA is going to be more robust for further research, it is of importance that it is possible to replicate the results from the original study.

The present investigation

In sum, the aims of the current investigations were twofold. The main aim was to test whether children high in executive functioning would evidence a more favorable course of aggression from 1st to 3rd grade as compared to children with lower executive functioning, and further to test whether the change in different forms of aggression differed according to different EFs.

However, to test whether different EFs predicted various forms of aggression it was necessary to first investigate whether the IRPA did differentiate between forms of aggression. Thus, to ask whether the factor structure of the IRPA could be replicated in a large and representative sample of 1st and 3rd graders in Norway with respect to identifying three forms of aggression, namely Physical, Verbal and Covert. Therefore, factor replication of the IRPA is a subordinate goal of this investigation.

Method

Participants and procedure

This study is part of the ongoing, longitudinal research project Trondheim Early Secure Study (TESS; Wichstrøm et al., 2012). Children born in 2003 or 2004, and living in the city

of Trondheim in Norway, were recruited at age 4 through a regular community health check-up in which 97.2 % of the population partakes. Of these children 82.0 % (N = 2,475) had parents who agreed to participate in the TESS. To increase variability, and thus statistical power, the children were screened with the Total difficulty scale (Crone, Vogels, Hoekstra, Treffers, & Reijneveld, 2008) of the parent-completed Strengths and Difficulties Questionnaire (SDQ) – which is a questionnaire valid for uncovering psychiatric disorders in children (Sveen et al., 2014). There was no exclusion criteria, apart from insufficient mastery of Norwegian to fill out the SDQ. Children were divided into four strata according to their SDQ scores, and defined proportions of families in each stratum were randomly drawn, with increased proportions with elevated SDQ scores. See Figure 1 for a full description of the recruitment-process. After adjusting for stratification the parents in the sample were comparable to the parents of same age children in the Norwegian population (Wichstrøm et al., 2012). At the first data collection (T1), the mean age of the children was 4.1 years (SD = .18). Tests of EFs and the IRPA were first administered when the children were in the 1st grade (T2), $M_{\text{age}} = 6.7$ years, SD = .17; and again in the 3rd grade (T3), $M_{\text{age}} = 8.8$ years, SD = .24. At T2 797 children participated in the study. At T3 689 children participated in the study. Children who provided data at either 6 years or 8 years form the analytical sample of the present investigation (n = 844).

All testing was conducted in the Department of Psychology at the Norwegian University of Science and Technology (NTNU), by skilled personnel with a degree in a relevant education, and with relevant work experience. The IRPA-forms were sent to teachers for completion, along with a pre-paid return envelope. Teachers were contacted as a reminder if they did not return the forms. Research procedures were approved by the Regional Committee for Medical and Health Research Ethics.

Measures

Forms of aggression. To measure the forms of aggression in children, the IRPA was applied. The IRPA is a teacher reported questionnaire created by Polman, de Castro, Thomaes, and van Aken (2009) that measure forms and functions of aggression. The present investigation only utilized the form aspect of the IRPA. Physical items included Kicking, Pushing, and Hitting; Verbal items were Name calling and Arguing; whereas Covert items comprised Doing sneaky things and Gossiping. For each child, teachers rated the frequency of the above mentioned items during the last 30 days. Good discriminant and satisfactory convergent validity has been reported for the IRPA (Polman et al., 2009). Because more items increase validity, and a valid factor structure was required to be able to test the main

hypothesis concerning the relationship between EFs and aggression, additional items were collected along with the IRPA items: Pinched, Destroyed or hidden other's things, and Excluded others. This physical item and these two alleged covert items would be added to an extension of the IRPA if the original items fail to yield a significant factor structure.

Executive functions. *Inhibition* was measured using the subtest "Statue" from the NEPSY battery (Korkman, Kirk, & Kemp, 2007). The child is asked to close their eyes and stand still while holding a flag with one hand, for 75 seconds. The test administrator preforms distractions at set points to interrupt the child from preforming the task, such as coughing and knocking the table. The child is rewarded points for each five second-interval of managing to stand still and not respond. Thus a higher score indicates better inhibition ability. This test has a moderate to high validity, and have been used to measure inhibition in several studies (Brooks, Sherman, & Strauss, 2009; Espy & Bull, 2005).

Shifting was captured by the Intra-Extra Dimensional Set Shift (IED) from the Cambridge Neuropsychological Test Automated Battery (Cantab; Cambridge Cognition, 2006). The test is administered on a computer and measures the child's ability to flexibly shift between two different relevant stimuli, analogue to the Wisconsin Card Sorting Test (Grant & Berg, 1948). The child will learn which stimulus is correct through feedback, and after six correct answers the target stimulus change. It has been argued that measures of accuracy are preferable for capturing the essence in shifting (Ven, Kroesbergen, Boom, & Leseman, 2013). Therefore the measure used here is "total number of errors", which has proven to be a valid and reliable measure of the shifting ability (Henry, Messer, & Nash, 2012; Luciana & Nelson, 1998; Smith, Need, Cirulli, Chiba-Falek, & Attix, 2013).

Working memory was assessed using the "number recall backward"-condition of the Weschler Intelligence Scale for Children (WISC-IV; Wechsler, 2003) subtest "Digit Span". In this condition the child is asked to name digits, read by the administrator, in the reverse order. Hence the child will have to keep the numbers in memory, while preforming the task; thus measuring an active component, which involves planning, unlike the condition with merely repetition which is considered to measure the short term capacity which is considered a more passive component (Schofield & Ashman, 1986; Swanson, 1993). The Digit Span subtest is widely used as a measure of working memory, and exhibits excellent reliability and validity (e.g., Rajan, Cuevas, & Bell, 2013; Williams, Weiss, & Rolfhus, 2003).

Results

Factor structure of the IRPA

Descriptive statistics of the IRPA items are seen in Table 1. To ease comparison with the Polman et al. study, identical items and statistical procedures to those used in their study were applied, i.e. an exploratory factor analysis (EFA) treating the variables as ordered categorical by using a robust weighted least square estimator (WLSMV) in Mplus (Muthén & Muthén, 1998-2013). The sample was first analyzed when the children were in 1st grade. To gain insight into the influence of age on the IRPA the sample was reanalyzed when they were in the 3rd grade. Results from EFAs can be seen in Table 2. Non-significant χ^2 , Confirmatory Fit Index (CFI) and Tucker Lewis Index (TLI) > .95, Root Mean Square Residual (RMSEA) and Standardized Root Mean Square residual (SRMR) < .05 was taken as indices of a model with good fit to the data. Evaluation of factor solution was based on the above statistical criteria, but also interpretability, absolute size of factor loadings (i.e. > .40), and on lack of cross-loadings of aggressive items. Note that both the Verbal and Covert factors were tapped by only two items each. Too few items may reduce reliability of a scale and may also be problematic in validity terms with respect to adequately covering the breath of phenomena covered by a construct, in this case the physical, verbal and covert forms of aggression. Therefore, irrespective of it being a replication of the Polman et al. findings or not, analyses was rerun with additional data using more items than in the Polman et al. study, namely *Pinched, Destroyed or hidden other's things, Excluded others* when a satisfactory factor solution was not reached.

Replication. One to three factor solutions were tested in the EFA. As can be seen in Table 2 the one-factor solution had modest fit to the data. A two-factor solution had a very good fit which was not significantly different from a perfect fit, and this was also a significant improvement above a one-factor solution, $\Delta\chi^2(6) = 98.16, p < .001$. Next, a three-factor solution evidenced a perfect fit as well, but which implied no significant improvement above the two-factor solution, $\Delta\chi^2(5) = 7.78, p = .17$. Moreover, in the three-factor solution, Name calling loaded on a factor together with the physical items, leaving the Verbal factor to be defined only by one item, namely Arguing. The three-factor solution was therefore considered to not be an optimal solution. However, the two-factor solution also has its problems. The two items originally loading on the Verbal factor in the Polman study evidenced high and equally strong cross-loadings on factor 1 and factor 2, respectively, in the present study, i.e. Arguing = .59 and .43, Name calling = .50 and .53. In sum, although statistical indicators showed two models with very good fits, the two-factor solution did not distinguish adequately between

physical and verbal aggression whereas the three-factor solution consisted of a mixture between physical and verbal items and one factor being defined by only one item. Both solutions were therefore discarded, and I thus investigated whether adding more items to the IRPA could produce a satisfactory factor structure.

Extension and revision. To increase reliability and separation of factors additional items were included: Pinched, Destroyed or hidden other's things, Excluded others. These results are also available in Table 2. Again, a one-factor solution evidenced modest fit, which was increased when an additional factor was included. The two-factor solution had modest fit to the data, which implied significant improvement compared to the one-factor solution, $\Delta\chi^2(9) = 172.25, p < .001$. A three-factor solution showed almost perfect fit, which further improved model fit, $\Delta\chi^2(8) = 27.88, p = .005$. However, in the latter solution Arguing cross-loaded on factor 1 (.58) and factor 3 (.60), and the 3rd factor was only defined by Excluding others (i.e. a supposedly Covert item; .61) and Arguing (a supposedly verbal item). This three-factor solution was therefore discarded due to lack of interpretability. In the two-factor solution the verbal items had high cross-loadings, Name calling .58 and .43, respectively and Arguing .49 and .54, respectively. Because verbal items were not possible to assign to either factor, the analyses were rerun without the verbal items. The results are reported in Table 2. Again, a one-factor solution evidenced modest fit, whereas a two-factor solution evidence very good fit. A three-factor solution did not improve the fit, $\Delta\chi^2(8) = 9.98, p = .27$. A two-factor solution was therefore preferred, consisting of one Physical dimension and one Covert dimension. This solution was subjected to a confirmatory factor analysis (CFA), again treating the variables as ordered categorical and using the WLSMV estimator. This model evidenced good fit, $\chi^2(19) = 27.19, p = .09$, CFI = 1.00, TLI = 1.00, RMSEA = .02. The CFA does not yield SRMR. Factor loadings on the Physical dimension were high (Kicked .92, Punched .91, Hit .95, Pinched .68) as were items on the Covert dimension (Hidden or destroyed others' things .65, Gossiping .92, Sneaky tricks .78, Excluded others .72). The correlation between Physical and Covert aggression was .60 ($n = 777$), $p < .001$.

This CFA model was rerun using data from 3rd grade. The two-factor Physical and Covert model did fit the data very well, $\chi^2(19) = 20.11, p = .39$, CFI = .1.00, TLI = 1.00, RMSEA = .01. Factor loadings on the Physical dimension were: Kicked .93, Punched .91, Hit .94, Pinched .81, and for items on the Covert dimension: Hidden or destroyed others' things .83, Gossiping .71, Sneaky tricks .97, Excluded others .63. It should be noted that the correlation between the two factors was high, .73 ($n = 602$), $p < .001$. In, sum a modified

two-factor solution consisting of Physical and Covert aggression received support and was therefore used in the remaining analyses.

Do executive function predict aggression?

The analyses proceeded in three steps. First, as preliminary analysis, the correlations between EFs and Covert and Physical aggression, respectively, were analyzed. The second step was to determine the multivariable cross-sectional association between EF and Physical aggression and Covert aggression in 1st and 3rd grade. The two forms of aggression were therefore regressed on the three EFs – in one model for 1st grade and one model for 3rd grade. The third and final step addressed whether EFs could predict change in aggression. Parallel growth curves for Covert and Physical aggression were therefore constructed initially. The intercept was set at T2 and growth was parameterized as yearly change. To accommodate growth curves with only two time points the error terms of the aggression measures were set to zero. Growth was regressed on the intercepts and growth and intercepts for the Covert and Physical aggression were allowed to correlate. Thereafter, growth in both Covert and Physical aggression were regressed on EFs in 1st grade (while adjusting for the intercepts). The two forms of aggression, Physical and Covert, were allowed to correlate as were the three EFs. Due to the expected skewness of the aggression data, a robust maximum likelihood estimator was applied, which is robust to non-normality. Missing data were treated according to a full information maximum procedure, implying that all available data were used as long as the children had teacher rating of aggression in 1st or 3rd grade. All analyses were performed on data weighted with the inverse of the drawing probability using robust standard errors in order to provide correct population estimates.

Correlational analyses showed that 1st grade shifting was uncorrelated with impulse control ($r = .03$, $n = 736$, $p = .50$) and working memory ($r = .01$, $n = 736$, $p = .81$), whereas working memory and impulse control were modestly correlated, ($r = .16$, $n = 736$, $p < .001$). The associations involving shifting were similar in 3rd grade: impulse control: $r = .03$, $n = 686$, $p = .51$ and working memory: $r = .04$, $n = 686$, $p = .39$, but here were no longer any associations between impulse control and working memory, $r = .03$, $n = 686$, $p = .49$. Hence, no indication of a common EF factor was seen and each aspect of EF was therefore analyzed separately.

The results from the three sets of multivariate analyses (steps 2 and 3) are shown in Table 3 and 4. As can be seen only working memory yielded a significant association with the IRPA factors. Working memory as measured in the 1st grade had a significant modest association with physical aggression and a nonsignificant association with covert aggression.

In the 3rd grade working memory had modest significant associations with both physical and covert aggression.

Physical aggression decreased from grade 1, $M_{\text{physical aggression}} = .62$, $SD = .96$, to grade 3, $M_{\text{physical aggression}} = .43$, $SD = 1.08$, as evidence by a negative of the growth parameter $M_{\text{growth}} = -.09$, $p < .001$. With respect to Covert aggression the mean value was .32 in 1st grade, $SD = .78$, and the corresponding figures in 3rd grade were .29, $SD = .74$, which was not a significant decrease, $M_{\text{growth}} = -.02$, $p = .39$. However, importantly for the coming analyses, variances in growths for Physical and Covert were highly significant, respectively .37 and .21, both $p < .001$. Results from the analysis of growth of forms of aggression by EFs can be seen in Table 4. There was no statistically significant effects of growth of either covert or physical aggression by the EFs. The intercept of working memory on physical aggression was significant, with a modest association.

Discussion

The main goal of the current study was to test whether executive functions could predict changes in different forms of aggression from 1st to 3rd grade. Because there are no validated instruments to measure different forms of aggression, while controlling for functions of aggression, during the early school years, I first examined whether the factor structure of a recently developed method to capture forms of aggression in children, the IRPA, could be replicated in a Norwegian sample. The latter was necessary to answer the first hypothesis, and will therefore be considered first. The original factor structure of the IRPA could not be replicated in this age group, but a significant two factor solution was found. The results showed modest correlations between the executive component working memory and physical aggression in 1st grade and 3rd grade, and also with covert aggression in 3rd grade. There were no indications of longitudinal effects of EFs on any form of aggression.

Replication of the IRPA-structure

The original IRPA was constructed to measure three forms of aggression: physical, verbal and covert. Exploratory factor analysis (EFA) of the original items did not yield a clear three-factor solution consistent with the alleged physical, verbal and covert forms. By adding items the covert factor became more reliable, but challenges with the verbal items remained. By further removing the verbal items and running an EFA, a two-factor solution evidenced a good fit with a clear physical and covert factor. The original IRPA three-factor solution was therefore discarded for the present age group, in favor of a revised two-factor solution. Two-

factor solutions are most common in earlier research on forms of aggression (e.g., Card et al., 2008; Ostrov et al., 2013; Underwood, Galenand, & Paquette, 2001).

Björkqvist (1994) argued that physical aggression would gradually be replaced by verbal aggression when verbal skills improve. The lack of a significant verbal factor and the failure to replicate the IRPA three-factor solution here might be because the children in the sample are going through the transition of verbal aggression replacing physical aggression. For the age group in the current study, Name calling might take the form of aggressive attacks that resemble physical aggression. A possible hypothesis is that verbal aggression first becomes a distinct form of aggression in pre- or early adolescence. Since children express aggression differently throughout development (Loeber & Hay, 1997), a two-factor solution of forms of aggression might be more appropriate in middle childhood. In the original Polman study, of youth in the age range 10 to 13 years old, the three-factor model showed a good fit to the data. Results of a two-factor model were not included in the original study, and it is therefore not certain that a two-factor solution would evidence a significantly poorer fit for their sample (Polman et al., 2009).

A search of the literature did not uncover any replication studies of the IRPA, thus the validity of the IRPA have not been supported previously. The expected three-factor structure did not appear in this trial. The original study focused mainly on the function-aspect of aggression, more so than on the form-aspect (Polman et al., 2009). In particular, the form-aspect was not compared to other measures of forms of aggression, while functions of aggression as measured by the IRPA was compared to several other measures. Thus the form-aspect of the measure has uncertain validity compared to the instrument as a whole. In the current study, removing the verbal items to obtain a significant factor structure was not an optimal solution to obtain validity. I recommend further testing for the IRPA to be considered a valid and reliable measure.

One possibility for considering the IRPA valid and reliable for assessing forms of aggression in middle childhood, is to repeat the extension and revision done here. Another possibility to increase statistical properties is to include additional items. Since the original instrument only included two verbal items (Polman et al., 2009), validity and reliability of the verbal scale might be reduced. Therefore, further items, for example Profanities and Yelling, might contribute to thicker descriptions of the verbal factor and thus increased construct validity and reliability. For the current sample, factors might have organized differently if more verbal items were included, and the inherent three-factor structure might have appeared. In the case of a further revision of the instrument, the source of information about the child's

behavior might also be meaningful to consider. The informant moderate the intercorrelation between the forms, and teachers report quite high intercorrelations (Card et al., 2008). Other informants, such as trained observers or peer review might decrease intercorrelation, resulting in the factors becoming more distinct.

Alternatively, other instruments might capture the form aspect of aggression, but there is an absence of measures for middle childhood which also consider the function aspect. Measures that account for both forms and functions of aggression are argued to increase validity (Little et al., 2003; Murray-Close & Ostrov, 2009). Aggression seems to be such a multifaceted construct that accurate measures are crucial to capture important risk factors and possibilities for interventions. The recommendation here is to further develop the IRPA to be valid for younger age groups; alternatively to adapt the other measures available to be valid for early school age. Nevertheless, for the current analysis a two-factor structure with verbal items removed was considered acceptable to answer the main hypothesis, whether EFs predict change in forms of aggression.

Can executive functions predict change in forms of aggression?

In the existing literature on relationships between executive functions and aggression longitudinal studies are scarce. The current study contributes to fill the gap in the literature by providing both concurrent and longitudinal connections between EFs and forms of aggression. The data unveiled no significant effects of executive functioning in 1st grade on change in forms of aggression from 1st to 3rd grade. A modest concurrent association between working memory and physical aggression at age 6 and 8, and covert aggression at age 8 was discovered.

Significant variance of growth in both covert and physical aggression in the current results, implicate individual differences in growth rate among the children. The current assumption that EFs might be particularly important for these individual differences in change in physical aggression in middle childhood did not gain any support. Similarly, there was no association between growth in covert aggression and EFs.

To my knowledge there is only one prospective study of the longitudinal relationship between EFs and aggression. Two executive components were first measured when children were 7 years and 11 months: sequencing ability and inhibitory control. 60 children participated in the study (Riggs et al., 2004). Over a two year interval inhibitory control predicted both teacher and parent rated externalizing behavior, and sequencing ability predicted teacher rated externalizing behavior. Externalizing behavior include physical aggression amongst other forms of rule breaking behavior (Stanger & Lewis, 1993).

Another longitudinal study found associations between change and stability in aggression and EFs as measured at the end of the study (Séguin et al., 1995). The participants in this study were only boys. Aggression was assessed at ages 6 through 12 years, and EFs were assessed later, at age 14 years for 177 of the boys. The study did not specify the executive functions, rather than using a sum score, so that single executive component did not prove to be decisive. Thus this study, although longitudinal, could not determine a prospective relationship between EFs and aggression.

In the current study 844 children participated, and statistical power was thus stronger for this study than the before mentioned. The children in the current study were younger than in the Riggs et al. (2004) study. The latter only discovered modest concurrent associations at age 8. The considerable impact of EFs on change of aggression in the Riggs study was interpreted as EFs first being important for aggressive behavior later, around age 10. If environmental demands cause EFs to predict aggression not before early adolescence, the limited association and the lack of causal effects found in the current study could be accounted for. In that case, further follow-up of the participating children might reveal connections between EFs and aggression.

Conversely, the current results could implicate that EFs might not be as predictive of aggression as often assumed. Publication bias favor studies that reject the null-hypothesis, thus the apparent association between EFs and aggression might therefore be exaggerated, which is even more likely when studies are underpowered. The limited prospective research on the subject, also analyzing large samples, do limit our knowledge about prospective relations.

Existing longitudinal studies did not investigate aggression per se, but a broad construct of externalizing behavior, which consist of different types of rule breaking aggression, including physical aggression (Stanger & Lewis, 1993). Thus, other rule breaking behavior could have been effected by EFs rather than physical aggression. Similarly, other authors have argued that there might not be a strong relationship between aggression and EFs in normal populations, but that this relationship might be stronger in excessively aggressive and antisocial individuals (Kramer, Kopyciok, Richter, Rodriguez-Fornells, & Munte, 2011; Ogilvie et al., 2011). Hence, these authors argue that EFs are associated with violent and grave antisocial behavior, which is not what have been measured in this study. At the same time these authors argue that EFs are not associated with more innocent forms of aggressive behavior, which is to a greater extent captured in the current study. Thus, these hypotheses match the current results. Further work should compare more normative forms of childhood

aggression with more grave forms to test the seriousness hypothesis more explicitly than could be done in the present investigation.

In earlier studies, impulsivity has been claimed to be the main reason for a connection between EFs and aggression, and impulsivity has indeed been associated with physical aggression in particular (e.g., Kimonis et al., 2006; Kramer et al., 2011). Nevertheless, there exist no prospective studies of children which measure aggression separate from other forms of externalizing behavior, so the predictive value of inhibition has not been tested before now. In the present study there was no support for a causal relationship between impulsivity and neither form of aggression. Notably, the failure to establish an association between aggression and impulsivity concurs with some other studies (Riccio et al., 2011).

Alternatively, the lack of a significant relationship between impulsivity might be due to the sensitivity of the Nepsy subtest Soldier, measuring impulsivity here. As noted this test has only a moderate validity (Brooks et al., 2009), and is not very well documented as a valid assessing-tool for early school age. A broader selection of tests for measuring impulsivity might have produced a different output, since different tests claiming to measure the same executive construct might give different results (Kramer et al., 2011). There are several neuropsychological methods for measuring executive functions (Diamond, 2013), and other tests might be better for capturing the aspects of executive functions potentially related to aggression. There is also a possibility that the IRPA is limited as a measure of forms of aggression for children from 6 to 8 years old, considering challenges with replication of the original structure. Hence, the results are characterized by some level of uncertainty.

Conclusion

Notwithstanding these limitations, the results state that dividing aggression into forms did not yield differential prospective effects of EFs. Concurrent associations also showed similar patterns for physical and covert aggression. Thus the current results do not support a predictive relationship between EFs and forms of aggression. No earlier studies have investigated the relationship between EFs and forms of aggression, neither longitudinal nor concurrent, hence this study contributes with information into the field of research.

The attempted replication of the IRPA (Polman et al., 2009) with a younger community sample did not yield the same factor structure as in the original study, but a satisfactory two-factor solution consisting of a physical and a covert factor was identified after adjustments to the initial instrument. The failure of the verbal items to organize under one factor in the current analysis, might, as discussed, be due to a transition of physical to verbal aggression. Alternatively, the missing verbal factor might be a consequence of the original verbal factor

being defined by too few items to obtain reliability. Further testing and revision of the IRPA are recommended, to increase robustness.

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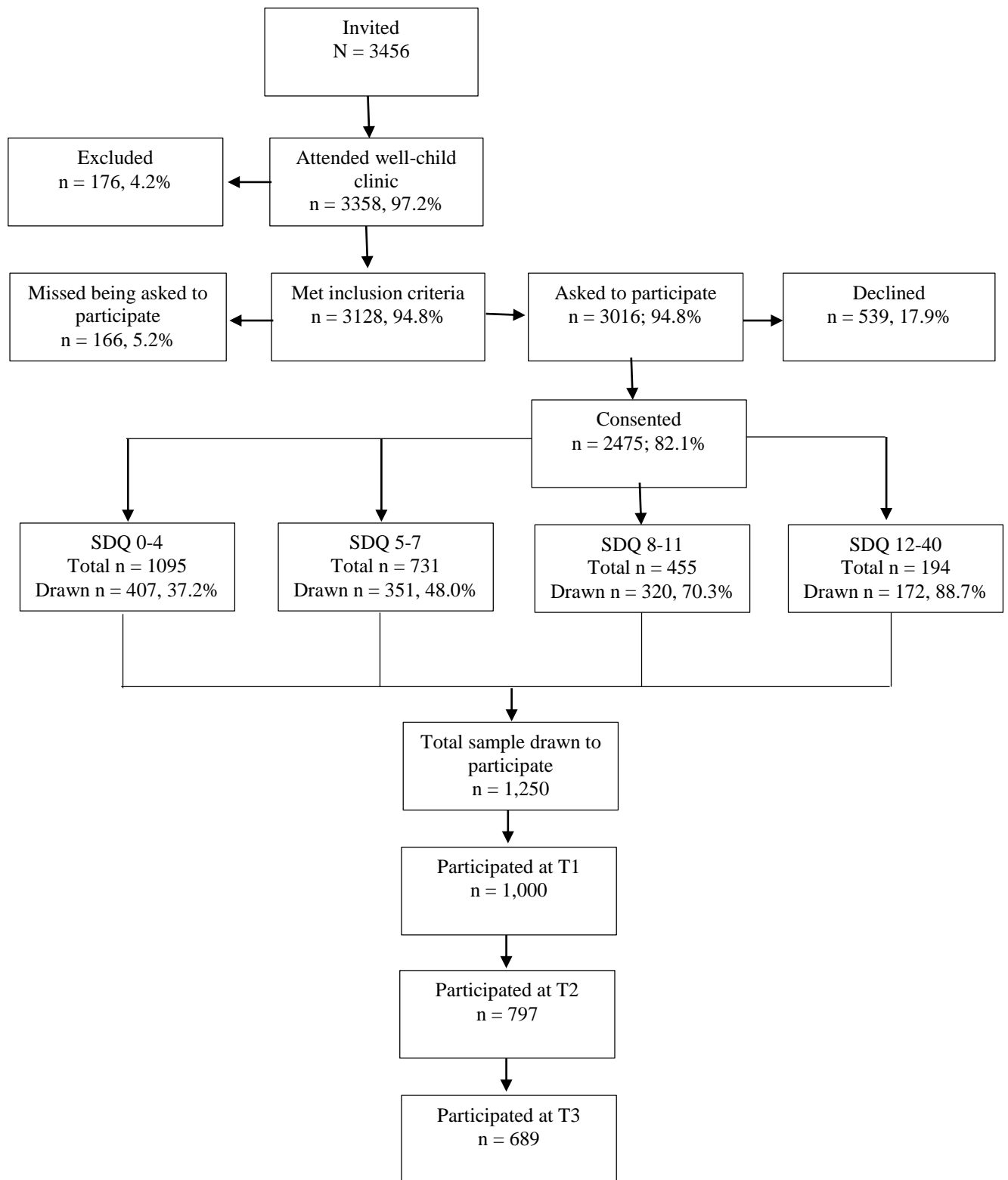


Figure 1. Sample recruitment

Table 1*Distribution of Items of Aggression in First and Third grade*

Forms of aggression	1st grade (n = 797)		3rd grade (n = 689)	
	Mean	SD	Mean	SD
Original IRPA items				
Physical				
Kicking	.13	.38	.09	.31
Pushing	.31	.59	.22	.74
Hitting	.14	.40	.11	.36
Covert				
Doing sneaky things	.05	.23	.03	.18
Gossiping	.04	.23	.05	.24
Additional aggressive items				
Pinched	.05	.25	.03	.19
Destroyed, or hidden other's things	.02	.16	.03	.17
Excluded others	.22	.46	.19	.47

Note: IRPA = Instrument of Reactive and Proactive Aggression.

Table 2*Replication of the IRPA, Extension and Revision*

	Goodness of fit indices					
	χ^2	p	CFI	TLI	RMSEA	SRMR
Original items						
1 factor model	106.52	<.001	.98	.98	.09	.11
2 factor model	8.36	.40	1.00	1.00	.01	.02
3 factor model	.58	.90	1.00	1.00	.00	.00
Items added						
1 factor model	219.37	<.001	.97	.96	.08	.13
2 factor model	47.12	.006	1.00	.99	.03	.04
3 factor model	19.24	.38	1.00	1.00	.01	.03
Verbal items removed						
1 factor model	152.26	.001	.96	.95	.09	.15
2 factor model	13.22	.43	1.00	1.00	.01	.03

Note: IRPA = Instrument of Reactive and Proactive Aggression; CFI = Confirmatory Fit Index; RMSEA = Root Mean Square Residual; SRMR = Standardized Root Mean Square Residual; TLI = Tucker Lewis Index.

Table 3

Associations between physical and covert aggression with executive functioning in 1st grade and in 3rd grade.

	Physical aggression						
	B	1 st grade			3 rd grade		
		95% CI	β	B	95% CI	β	
<i>Shifting</i>	.00	-0.00, .01	.03	-0.00	-0.00, .00	-.02	
<i>Working memory</i>	-.07**	-.11, -.02	-.09**	-.10***	-.16, -.05	-.14***	
<i>Impulse control</i>	-.18	-.56, .20	-.04	.78	-.39, 1.94	.04	
	Covert aggression						
	B	1 st grade			3 rd grade		
		95% CI	β	B	95% CI	β	
<i>Shifting</i>	.00	-0.00, .00	.01	.00	-0.00, .00	.08	
<i>Working memory</i>	-.01	-.05, .02	-.03	-.05**	-.09, -.01	-.11**	
<i>Impulse control</i>	.05	-.16, .26	.02	-.27	-1.73, 1.20	-.02	

Note: CI = confidence interval. * = $p < .05$, ** = $p < .01$, *** = $p < .001$

Table 4

Multivariable prediction of intercept and growth in physical and covert aggression from 1st to 3rd grade from executive functions in 1st grade

Physical aggression						
	Intercept			Growth		
	B	95% CI	β	B	95% CI	β
<i>Shifting</i>	.00	-.00, .01	.03	.00	-.00, .00	.00
<i>Working memory</i>	-.07**	-.12, -.02	-.09**	.00	-.03, .00	.00
<i>Impulse control</i>	-.16	-.56, .23	-.03	.07	-.10, .23	.03
Covert aggression						
	Intercept			Growth		
	B	95% CI	β	B	95% CI	β
<i>Shifting</i>	.00	-.00, .00	.01	.00	-.00, .00	-.01
<i>Working memory</i>	-.01	-.05, .02	-.03	-.01	-.03, .01	-.05
<i>Impulse control</i>	.06	-.15, .28	.02	-.04	-.18, .11	-.02

Note: CI = confidence interval * = $p < .05$, ** = $p < .01$, *** = $p < .001$