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Petri Juujärvi

A Three-Level Analysis of Reactive Aggression Among Children

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UNIVERSITY OF JYVÄSKYLÄ

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ABSTRACT

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The present series of studies sought to confirm the hypothesis that simulated physical proactive aggression would give rise to simulated physical reactive aggression, but the relationship between the intensity of the acts and the reactions would be mediated by children's prior experiences of the rewards or punishments that ensue. In addition, it was hypothesised that the relationship between the intensity of proactive and reactive aggression would change from one child to another because of individual differences in the propensity for emotional reactivity and its cognitive regulation. The Pulkkinen Aggression Machine (PAM) paradigm varied the intensity of proactive and reactive aggression as well as the physical and social characteristics of six attackers. During all conditions of the paradigm, the participants maintained the role of the defender. The computerised PAM and the associated monitoring of cardiovascular activity, a battery of eight cognitive tasks, and a short form IQ test were completed by 109 children (61 boys and 48 girls) aged between 8 to 13 years. Complementary information on the participants' socio-emotional behaviour at school was collected based on teacher ratings. As regards the first hypothesis, the findings indicated that the relationship between the intensity of proactive and reactive aggression varied from one condition to another according to the respective characteristics of the attacker and the defender. For example, an act of pinching was reciprocated with a reaction of pinching when the opponents were of equal status, but the same act was countered with a less intensive reaction when the attacker was of superior physical or social status. In regard to the second hypothesis, the findings indicated that high levels of emotional reactivity were negatively associated with the relationship between the intensity of proactive and reactive aggression, but only when the intensity of the instigating acts was low. In addition, high levels of self-regulation capacity was positively associated with the attenuation of the relationship between the intensity of proactive or reactive aggression, whether the individual dispositions were inferred from the cardiac reactivity, the cognitive performance, the intelligence performance, or the teacher rating data. To investigate the interactions between the multiple situational and the multiple individual factors in a more precise way, however, several steps should be taken to develop the PAM and the associated methods further.

Key words: conflicts, aggression, emotion regulation, experimental study

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Professors Heikki Lyytinen and Dennis Molfese arranged for me to visit the Department of Psychological and Brain Sciences at the University of Louisville. During my three months in Kentucky, I was offered an opportunity to enjoy the companionship of the Developmental Neuropsychology Laboratory members, to familiarise myself with contemporary EEG techniques, and to devote myself to the investigation of the themes I have discussed in the pages that follow. For all this, I am also grateful.

Scientific research is a collaborative endeavour. Dr. Jukka Kaartinen proposed both the calculation of the mean difference between the intensity of stimuli (attack) and responses (defence) and the consideration of reactive aggression towards minor and major proactive aggression. Dr. Tomi Laitinen and Esko Vanninen, who are physicians at the Department of Clinical Physiology at the Kuopio University Hospital, supervised the pre-processing of the ECG, the analysis, and the interpretation of the physiological data. During his tenure as a post-doctoral researcher, Dr. Libbe Kooistra went to great lengths in introducing me to the art of scientific writing. During his tenure as a post-doctoral researcher, Dr. Juhani Lehto undertook the analysis of executive cognitive functioning that I utilised in this thesis. My fellow graduate students and those who graduated recently provided me with emotional and instrumental support in numerous hours of need. Words fail me. Thank you.

In the spirit of the philosopher A.F. Chalmers: To my family and friends who don't care about dissertations, who won't read them, and who had to put up with me while I wrote this one, I say Hello.

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On my way home to the middle of the strawberry fields,
Petri Juujärvi

CONTENTS

LIST OF ORIGINAL STUDIES

I. Juujärvi, P., Kooistra, L., Kaartinen, J., & Pulkkinen, L. (2001). An Aggression Machine. V. Determinants of reactive aggression revisited. *Aggressive Behavior*, *27*, 430-445.

II. Juujärvi, P., Kaartinen, J., Laitinen, T., Vanninen, E., & Pulkkinen, L. (in press). Effects of physical provocations on heart rate reactivity and reactive aggression in children. *Aggressive Behavior*.

III. Juujärvi, P., Kaartinen, J., Vanninen, E., Laitinen, T., & Pulkkinen, L. (resubmitted). Controlling the intensity of reactive aggression through the cognitive evaluation of proactive aggression cues.

INTRODUCTION

The Research Problem

Social relationships and interactions facilitate children's development (Hughes, 1999; Rogoff, 1998; Rubin, Bukowski, & Parker, 1998). Play provides mutual pleasure and supports the reciprocal acquisition of various skills, but it also gives rise to conflicts between children (C. Shantz, 1987). The occasional episodes of mutual opposition and persuasion serve as the basic context for reciprocal aggression, the versatile repertoire of physical and verbal acts that deliberately harm the other person. Proactive or offensive aggression advances, for instance, the enactment of the play roles or the distribution of the toys to the advantage of the offending child (Dodge & Coie, 1987; Pulkkinen, 1987). Reactive or defensive aggression restores the balance in the domination of the activities or the resources to the benefit of the defending child.

The social level of analysis that pertains to conflict and aggression also applies to emotion (Averill, 1982), but the individual and biological levels of analysis become relevant as well (Berkowitz, 1993; Bradley, 2000; Lazarus, 1991; Levenson, 1999). The unpleasant acts of offensive aggression trigger both conscious feelings and unconscious affective tendencies that together bring about the unpleasant reactions of defensive aggression. My colleagues and I addressed the following problem: How is the relationship between attack and defence mediated by emotions among children? Our first hypothesis was that although physical attacks would give rise to physical defence, the relationship between the intensity of offensive and defensive aggression would depend on the expected reward or punishment, such as the immediate termination or escalation of the bout (Pitkänen, 1969, 1973*a*). Our second hypothesis was that the relationship between the intensity of proactive and reactive aggression would vary from one child to another due to individual differences in the disposition towards emotional reactivity and for its cognitive regulation (Pitkänen, 1973*b*; Pulkkinen, 1995).

Conflicts and Aggression

Observation designs have yielded important findings about play situations, and the unfolding of conflicts in terms of the duration, tactics, and outcomes of the episodes. The focal sampling design of Hartup, Laursen, and colleagues followed a systematic scheme specifying the time intervals and the play interactions that were to be verbally recorded and transcribed to the text database. In the course of three months and 61 hours of active observation, 146 conflicts occurred, involving almost everyone in the sample of 53 pre-school children (Hartup, Laursen, Stewart, & Eastenson, 1988). While six conflicts out of ten were associated with play roles and rules, the remaining episodes were related to possession of the available toys. Two thirds of the conflicts lasted less than ten seconds and included at least three turns. As regards affective intensity and reciprocal aggression, most episodes were characterised by low levels of emotion (56 %) and (threats of) proactive or reactive aggression (66 %). Further analyses of the data revealed, however, that the longer the conflicts were in duration, the more often they involved high levels of affect as well as offensive and defensive aggression (Laursen & Hartup, 1989). These factors were, in turn, related to the discontinuation of the subsequent activities.

D. Shantz (1986) obtained a complete record of the observation of organised play situations for a sample of 96 grade school children. Compared to the transcribed text data of Hartup and his co-workers, the audio-visual data of Shantz indicated a slightly higher rate of conflicts on the one hand, but a lower proportion of acts of offensive and reactions of defensive aggression on the other. Analysis of the relationship between the individual rate of participating and the specific tactics used indicated that the more frequently the children were involved in conflicts, the more often they employed physical attack or defence. The psychological dynamics underlying this result were viewed with caution, but it appeared that some children may find themselves in unpleasant situations more often than others because of their tendency to become highly concerned for their own position (D. Shantz, 1986). The main contribution of these studies is, however, in showing that conflicts are rare events, and most episodes do not involve aggression; two conclusions that hold for naturalistic observation data in general (C. Shantz, 1987).

Experimental designs enable the systematic manipulation of one or several factors of the play situation. Yet another study by Hartup and his colleagues (Hartup, French, Laursen, Johnston, & Ogawa, 1993) illustrated how the structuring of the interaction increased the probability of conflicts between two children. These investigators devised a board game and a partially diverging set of rules pertaining to the moving of pegs on the board. In contrast to the naturalistic situations, during a period of 12 minutes an equal number of conflicts occurred in the 66 dyads involved in the study as the pairs of grade school children challenged one another on the basis what

each had been taught to were the proper rules of the game. Consistent with the naturalistic situations, however, the presence of aggression was very rare. Thus, even the experimental induction of conflicts does not always initiate a reciprocal cycle of aggression.

One paradigm that has generated a considerable body of studies consists of hypothetical situations that may evolve into conflicts as well as proactive and reactive aggression (Crick & Dodge, 1994). Children are shown video clips in which, for instance, one child takes a toy away from another. The first child may act on purpose; either he wants to play with the toy himself or he wants to show the other what to do with it. But he may act by accident, because he has not noticed that the other child had been playing with the toy a moment earlier. The motives of the first child may also be ambiguous, as there is no apparent reason for his action.

These intentions are varied from one video clip to another through the manipulation of facial and verbal gestures. The video clips are presented in two conditions: as a discrimination task or as an identification task. In the first condition, three clips are shown in sequence and the participants have to decide which clip displays a different intention (e.g., purposeful, but malevolent) from the two others (e.g., purposeful, but benevolent). In the second condition, only one clip is shown at a time, and the participants report not only the intention but also their own reaction, were they to be in the situation in the role of the second child.

The results of a representative study showed that the manipulations affected 176 kindergarten and elementary school participants' ability to identify the intentions of the first child (Dodge, Murphy, & Buchsbaum, 1984). In the discrimination condition, the children made the highest proportion of errors when the triad comprised a combination of benevolent and accidental intentions. On the other hand, the lowest proportion of errors was found in triads that consisted of malevolent and accidental intentions. In the identification condition, the participants were most accurate at recognising a malevolent intention, followed by an accidental, benevolent, and ambiguous intention, respectively. Especially the first and fourth types of acts evoked a greater proportion of verbal reactions that were aggressive than the second and third types of acts did. In general, the highest number of misinterpretations and, consequently, the highest proportion of unwarranted malevolent reactions tend to be found among frequently or chronically aggressive children (Dodge & Coie, 1987; Dodge, Price, Bachorowski, & Newman, 1990; Dodge & Somberg, 1987).

Original Study I: Situational Factors and the Relationship between the Intensity of Proactive and Reactive Aggression

The foregoing findings both illustrate the distinction between proactive and reactive aggression and explain why some children display reactive aggression more often than others do. The nature of reactive aggression also depends, however, on its consequences (Juujärvi, Kooistra, Kaartinen, &

Pulkkinen, 2001). Our view originates from the early studies of Pulkkinen (f. Pitkänen) who utilised verbal and visual descriptions of 'thwarting situations' (Pitkänen, 1969). Her experiments did not involve variation in the intentions of the child who started the interaction (i.e., whether the act was deliberately harmful or not), but the characteristics of the offender (sex and physical size) and the type of the offending act (verbal and physical aggression) were varied. Pulkkinen found that stories depicting a peer who committed an act of direct offensive aggression evoked verbal reactions indicating the use of direct defensive aggression. Alternatively, when the stories described adults who acted in a similar manner, the verbal reactions exemplified both direct and indirect defensive aggression; the latter is including reactions such as angry facial or verbal expressions. Furthermore, only the former type of stories elicited the type of variation in the verbal reactions that was associated with the individual tendencies for aggressiveness (Pitkänen, 1969).

The pictorial stimuli comprising the *Pulkkinen Aggression Machine* (PAM) were designed on the basis of the verbal data (Pitkänen, 1969; 1973*a*). The situation was specified as a quarrel between two persons, and the contents of the eight hostile acts and reactions was further limited to physical aggression. The hypothesis, derived from social learning theory, was that although the physical attacks would evoke physical defence, the correspondence of the intensity of defence to that of the attack would reflect the participants' prior experiences of the rewards or punishments that would be likely to follow.

The acts of offensive aggression were presented and the reactions of defensive aggression were recorded under the conditions of impulsive and controlled aggression, respectively. In the former condition, there were no cues to identify either the offender or the defender. The participants defended themselves in whatever way that pleased them, without thinking of the possible consequences. In the latter condition, two pictures were shown to that specified the offender and the defender. Six figures served as the offender; a same-sized peer of the same sex (A), a bigger child of the same sex (B), a same-sized peer of the opposite sex (C), a smaller child of the same sex (D), a parent of the same sex (E), or a parent of the opposite sex (F).[1] The participants were now instructed to defend themselves in the way they would in a real situation.

Both the original data of 60, and the replication data of 109 elementary school children generated data that supported the hypothesis (Juujärvi,

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[1] The original PAM apparatus included a program disk, a row of lamps and a row of buttons. Between these rows were the pictures denoting the acts of physical aggression. The stimuli and responses were recorded on plotter paper as bars of varying height and width. The records obtained were manually coded into numerical form prior to the statistical analyses. The new PAM paradigm was run by a VisualBasic program controlling a computer and a touch-sensitive screen. The numerical stimulus and response data were stored in ASCII files that were automatically compiled as part of an SPSS data file. The picture of the computerised PAM and the specific instructions for the conditions of impulsive and controlled aggression have been published in Juujärvi et al. (2001), pp. 432-434. The participants, procedures, variables, and statistical designs of the original studies are summarised in the Appendix.

Kooistra, et al., 2001; Pitkänen, 1973*a*). As expected, the intensity of the acts of offensive aggression corresponded to the intensity of the reactions of defensive aggression primarily in the condition of impulsive aggression (Original Study I, p. 436). In contrast, the difference between the intensity of attack and defence varied in the six sub-conditions of controlled aggression (Original Study I, p. 438). The difference between the intensity of offensive and defensive aggression was smallest in condition A (–0.37 units of the intensity scale) and largest in condition E (–1.45 units), followed by condition F (–1.42 units). Together, these results indicated that defensive aggression was reinforced in different ways against the offensive aggression of equal-status versus dominant offenders (Strayer & Strayer, 1976). While the parity of proactive and reactive aggression may not escalate the bout or result in social sanctions between equal partners, such consequences are likely when one partner is an adult and the other partner is a child (Suomi, 2001; Youniss, 1980).

The effects of the individual tendencies towards aggression, as determined from the independent ratings of teachers at school, were also investigated; and the results were in agreements with those previously obtained (Pitkänen, 1969). While the original study showed that higher levels of aggressiveness were related to more intense defence against the attacks of same-sized peer of the same sex in condition A (Pitkänen, 1973*b*), the replication study also revealed differences between the aggressive and non-aggressive children in the correspondence of the intensity of offensive and defensive aggression towards the same-sized peer of the opposite sex in condition C and the smaller child of the same sex in condition D (Original Study I, p. 440). Further analyses of the replication data also indicated that these differences in the intensity of reactive aggression were either amplified or eliminated, depending on the intensity of the proactive aggression, but I will return to these results in the following chapter.

In conclusion, then, the observation studies demonstrate that unshared conceptions about the course of play function as antecedents to conflicts, but not to reciprocal aggression. Nevertheless, the more prolonged the conflicts are, and the more self-concerned the children become, the more often proactive and reactive aggression ensues. Although the basic events of this sequence are modelled in the PAM, our experimental design is by no means complete. The studies of Hartup, Laursen, and colleagues showed that friendship increases constructive overtures at the expense of aggressive ones (Hartup, French, et al., 1993; Hartup, Laursen, et al., 1988; Laursen & Hartup, 1989). In the PAM, neither the status of the prior relationship between the attacker and the defender nor the repertoire of non-aggression is specified in such detail. Nevertheless, once the focus moves from a pair of children to one child, the dynamics of conflicts may also be considered in terms of the individual processes that either facilitate or inhibit the expression of aggression.

Emotion and Aggression

In case children share an understanding of the pleasurable nature of the interaction, rough-and-tumble play may encompass the same repertoire of acts that conflicts and aggression do (Humphreys & Smith, 1987). Even in this case, the physical proximity and teasing may suddenly turn to interpersonal conflicts and reciprocal aggression (DeRosier, Cillessen, Coie, & Dodge, 1994; Keltner, Capps, Kring, Young, & Heerey, 2001). These observations characterise Averill's (1982) position on the social origins of emotion. Human beings enter social situations with anticipations of the actions that will happen. The enactment of social roles follows the prescribed norms and rules that also influence the way emotions are experienced. Those interactions that transgress against the norm of reciprocity provoke the individual feeling of anger (Averill, 1982; Bugental, 2000). The deliberate deprivation of the available benefits or opportunities and the resulting feeling of anger pave the way for expressive reactions and instrumental behaviour attempting to correct the harmful state of affairs. Thus, Lazarus (1991) defines anger as the primary appraisals allowing the individual to evaluate the harm the other person does to the attainment of personal goals and as the secondary appraisals permitting the individual to judge the intentionality of the harmful action. Although anger induces various reaction tendencies, individuals seek to modulate either their feeling of behaviour through coping; the third form of appraisal that involves evaluating, among other things, the effectiveness (i.e., the rewards) and the appropriateness (i.e., the punishments) of different reactions (e.g., aggression).

Eisenberg and her colleagues focused on coping and temperament theories in their study of play interactions, conflicts, and anger in a sample of 93 pre-school children (Eisenberg, Fabes, Bernzweig, Karbon, Poulin, & Hanish, 1993; Eisenberg, Fabes, Nyman, Bernzweig, & Pinuelas, 1994; Fabes, Eisenberg, Smith, & Murphy, 1996). The authors applied a focal sampling design to collect observation data on the participants' playground behaviour. They also administered global ratings to gather information about the children's attentiveness towards the emotional events, the intensity of expressive reactions, and the preferred form of instrumental behaviour in general.

The observation data showed that attempts to gain possession of toys or acts of proactive aggression evoked anger in participants (Fabes et al., 1996). When angered, the children simply repossessed the toy or objected to their partner's actions. Other reactions included both venting of anger through facial or verbal expressions or aggression (cf., Averill, 1982, p. 193). The rating data revealed that the more intense the emotional expressions that participants were reported to display overall, the less egalitarian and reciprocity-promoting behaviour they were considered to show in general (Eisenberg et al., 1993). Once the observation data were regressed on the rating data, the results indicated that more intense orienting of attention towards emotional events, higher levels of emotional expressiveness, and aggression predicted greater

venting of anger and aggression in the observed conflict situations (Eisenberg et al., 1994). Alternatively, displays of constructive behaviour predicted the use of verbal objections towards the partner. Thus, individual tendencies to become easily angered contribute to the differences between children in the use of aggressive tactics in everyday conflict situations (cf., D. Shantz, 1986).

Original Study I: Individual Dispositions and the Relationship Between the Intensity of Proactive and Reactive Aggression

The relationships between the observation and rating data obtained by Eisenberg and her colleagues agree, in part, with the associations between the experimental and rating data obtained by ourselves (Juujärvi, Kooistra, et al., 2001). Recall that the PAM varied the intensity of proactive and reactive aggression under the conditions of impulsive and controlled aggression. The conditions manipulated, in turn, the physical and social characteristics of the attacker and the consequences of the defensive aggression. Beyond the general result that the same attacks evoked differential defence when the attacker was a same-sized peer of the same sex (condition A) rather than a parent of the opposite sex (condition F), the aggressive participants defended themselves more intensively than the non-aggressive participants did in three conditions, A, C, and D. This results corroborates that of Eisenberg et al. (1993, 1994) in demonstrating that the effects of individual dispositions for aggression manifest themselves primarily during interactions between peers of equal or nearly equal strength.

Our additional comparisons between the aggressive and non-aggressive participants showed that the effects of dispositional factors were present in the defence to minor attacks such as slight pushes or pinches, but not to major attacks, like being knocked to the ground or punched in the face (Original Study I, pp. 441 – 442). In terms of the units of the intensity scale, the differences between the two groups were 0.63 and 0.47 units, respectively. These results are intriguing, for they suggest that the aggressive children were only partially insensitive to the punishing aspects of defensive aggression. Under low-intensity circumstances, regardless of the physical or social status of the opponent, the aggressive participants defended themselves with an intensity that exceeded that of the attacks. I hasten to note that the non-aggressive participants too displayed reactions that matched the acts of the opponent; as one would expect on the basis of the literature on the norms of reciprocity and legitimate self-defence (Bettencourt & Miller, 1996; Bugental, 2000). Under high-intensity circumstances, however, the aggressive children appeared to have the same (*i*) understanding of the consequences of a too-intense defence against the attacks of figures who are in a superior physical or social position, (*ii*) ability to appraise the potential threat of future harm, and (*iii*) capacity to inhibit the intensity of their aggressive reactions relative to the intensity of the aggressive actions, as the non-aggressive children did.

What factors, then, push away and pull towards the conscious contemplation of the social costs of defensive aggression? Eisenberg and her

colleagues, like many others, believe that the answer to this question lies in the constitutionally organised individual differences in emotional reactivity and its cognitive regulation (e.g., Eisenberg, Fabes, Nyman, et al., 1994; Eisenberg, Fabes, Guthrie, & Reiser, 2002). This proposition is also a variant of the argument that the emotions that organise behaviour are fundamentally of biological origin.

Original Study II: Cardiac Reactivity and Aggression

Berkowitz (1993, 2000) maintains that overt unpleasant acts evoke covert affective and motor-expressive tendencies that are realised as overt reactions, including aggression. The covert tendencies correspond to the activity of the central and autonomic nervous systems that can be referenced, for instance, to the contraction rate of the heart muscle (Levenson, 1992).[2]

The classic experiments of Ax (1953) and Frodi (1978) demonstrate how heart rate (HR) illustrates the covert tendencies that are elicited in response to an interpersonal provocation. Both investigators disclosed an ostensible purpose for the study to their participants and had a trained confederate to interact with the participants, either in a neutral or an unfriendly manner. Whether the participants were accused of disturbing the recording of their physiological activities, or their personal qualities were commented on in a condescending and hostile way, the unexpected provocations resulted in an increase of HR. In Frodi's study, the provocation situation was followed by the Buss aggression paradigm, which allowed the participant to punish the confederate for his or her errors in a signal-detection task. In accordance with the proposal of Berkowitz, she found that the provoked participants who had experienced an unpleasant event awarded more severe punishments than the non-provoked participants did.

We monitored the cardiovascular activity of the children who participated in the replication study (Juujärvi, Kooistra, et al., 2001) while the participants confronted the acts of offensive aggression with the reactions of defensive aggression (Juujärvi, Kaartinen, Laitinen, Vanninen, & Pulkkinen, in press). Although the two studies mentioned above and as well as certain other studies suggested that physical attacks might elicit an increase in HR to promote physical defence, we weighed two additional hypotheses concerning the particular properties of the PAM paradigm and the individual dispositions of the participants.

Unlike Averill (1982) or Lazarus (1991), Berkowitz (1993, 2000) does not

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[2] Each contraction of the heart muscle pumps oxygenated blood to the circulatory system and this activity generates an electrophysiological waveform including the R wave at the end of each cycle (e.g., Brownley, Hurwitz, & Schneiderman, 2000). The waveforms oscillate to the body's surface from where they can be recorded with pairs of electrodes measuring the electrical potential difference between two locations. The continuous signal is analysed to detect the successive R waves, and the intervals that have elapsed in between are calculated in milliseconds (1/1000 s). The R-R intervals can be transformed to the more common measure of heart rate with the following equation: heart rate = (60×10^3) / R-R interval (e.g., Hugdahl, 1995).

acknowledge that cognitive appraisals are a necessary condition for emotion and aggression, he recognises that conscious judgements on the consequences of aggression can inhibit overt reactions. Therefore, drawing on data from experiments that varied the affective, attentional, memory, or motor requirements of sophisticated tasks, we expected that the varying unpleasantness of the offensive aggression would manifest itself as a decrease component in the mean HR reactivity score (e.g., Hare, Wood, Britain, & Shadman, 1970; Hare, Wood, Britain, & Frazelle, 1971). Further, we expected that the consideration and the execution of the defensive aggression would express themselves as an increase component in mean HR (e.g., Hare, 1972*a*, 1972*b*, Sherwood, Allen, Murrell, & Obrist, 1988; Yuille & Hare, 1980). In view of Eisenberg and her colleagues' (2002) assumption that children vary in their emotional reactivity and its cognitive regulation, we assumed that the individual dispositions would influence the magnitude of the mean HR components from one participant to another (Bradley, 2000; Hare, 1973). [3]

The results showed individual variation in the direction and magnitude of mean HR reactivity (Original Study II, p. 11). The patterns of (*i*) strong increase of HR, (*ii*) moderate increase of HR, and (*iii*) decrease of HR were interpreted against the variation in heart rate reactivity and the correspondence between the intensity of proactive and reactive aggression.

The fluctuation of HR is highly dependent on the parasympathetic and the sympathetic activity of the autonomic nervous system that is reflected in the low (LF: 0.04 – 0.15 Hz) and high (HF: 0.15 – 0.40 Hz) frequency bands of heart rate variability (e.g., Akselrod, Gordon, Madwed, Snidman, et al., 1985; Akselrod, Gordon, Ubel, Shannon, et al., 1981). The parasympathetic activity can manifest itself in both frequency bands, but the sympathetic activity is confined to the low frequency band. This division characterises the difference between the two systems in their temporal effectiveness, i.e., in the time in which their influences can vary the contraction rate of the heart muscle. Our results indicated that the variation in HR reactivity related primarily to the changes in the parasympathetic activity, for the power of the frequency spectra changed in the HF rather than LF band of heart rate variability (Original Study II, p. 12).

Furthermore, children who displayed either a strong increase or decrease of HR exhibited less intense defence in response to major attacks than children who showed a moderate increase of HR (Original Study II, p. 13). The differences between the three groups were as follows: strong HR increase vs. HR decrease = 0.47 units of the intensity scale; HR decrease vs. moderate HR increase = 0.64 units; and strong HR increase vs. moderate HR increase = 1.11

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[3] In previous studies that have investigated the effect of provocations on cardiovascular activity, the dependent variable represents the difference between the mean levels of HR during the manipulation and the preceding baseline period. In our study, the HR components within the mean HR scores, calculated for each of the six task conditions (A to F), characterise our hypothesis of the set of the covert tendencies that mediated the relationship between the offensive and defensive aggression. The empirical derivation of the component processes from the ambulatory data would have required an inconceivable effort.

units, respectively.

Thus, our results indicated that offensive aggression evoked a set of affective, cognitive, and motor tendencies that contributed to the expression of defensive aggression (Berkowitz, 1993, 2000; Lazarus, 1991). The presence of the three distinct patterns of mean HR reactivity suggested that this set varied from one participant to another because of variations in individual predispositions to emotional reactivity and its cognitive regulation (Eisenberg, Fabes, Nyman, et al., 1994; Eisenberg, Fabes, Guthrie, et al., 2002).

We presumed that the pattern of strong HR increase reflected the net effect of high emotional reactivity and sufficient allocation of cognitive resources to promote the most optimal levels of defensive aggression. Similarly, we assumed that the patterns of moderate HR increase and HR decrease differed in terms of emotional reactivity, but not in terms of the apportionment of cognitive resources. The correlation between mean HR reactivity and teachers' ratings of low self-control of emotions indicated that the greater the decrement of HR was, the higher the participants scored on the scales for depressive symptoms, anxiety, and aggression. Thus, our conclusion was that the pattern of moderate HR increase illustrated lower levels of emotionality and scant allocation of cognitive resources, but the pattern of HR decrease highlighted higher levels of emotionality and scant apportion of cognitive resources.

To the extent that our characterisations of the different HR reactions are accurate, our results imply that the interaction between low levels of emotional reactivity and its cognitive regulation carries a more severe risk for future punishment than the interaction between high levels of emotional reactivity and low levels of cognitive regulation does. This suggestion stems from comparisons between the three groups of children in their defence to minor and major attacks (cf., Juujärvi, Kooistra, et al., 2001).

Both analyses indicated that the participants varied, to some degree, the intensity of the defensive reactions relative to the intensity of the offensive acts when the characteristics of the attacker were changed from one condition to another. The children who displayed a moderate increase of HR exhibited the most intense defence towards the minor attacks, followed closely by the children who showed a decrease of HR. Those children who displayed a strong increase of HR expressed the least intense reactions, but they also tended to match the acts of the attacker.[4] The pattern of responses to major attacks was somewhat different. While the children with a moderate HR increase continued to display the most intense defence against the major attacks, the children with a decrease of HR now reacted in a way that mirrored the reactions of the children with strong HR increase.

Thus, it seems that under high-intensity circumstances, high levels of emotional reactivity push the children towards some sort of inhibition of defensive aggression, regardless of the resources they have for the deliberate

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[4] In the statistical analysis of the data, these differences between the three groups were not significant.

contemplation of the associated rewards or punishments in general.

Original Study III: Effortful Control and Aggression

The results of original studies I and II suggested that the individual dispositions for emotional reactivity and its cognitive regulation moderated the relationship between the intensity of proactive and reactive aggression. However, elucidation of the unique and joint contributions of these factors proved to be difficult (cf., Bradley, 2000; Eisenberg et al., 1993; Hubbard, Smithmyer, Ramsden, Parker, et al., 2002).

In principle, however, the distinction between the unconscious affective and the unconscious / conscious cognitive components of emotion is a straightforward matter. Emotion theorists contend that these processes are subserved by two hierarchically-organised neurophysiological systems that interact to bring about the overt reactions that are actually observed (e.g., R. Davidson, 1992; R. Davidson, Jackson, & Kalin, 2000; Lang, Bradley, & Cuthbert, 1990, 1998; LeDoux, 1996). While the information about a pleasant or an unpleasant act is being relayed from the sensory organs to the designated areas of the sensory cortex, the thalamic nuclei along these pathways generate signals that also activate a number of sub-cortical nuclei, the rudimentary affective-motivational systems. The amygdaloid-hypothalamic-periaqueductal network is, in turn, in a position to alter the activity of both anterior cortical nuclei and autonomic nervous system. Once the sensory information is transformed to a cortical representation, the anterior regions of the cortex promote, maintain, or inhibit the activity of the autonomic and somatic systems that have already been primed to enact the overt reaction.

Temperament theorists complement this view of emotions and their biological underpinnings with an auxiliary assumption of constitutional dispositions in the physiology of emotional reactivity and/or its cognitive regulation (Rothbart & Bates, 1998; Rothbart & Putnam, 2002). Rothbart and her colleagues define effortful control as voluntary attentional regulation of emotional reactivity and ensuing reaction tendencies (Posner & Rothbart, 1998, 2000; Rothbart, Derryberry, & Posner, 1994). Drawing on neurophysiological data from animal and human experiments, these investigators distinguish between three attention systems, one being the executive attention network that is subserved by the dorsal prefrontal cortex. This form of attention may be conceived as subsumed in working memory, inhibitory, and motor-preparatory processes that become co-activated in varying degrees of strength during cognitive challenges as well as pleasant and unpleasant situations (e.g., Fuster, 1997; Groenewegen & Uylings, 2000).

Our participants completed a battery of executive cognitive tasks (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003) and we submitted these data to principal axis and confirmatory factor analysis. The results indicated that latent working memory, inhibition, and shifting processes were differentially activated during the respective tasks, although they remained strongly

correlated (Miyake, Friedman, Emerson, Witzki, et al., 2000; van der Meere, 1996). Following the temperamental tenet that differences between individuals may be viewed in dispositional terms only when they persist across situations and over time, we investigated how effortful control moderated the relationship between the intensity of offensive and defensive aggression during the PAM (Juujärvi, Kaartinen, Vanninen, Laitinen, & Pulkkinen, 2003).

The correlation structure of the cognitive task variables also represented the rank ordering of the participants' cognitive performances. For this reason, we tested the hypothesis that these differences between children would also manifest themselves as individual variation in the cognitive control of reactive aggression in the PAM. In view of the fact that the individual variation found in executive cognitive functioning is related to the individual variation in intelligence both conceptually (e.g., Sternberg, 2000) and empirically (Lehto et al., 2003), we adjusted the cognitive and aggression data to the levels these would have been if the participants had scored identically on the short-form intelligence test.

In contrast to the results of the original studies I and II, the difference between the intensity of offensive and defensive aggression did not vary statistically significantly according to the offender's physical and social status in the six sub-conditions of controlled aggression. As expected, however, the better the participants were at focusing their attention on certain sensory cues while ignoring others, on the basis of rules that were maintained active in the working memory, the more they attenuated the intensity of their defence relative to the intensity of attacks during the PAM (Original Study III, p. 14).

When the analysis was concerned with the defence towards minor attacks, those children who were assigned to the highest tertile of working memory performance differed from the middle and lowest tertiles by 0.28 and 0.47 units of the intensity scale.[5] When the analysis was confined to the reactions towards the major acts, the differences between the three groups were more pronounced: high vs. middle tertile = 0.53 units; middle vs. low tertile = 0.61 units; and high vs. low tertile = 1.15 units. In contrast, the ability to inhibit a particular response until the potential repertoire of responses was sufficiently weighed in the cognitive tasks was *not* predictive of the attenuation of defensive aggression relative to offensive aggression during the PAM (Original Study III, p. 14). Further investigations on the relationships between effortful control, intelligence, and aggression revealed that the better the children performed on the four working memory tasks and the Vocabulary task of the WISC-R intelligence scale, the greater was the difference between the intensity of proactive and reactive aggression (Original Study III, p. 21).

We also sought to verify our conclusions concerning the effects of cognitive processing on cardiovascular reactivity (Juujärvi, Kaartinen, Laitinen, et al., in press), but the analyses yielded mixed results. While the

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5 In the statistical analysis of the data, these differences between the three groups were not significant.

three levels of working memory were differentially related to the withdrawal of the parasympathetically-sympathetically mediated low frequency (LF: 0.04 – 0.15 Hz) activity, the continuous working memory score did not predict the magnitude of reactivity in heart rate variability.

The Research Problem: Main Findings of Original Studies I – III

The findings from the three original studies demonstrate that Pulkkinen's original hypothesis (1969, 1973*a*) regarding the relationship between proactive and reactive aggression can also be interpreted in emotional terms. The most well-established finding was that the children's appraisals of the consequences of their reactions mediated the relationship between the intensity of offensive and defensive aggression, as the participants varied their reactions according to the physical and social characteristics of the attacker (Averill, 1982; Lazarus, 1991). The findings of the original study III showed, however, that also the proportion of the variance that had been attributed in studies I and II to the manipulation of the situational factors was to be explained with individual variation in 'crystallised' intelligence (J. Davidson & Downing, 2000; Kihlstrom & Cantor, 2000). Hence, although the participants' conscious cognitions did modulate the evoked unconscious affective and motor-expressive tendencies, the differences between children in their learning and resulting knowledge of the consequences of aggression emerged as an important dimension of social cognition.

At the same time, the findings indicated that the covert cognitive, affective, and motor-expressive tendencies may be viewed also in neurophysiologically and dispositional terms (R. Davidson et al., 2000; Rothbart & Bates, 1998; Rothbart & Putnam, 2002). Whether the cognitive regulation of emotional reactivity was inferred from teacher rating questionnaire items to show high self-control of emotions (e.g., "Tries to act reasonably even in difficult situations."), strong increase of cardiovascular activity, or good performance in the working-memory tasks, higher levels of self-regulation capacity had a positive effect to the relationship between the acts of offensive aggression and the reactions of defensive aggression. By contrast, the dispositional emotional reactivity seemed to have both positive and negative effects on children's behaviour. Teachers' ratings of low self-control of emotions (e.g., "May hurt others when angry, e.g., by hitting, kicking, or throwing things at them.") and a decrease of cardiovascular activity were related to unwarranted intensity of defence only towards the minor, not the major attacks. In fact, the findings of the original study II suggest that high levels of emotional reactivity promote more optimal levels of defence than low levels of emotional reactivity do; a conclusion that is consistent with the proposition that emotions, even negative ones, serve to adapt behaviour in unpleasant situations (Levenson, 1999).

GENERAL DISCUSSION

The three decades since the publication of the article that introduced the PAM paradigm (Pitkänen, 1973*a*) have witnessed the revival of interest in emotion (Ekman & Davidson, 1994). The ongoing debate between the social-cognitive and biological theorists over specific emotions versus motivational tendencies as providing the most valid theoretical basis, and the most appropriate levels of analysis for research has stimulated the empirical activities to their current vigour. I have interpreted the behavioural and the physiological data of the three original studies as subscribing to a hierarchical view of emotion (Levenson, 1999) with special emphasis on the insight that each level of analysis is susceptible to the concurrent social, psychological, and biological influences (Averill, 1982). Therefore, I argue that the varying relationship between the intensity of simulated physical offensive and defensive aggression represents the interaction between the socio-individual and the biological emotion systems.

We have sought to explain our findings within the framework of a sophisticated control system that tunes the input and output of a rudimentary core system, yet the adoption of this position necessitates the exploration of its empirical implications. To ascertain the role of conscious appraisal, and individual differences in the knowledge of the consequences of reactive aggression, for instance, one would need to develop a series of questions probing the children's thoughts about the instigation for reactive and proactive aggression in the different situations of the PAM paradigm (e.g., Averill, 1982; Dodge et al., 1984; Kihlstrom & Cantor, 2000). The breaking-down of the PAM paradigm into various specific conditions that would activate only a certain executive, affective, or motor-expressive tendency, or a combination of such tendencies, would facilitate the psychophysiological study of the cycle of proactive and reactive aggression in general and the individual differences thereof in particular (e.g., Gross, 1998; Gross & Levenson, 1993, 1997; Juujärvi, Kaartinen, Laitinen, et al., in press).

In regard to future research, then, what unique and joint influence do the

conscious appraisals and the unconscious executive functions have on reciprocal aggression in familiar and in unfamiliar conflict situations, like between two peers as opposed to a child and an adult? How do the unconscious affective tendencies vary and interact with the unconscious / conscious cognitive processes during the cycle of proactive and reactive aggression under different circumstances? A careful perusal of the set of overt and covert tendencies is a *sine qua non* for the interpreting of the (probably non-linear) interactions that yielded the strongest influence on the difference between the intensity of proactive and reactive aggression as considered in terms of the statistical effect sizes from the original studies II and III (cf., Fischer & Bidell, 1998; Gottlieb, Wahlsten, & Lickliter, 1998).

Thus, the hierarchical framework employed in connection with emotion has both theoretical and methodological ramifications, but the latter have seldom been considered in the developmental-temperamental research on children (e.g., Cole, Martin, & Dennis, in press; Gross, 1999; Parrott & Hertel, 1999; Rothbart & Putnam, 2002; Thompson, 1990). I maintain that the quality of information about the complicated interactions between the multiple situational and the multiple dispositional factors responsible for children's emotions and for their social behaviour could be improved through concurrent implementation of experimental studies with physiological measurements, and direct observation that is supported by questionnaires (e.g., Eisenberg, Fabes, Guthrie, & Reiser, 2000; Eisenberg, Fabes, et al., 2002).

Besides the advances in emotion research, the last three decades have also witnessed a renewed interest in peer interactions and relationships (Ladd, 1999). Although the correlation between the observed acts of proactive and reactive aggression (Fabes et al., 1996) parallels the relationship between the offensive and defensive aggression in our experimental thwarting situations, certain aspects of children's conflicts and aggression are rather ill-portrayed in the PAM. Manipulation of children's knowledge of the prior relationship between themselves and the attackers, the implementation of reaction alternatives that are constructively non-aggressive, and the enactment of longer sequences of reciprocal aggression would improve the validity of our paradigm (Coie, Dodge, Terry, & Wright, 1991; Hartup, Laursen, et al., 1988; Juujärvi, Kaartinen, Vanninen, et al., 2003; Juujärvi, Kooistra, et al., 2001; C. Shantz, 1987). Consider, for example, two algorithms that escalate the cycle of aggression but terminate randomly; either in an act of proactive aggression or in an act of reactive aggression. The differential weighing of these algorithms would permit the discriminant conditioning of the reactions to the punishing (i.e., the presence of a new aversive action) or the rewarding (i.e., the absence of a new aversive action) consequences, that is, the study of learning about and adapting to the various challenges of the social life (Bugental, 2000).

YHTEENVETO

Lasten aggressiivisiin puolustusreaktioihin vaikuttavien tekijöiden kolmitasoinen analyysi

Lasten ristiriitatilanteiden ja niihin liittyvän aggressiivisen käyttäytymisen tutkimuksella on vahvat perinteet. Havainnointiin perustuvat tutkimukset tuottavat yksityiskohtaista tietoa ristiriitatilanteiden synnystä, niiden kestosta ja ratkaisuista, mutta aineistojen kerääminen on työlästä. Kokeellisia menetelmiä hyödyntävät tutkimukset eivät kykene yhtä kattavan tilannetekijöiden kirjon kuvaamiseen, mutta ne tarjoavat mahdollisuuden keskeisten tekijöiden järjestelmälliseen muuntelemiseen.

Pulkkinen Aggression Machine (PAM) kuvaa kahden lapsen ristiriitatilannetta, joka saa aggressiivisen hyökkäyksen ja puolustautumisen muodon. Kokeen aikana tapahtuvien aggressiivisten hyökkäysten ja puolustusreaktioiden voimakkuus vaihtelee harmittomista teoista kasvoihin suuntautuviin lyönteihin. PAM alkaa impulsiivisen aggression tilanteella, jossa hyökkääjää ei määritellä ja puolustautujan asemassa olevien tutkittavien ei tarvitse harkita tekojensa seurauksia. Seuraavaksi on kuusi kontrolloidun aggression tilannetta, joissa hyökkääjänä toimivat samaa sukupuolta oleva samankokoinen lapsi, samaa sukupuolta oleva suurempi lapsi, eri sukupuolta oleva samankokoinen lapsi, samaa sukupuolta oleva pienempi lapsi, samaa sukupuolta oleva vanhempi ja eri sukupuolta oleva vanhempi. Nyt tutkittavien tehtävänä on puolustautua samalla tavalla, kuin he tekisivät todellisessa tilanteessa.

Ensimmäinen tutkimushypoteesini oli, että aggressiiviset hyökkäykset saavat aikaan aggressiivisen puolustusreaktion, mutta näiden tekojen voimakkuuden välinen ero riippuu puolustusreaktion fyysisistä tai sosiaalisista seurauksista. Esimerkiksi nipistykseen reagoiminen uudella nipistyksellä voi aikaansaada hyvin erilaisia seurauksia riippuen siitä, ovatko hyökkääjä ja puolustaja tasavertaisia tovereita vai eivät. Tutkimukseni toinen hypoteesi oli, että tunteiden viriämiseen ja niiden säätelyyn liittyvät yksilölliset taipumukset muuntaisivat aggressiivisten hyökkäysten ja puolustusreaktioiden voimakkuuden välistä erotusta.

Tutkimukseni perustui professori Lea Pulkkisen Lapsesta aikuiseksi-seurantatutkimukseen, joka on seurannut 369 henkilön elämää vuodesta 1968 vuoteen 2001 saakka. Kaikkiaan 109 henkilöä ja heidän perheenjäsentään osallistui vuosina 1997 - 1999 laboratoriotutkimukseen, jonka eräänä tavoitteena oli arvioida perheisiin kuuluneiden lasten tunne- ja kognitiivisia taitoja. Tutkimusaineiston keruu suoritettiin edellä kuvatun PAM-menetelmän ja sen aikana suoritetun sydämen lyöntinopeuden mittaamisen, kahdeksan kognitiivisen tehtävän, lyhyen älykkyystestin ja opettajille suunnatun kyselylomakkeen avulla 61 pojalta ja 49 tytöltä. Tutkittavia ryhmiteltiin sekä hierarkkisen klusterianalyysin että faktorianalyysin avulla tuotettujen muuttujaprofiilien perusteella. Tilastollisten menetelmien avulla saavutetut ryhmät kuvasivat lasten välisiä eroja aggressiivisessa käyttäytymisessä kouluympäristössä, sydämen sykkeen muutoksissa ja kognitiivisessa suorituskyvyssä. Ryhmävertailuja suoritettiin sekä yhden (ANOVA, t-testi) että usean (toistettujen mittausten ANOVA) riippuvan muuttujan suhteen. Lisäksi laskettiin faktorianalyy-

sin avulla tuotettujen painotettujen summapistemäärien välisiä korrelaatiokertoimia ja hierarkisia regressioyhtälöitä.

Ensimmäisen osatutkimuksen tulokset olivat asetettujen hypoteesien mukaiset. Aggressiiviset hyökkäykset ja puolustusreaktiot olivat voimakkuudeltaan yhtä suuria, jos lasten ei tarvinnut harkita puolustusreaktioiden seurauksia tai hyökkääjä ja puolustautuja olivat fyysisten ominaisuuksien ja sosiaalisen aseman suhteen tasavertaisia tovereita. Mitä enemmän hyökkääjän ja puolustajan ominaisuudet poikkesivat toisistaan, sitä suurempi oli hyökkäysten ja puolustusreaktioiden voimakkuuden välinen erotus. Opettajille suunnatun kyselylomakkeen perusteella aggressiivisiksi arvioidut lapset reagoivat kiivaammin kuin ei-aggressiivisiksi arvioidut lapset silloin, kun hyökkäysten voimakkuus oli vähäinen. Aggressiivisten ja ei-aggressiivisten lasten puolustusreaktiot eivät poikenneet toisistaan silloin, kun hyökkäysten voimakkuus oli suuri.

Toisen osatutkimuksen tulokset osoittivat, että aggressiivisten hyökkäysten herättämä tunnetila ja pyrkimys sen säätelemiseen vaihtelivat tutkittavasta toiseen. Vähäistä tunnetilan viriämistä ja kognitiivista säätelyä kuvanneen sykeprofiilin omanneet lapset reagoivat kiivaammin kuin suurta tunnetilan viriämistä kuvanneen sykeprofiilin omanneet lapset, riippumatta näiden tutkittavien erilaisista pyrkimyksistä tunnetilan säätelemiseen. Kolmannen osatutkimuksen tulokset osoittivat yhtäältä, että aikaisempien tutkimusten osoittama aggressiivisten hyökkäysten ja puolustusreaktioiden voimakkuuden välinen suhde eri koetilanteissa riippui myös lasten välisistä eroista oppimisen kautta syntyvän älykkyyden tasoa mittaavassa tehtävässä. Toisaalta, mitä paremmat edellytykset lapsilla oli puolustusreaktion seurausten arvioimiseen eli tunnepitoisen toimintataipumuksen kognitiiviseen säätelemiseen, sitä paremmin aggressivisten hyökkäysten ja puolustusreaktioiden voimakkuuden välinen erotus kuvasi käyttäytymisen joustavaa sopeuttamista kulloisenkiin tilanteeseen.

Tutkimukseni keskeisin havainto on, että kaikki tutkittavat yrittivät sopeuttaa aggressiivisten puolustusreaktioidensa voimakkuutta suhteessa aggressiivisen hyökkäyksen voimakkuuteen, riippumatta heidän yksilöllisistä taipumuksistaan aggressiiviseen käyttäytymiseen. Aikaisemmat tutkimustulokset antoivat aiheen odottaa, että vahvan tunnetilan viriäminen ja sen heikko sääteleminen heijastuisivat kielteisesti kykyyn suunnata aggressiivisia puolustusreaktioita siten, että niistä seuraavat kielteiset vaikutukset olisivat mahdollisimman vähäiset. Tämä näkemys ei saanut yksiselitteistä tukea, koska yksilöllisten taipumusten yhdysvaikutus aggressiivisten hyökkäysten ja puolustusreaktioiden voimakkuuden väliseen yhteyteen riippui kulloinkin vallitsevien tilannetekijöiden yhdistelmästä. Millaisin perustein lapset arvioivat puolustusreaktioidensa seurauksia ja millä tavalla sosiaalisen oppimisen kautta syntyvät lasten väliset erot toiminnan seurausten arvioimisessa säätelevät tunnekokemusta ja/tai tunnepitoisia toimintataipumuksia? Voiko lapsille tyypillisiä puolustautumistapoja muuttaa niistä aiheutuvien seurausten järjestelmällisen muuntelemisen avulla? Näihin kysymyksiin vastaaminen edellyttäisi niin PAM-menetelmän kuin sen yhteydessä suoritettavien psykofysiologisten mittausten uudelleen suunnittelemista ja uuden koesarjan toteuttamista.

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APPENDIX: THE VARIABLES AND THE STATISTICAL ANALYSES OF THE ORIGINAL STUDIES

Participants

The present series of studies is a part of a larger program, the ongoing Jyväskylä Longitudinal Study of Personality and Social Development (Pitkänen, 1969; Pulkkinen, 1982, 1998). The original sample included every 8-year-old child enrolled in one of the twelve schools that were selected on a random basis from the schools of Jyväskylä, Finland. These 369 individuals (196 boys and 173 girls) have been contacted at ages 14, 20, 27, 33, and 36 for interviews and collection of questionnaire data.

At age, we contacted 145 original sample participants who were married and had at least one 8-to-14-year-old child of the same sex as themselves. One hundred and nine individuals (55 men and 54 women), their spouses (34 men and 42 women), and offspring (61 boys and 48 girls) participated in the laboratory study of children's cognitive and emotional development.

The comparisons between the eligible original sample and the participating individuals revealed no differences in terms of labour market situation, occupational status, or occupational education. The comparisons between the data from the longitudinal study and the data from Statistics Finland indicated, in turn, that the original sample individuals represented the 1959 cohort of Finns (Pulkkinen, Fyrstén, U. Kinnunen, M.-L. Kinnunen, et al., 2003).

Laboratory Protocol

The laboratory protocol involved a large battery of tests and questionnaires for the children, as well as dyadic and family interaction tasks. The order of presentation of the tasks was the same for all children.

During the first visit everyone completed two tasks with the experimenter followed by three additional tasks with family members. After a 20-minute break, children completed four tasks from the cognitive assessment battery, the Auditory Attention and Response Set task (AARS; Korkman, Kirk, & Kemp, 1998), Mazes from the WISC-R battery (Wechsler, 1974), the Trail Making Test (TMT; Reitan & Wolfson, 1992; Närhi, Räsänen, Metsäpelto, & Ahonen, 1997), and the Verbal Fluency test (VF; Korkman et al., 1998). In addition, IQ was estimated with a short form of the WISC-R (Sattler, 1992; Wechsler, 1974).

When the children returned to the laboratory for their second visit, electrocardiogram (ECG) electrodes were attached to their chests after which the participants were asked to perform a task that lasted from 30 to 60 minutes. Next, there was a 20-minute break followed by the recording of baseline ECG for 3 minutes. Then, the participants were presented with the PAM paradigm (Juujärvi, Kooistra, et al., 2001; Pitkänen, 1973). Finally, the participants were required to complete the four remaining tasks in the cognitive assessment

battery: the Matching Familiar Figures Test (MFFT; Kagan, Rosman, Day, Albert, & Phillips, 1964), Spatial Span (SPAN; Owen, Downes, Sahakian, Polkey, & Robbins, 1990), the Spatial Working Memory test (SWM; Owen et al., 1990), and Tower of London (TOL; Owen et al., 1990).

An informed consent was obtained from the parents to have the teachers to complete the Multidimensional Peer Nomination Inventory (MPNI; Pulkkinen, Kaprio, & Rose, 1999) on their offspring.

Procedures

We determined children's cognitive capacity on the basis of their performance across eight computerised or paper-and-pencil tasks. These were administered by psychology students who had completed a supervised field-training program prior to their recruitment, and then undergone further training at our laboratory.

AARS. In the first condition of the AARS, children monitored an audiotaped list of 60 words that were presented with an inter-stimulus interval (ISI) of 1 s. The instruction was to detect a cue word '*red*', pick a red token from the table, and put it into a box within 2 s from cue presentation. In the second condition of the AARS a new list of 60 words was presented, again with an ISI of 1 s, but the relationships between the cues and the tokens were changed: detection of a cue word 'red' was now supposed to prompt the selection of a yellow token and *vice versa*. In addition, children also needed to react to the presentation of a cue word '*blue*' by picking up a blue token and putting it into the box.

Mazes. Children completed 10 mazes of increasing difficulty. The instruction was to trace the path from the centre of the maze to the exit without entering dead-end alleys or crossing the walls.

TMT consisted of three arrays of stimuli that were dispersed irregularly across a piece of paper and the instruction was to connect the items in a specified order. The first array (part A) consisted of numbers (1 to 15) that needed to be connected from the smallest to the biggest. The second array (part B) included both numbers {*1*, *2*,…,*8*} and letters {*A*, *B*,…,*H*} that were connected in the following order: {1, A, 2, B, … , 8, H}. In part C children needed to the follow alphabetical order in connecting the letters from A to O.

VF. In the variant of the VF task used in our laboratory children listed as many words as possible from four categories (animals, food, and words beginning either with '*k*' or '*s*') in the course of 60 s.

MFFT comprised 12 sets of a target picture and six variants. The sets included both animate (cats, cowboys, giraffes, trees, and tree leaves) and inanimate (boats, dresses, scissors, houses, teddy bears, and telephones) objects. Children matched the target with one of the six variants. They were instructed to use as much time as necessary in finding the perfect match.

SPAN. In each trial of the SPAN task children were presented with a display of 10 squares that changed colour for 3 s with an ISI of 0.5 s. The presentation of the last item in the series of squares, one changing after the other, was followed by the auditory cue with a duration of 1 s. Children attempted to

recall the series by touching the squares, one after the other, in the specified order. If their response to the shortest sequence of two squares was correct, the length of the series was increased by one for the next trial. The sequence was prolonged until children made three incorrect responses at a given level or completed the longest possible sequence of nine squares.

SWM. Children searched for three, four, six, or eight blue tokens that were hidden, one at a time, under a corresponding number of boxes. The instruction was to avoid returning to those boxes from which the token had already been retrieved. Children completed four problems at each level of difficulty.

TOL consisted of two-, three-, four-, and five-move problems. Children were presented with a goal and a starting configuration of three balls (corresponding to the balls in the original design) on three stockings (corresponding to the pegs in the original design). The instruction was to first generate and then execute the shortest possible sequence of moves that would make the starting configuration look like the goal configuration without violating the following rules: a ball cannot be moved if it is beneath another one; only one ball can be moved at a time; each ball needs to be placed within one of the stockings at all times.

The IQ estimate was derived from two sub-tests, the Block Design and the Vocabulary, that were administered according to the standard procedures.

PAM. The participants' aggressive defence reactions to the aggressive offences were determined from their performance in the PAM paradigm. A VisualBasic program run on a personal computer controlled the presentation of the stimuli on, and the collection of the responses from, a touch-sensitive monitor.

Two vertical rows of 8 stimulus and 9 response icons were presented on the left and right sides of the monitor. Both the stimulus (attack) and response (defence) icons depicted acts of physical aggression of varying intensity: row 0 = a harmless interaction, row 1 = you are slightly pushed, row 2 = you are pinched, row 3 = you are slapped, row 4 = you are knocked to the ground, row 5 = your hair is being pulled, row 6 = you are hit with a stick, and row 7 = you are punched in the face. On the top of the row of the response icons, there was an additional response icon, row 8 = the attacker is kicked while lying on the ground. The range of the response options was extended to guard the data against ceiling effects. Two additional pictures were presented at the centre of the monitor. The figure on the left specified the characteristics of the attacker and the figure on the right specified the defender.

A rectangle around one of the stimulus icons marked the delivery of an attack. Children touched one of the response icons to counter with defence. The response triggered the next stimulus at a constant interval of 3 s. The participants were instructed to select the response icons in a way they would in a real confrontation.

The eight stimulus icons were delivered two times in a pre-determined order: 3-5-4-2-7-0-1-6-2-5-7-3-1-4-6-0. The 16 stimuli were presented under six conditions of controlled aggression manipulating the characteristics of the

attacker: condition A (a same-sized peer of the same sex), condition B (a bigger child of the same sex), condition C (a same-sized child of the opposite sex), condition D (a smaller child of the same sex), condition E (a parent of the same sex), and condition F (a parent of the opposite sex). The conditions were presented in random order.

ECG. The participants' cardiovascular reactions during the PAM were evaluated from the ECG recordings. After abrasion and cleansing of the skin, five Ag-AgCl electrodes were placed on the child's chest. Two bipolar leads with the negative electrodes below the right and left clavicles and the positive electrodes at the conventional V1 and V5 positions, respectively, were connected to the battery powered analogue ECG tape recorder. The ground electrode was placed over the right side of the chest at the level of the lowest ribs. The quality of the signal was screened with a two-channel oscilloscope.

Variables

The following variables were obtained from the eight cognitive tasks, the short form IQ test, the PAM and the associated recording of the ECG, as well as the teacher rating form (Table 1).

TABLE 1 The Measures and Variables in the Original Studies I - III.

Task / Condition	Variable
AARS	Difference score between correct and incorrect responses
Mazes	Sum score based on accuracy and speed in each Maze
TMT	Completion time (s)
VF	Sum of correctly listed words
MFFT	Mean completion time of the first variant-target match
SPAN	Longest correctly recalled sequence
SWM	Sum of the locations that were visited after their contents had been retrieved
TOL	Sum of the correctly solved problems without additional moves
IQ	Standardised sum of the standardised subtest scores
PAM, impulsive aggression	Mean response intensity at the eight levels of stimulus intensity
PAM, controlled aggression[a]	Mean difference between the stimulus and the response intensity
ECG, baseline	Mean HR (beats per minute), mean TP, LF, HF (ms^2)
ECG, controlled aggression[a]	Mean difference between the task condition and the baseline activity, i.e., the mean HR, TP, LF, and HF reactivity scores
MPNI	Mean of the item scores

Note. [a]These variables were calculated separately for the six conditions of controlled aggression: A = same-sized peer of the same sex, B = bigger child of the same sex, C = same-sized peer of the opposite sex, D = smaller child of the same sex, E = parent of the same sex, and F = parent of the opposite sex.

The second condition of the AARS was scored in terms of the selection of the cubes. If the children picked up the cube while the cue word was being presented, they received two points. If the children picked up the cube during the two subsequent non-cue words, they received one point. The selection of the cubes in the absence of a cue word was penalised by with the loss of a point. The

arithmetic difference between the plus and the minus points served as a measure of the shifting of attention according to the cue-cube relationships maintained in the memory.

The Mazes was scored in regard to the predetermined time limit and the number of tracing errors. The sum score indexed the focusing of attention and the maintaining of information in the memory during tracing performance.

Part B of the TMT was scored as the mean completion time (s) that illustrated the shifting of attention between the numbers and the letters.

The VF was scored in terms of the sum of correctly listed words across the four categories. The sum score represented the shifting of attention between semantically different categories.

The MFFT was scored in terms of the mean completion time (s) of the first answer across the stimulus sets. The completion time served as a measure for inhibiting oneself from matching the target with one of the variants until all the pairings had been evaluated.

The SPAN was scored as the longest correctly recalled sequence of squares; which was an index of the storage of information in the memory.

The SWM was scored in terms of the search errors, i.e., the total number of returns to those boxes from which the token had already been retrieved. The sum of between-search errors depicted the children's ability to maintain and update search-related information in the memory.

The TOL was scored in terms of the sum of moves above the minimum number. The score served as a measure of the inhibition of prepotent responses.

The IQ estimate was derived from two tasks, the Vocabulary and Block Design administered and scored according to the standard procedures.

PAM. The arithmetic difference scores were calculated by subtracting each response intensity score from the corresponding stimulus intensity score for each trial. Since each of the eight stimulus levels (i.e., stimulus icon numbers 0 to 7) were presented twice during each condition of controlled aggression, the mean difference scores were calculated over 16 individual scores. Our previous analyses of the data indicated that the intensity of proactive aggression was an especially important determinant of the intensity of reactive aggression (Juujärvi et al., 2001). Therefore, the mean difference scores were also computed separately for minor (stimulus icon numbers 0 to 3 = a harmless interaction to slapping) and major (stimulus icon numbers 4 to 7 = a knock to the ground to a punch in the face) provocations.

ECG. After the A/D conversion of the raw ECG signal and the careful detection of the artefacts, cardiac activity was determined in both time and frequency domain at the Department of Clinical Physiology, Kuopio University Hospital. The heart rate (HR) and the heart rate variability (HRV) parameters were derived using the Excel Medilog system (cf., Simula, Laitinen, & Hartikainen, 1998; Task Force, 1996).

First, the mean length of the R-R interval was calculated in milliseconds across the 16 stimulus-response trials within each condition of controlled aggression. Then, the time series data were transformed into the frequency

domain using a Fast Fourier algorithm. The resulting total power spectra (TP: 0–0.40 Hz) were split further into the parasympathetically-sympathetically mediated low frequency (LF: 0.04–0.15 Hz) and the parasympathetically mediated high frequency (HF: 0.15–0.40 Hz) band of HRV.

The pre-processed data were returned to the Department of Psychology at University of Jyväskylä, where the mean RRI data were transformed into the mean HR data following the equation $HR_{bpm} = (60 \times 10^3) / \text{mean RRI}$ (e.g., Hugdahl, 1995). The arithmetic reactivity scores were calculated by subtracting the mean HR during the baseline from the mean HR during the respective conditions of controlled aggression (e.g., Llabre et al., 1991). The reactivity scores for the TP, LF, and HF parameters were computed in a similar manner.

The following MPNI scales were used in the present series of studies: Constructiveness (5 items, e.g., "Is able to sort things out by talking."), Compliance (3 items, e.g., "Never quarrels with others."), Social Activity (3 items, e.g., "Is a good leader and would be suitable to lead a class outing."), Aggressiveness (6 items, e.g., "Teases other kids and attacks them for no reason at all."), and Anxiety/Depression (8 items, e.g., "Is sad and depressed.").

Statistical Designs

The main statistical design was the repeated measures analysis of variance (ANOVA). The between-subject factors were derived from the hierarchical cluster analysis of teacher rating or ECG variables or from the trichotomisation of principal axis factor scores for the cognitive variables (Table 2). Gender was the second between-subject factor in all three studies.

TABLE 2 The Between-Subject Factors in the Repeated Measures ANOVA Designs.

Study	Statistical Method of Derivation	Levels of the Between-Subject Factor
I	Hierarchical cluster analysis (Ward) of the five teacher rating scales	Maladjusted (67) and Adjusted (26) Children Gender (61 boys, 48 girls)
II	Hierarchical cluster analysis (Ward) of the six mean difference score between baseline and task condition HR	Strong Increase (8 boys, 8 girls), Moderate Increase (8 boys, 8 girls), Decrease (8 boys, 8 girls) of HR Reactivity Gender (24 boys, 24 girls)
III	Principal axis factoring (Varimax) of the eight cognitive variables	Low (17 boys, 9 girls), Intermediate (13 boys, 12 girls), High (11 boys, 15 girls) Working Memory Capacity Low (9 boys, 17 girls), Intermediate (15 boys, 10 girls), High (9 boys, 17 girls) Inhibition Capacity Gender (41 boys, 36 girls)

Note. The numbers in parentheses indicate the number of children in each cell of the ANOVA design. The number of participants varied from one analysis to another due to missing data or the balancing the design. The Maladjusted and Adjusted children refer to the aggressive and non-aggressive children referred to on pages 12-15.

In the original study I, the mean response intensity score, the mean

difference between stimulus and response intensity score served as the within-subject factors. Since the intensity of the proactive aggression was an especially important determinant for the intensity of reactive aggression, the mean difference scores were computed also separately for minor (stimulus icon numbers 0 to 3) and the major (stimulus icon numbers 4 to 7) provocations. In the original studies II and III, the mean difference between stimulus and response intensity, as well as the reactivity scores for HR, TP, LF, and HR were the dependent variables, respectively.

In the analysis regarding the ECG data, the baseline values of HR and HRV reactivity were entered as covariates to the respective analyses (Benjamin, 1967). In the analyses regarding the working memory and inhibition factors, the estimated IQ served as a covariate in the design (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003).

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