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Intelligence and aggression: The role of cognitive control and test related stress ☆

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ABSTRACT

In three studies we explored the relationship between cognitive ability and various aspects of aggression. In the first investigation, we found that intelligence was not associated with external aggression (physical or verbal), although it tended to correlate negatively with internal processes related with aggressive behavior (anger and hostility). The results of study 2 indicated that higher anger was associated with poorer cognitive control. However, this relationship was attenuated when cognitive ability was added to the model. In the last study we sought psychological states that might accompany individuals with high level of anger and hostility while they are completing an intelligence test. It revealed that the state of worry mediates the relationship between trait anger and hostility and the cognitive ability score. High trait anger and hostility individuals exhibit higher level of negative thoughts about performance and focus on personal concerns while solving a demanding cognitive test.

1. Introduction

Many researchers emphasize the adaptive nature of intelligence (Gottfredson, 1997). One of the facts that favor this view is the observed reduced antisocial behavior at high level of general cognitive ability (Lynam, Moffitt, & Stouthamer-Lauber, 1993). It has also been found that cognitive ability is negatively related to aggression, which, per traditional definition, includes antisocial aspects, i.e., the intention to harm another living being (Berkowitz, 1993). The meta-analytic research by Ackerman and Heggestad (1997) reported a negative association between general intelligence and general aggression as a personality trait (effect size = −.19), and the same direction of relationship between trait anger and cognitive ability was found by Austin et al. (2002). Despite these findings, still little is known about the nature of the intelligence-aggression association.

Much research has explored the relationship between cognitive control and the self-regulation of aggressive behavior. A number of studies have reported that poorer control is associated with direct aggression and that prefrontal cortex might be a common substrate of both (cf. Campbell, 2006). Interesting findings concern also the recruitment of cognitive control resources within hostile situations of individuals with low trait anger (Wilkowski & Robinson, 2010). Furthermore, it has been shown that cognitive control is one of the most important functions determining individual differences in intelligence (Kane, Conway, Hambrick, & Engle, 2007). Thus, cognitive control seems to be a natural factor explaining the inverse intelligence-aggression relation. Indeed, few studies considered intelligence, control and aggression together. For instance, it was found that the Conditional Association Task (CAT; assesses the ability to learn a series of conditional associations between unrelated stimuli; see Petrides, 1985) produced an anomalous pattern in which unstable-aggressive boys performed more poorly than both stable aggressive and non-aggressive boys (see Seguin, 2009). These latter two groups did not differ when intelligence was controlled. Ogilvie, Stewart, Chan, and Shum (2011) in a meta-analytic study found that antisocial and highly aggressive groups had significantly poorer executive functions and cognitive ability than control groups. The authors indicated that larger intelligence group differences in part accounted for larger effect sizes in executive functions.

Researchers investigated mainly the contribution of cognitive functions into aggressive responses. However, one may wonder whether the tendency toward aggressive feelings and thoughts might influence the process of solving a demanding intellectual test. This possibility was previously examined with respect to neuroticism (Eysenck, 1994). It is possible that poorer scores on intellectual tasks exhibited by high trait anger and hostility subjects

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might be partially explained by increased negative affect and stress states during task performance, since the latter often accompanies aggressive response (Berkowitz, 1993).

The aim of the present studies was deeper understanding of the association between cognitive abilities and aggression-related phenomena. In the first study we explored the link between cognitive ability and aggression. Prior work focused mainly on aggressive behavior and its consequences (e.g. Lynam et al., 1993), often neglecting internal aspects of aggression. However, recent data suggest that cognitive regulation might be also important for hostile thoughts and feelings (Wilkowski & Robinson, 2010). Therefore, we decided to include both external and internal aspects of aggression. Further, we tested the role that other variables may play in the relationship between intelligence and aggression. In study 2 we considered cognitive control, because of its significance for both intelligence and aggressive responses. In the last study, we sought psychological states that might accompany individuals with high levels of anger and hostility while they were solving a demanding cognitive task. We referred to the concept of task related stress states, because it distinguishes between cognitive and emotional experiences related to performance (Matthews et al., 2002).

In the present study, we referred to Buss and Perry (1992) who distinguished physical and verbal aggression (i.e., tendency to use physical means or words to harm another person) as well as two components of aggression: anger and hostility. Anger represents individual differences in the frequency of experiencing and the reactivity toward angry feelings, while hostility reflects mainly the cognitive aspect (i.e., a tendency to negatively evaluate other people) often accompanied by a desire to harm particular others. Additionally, we examined other variables important for the relationship between cognitive ability and aggression: cognitive control and stress states. Since cognitive ability and control are very broad constructs, we decided to focus on their more narrow components. Specifically, we considered inhibition (an ability to suppress prepotent and inappropriate responses; Miyake & et al., 2000), because it has been already shown that this aspect of cognitive control is relevant for stopping the effects of activated angry feelings and hostile thoughts (e.g. Tang & Schmeichel, 2014; Wilkowski & Robinson, 2008). Furthermore, we included fluid aspect of intelligence, because it represents maliny the information-processing ability and is highly correlated with cognitive control (including inhibition; Kane et al., 2007).

2. Study 1

In the first study we examined the associations between fluid intelligence and four aspects of aggression distinguished by Buss and Perry (1992): physical and verbal aggression, anger, and hostility.

2.1. Method

2.1.1. Participants

The study involved 314 students (168 male, 146 female) from various universities in Warsaw. The proportion of men and women differed from the student population, which in Poland is 45% men, and 55% women. The mean age of the sample was 22.90 years (SD = 2.61). Participants were recruited through local website announcements and advertisements at the universities. There were no missing data.

2.1.2. Materials

The Aggression Questionnaire (AQ; Buss & Perry, 1992) is comprised of 29 items divided to four subscales; two of them relate to overt expressions of aggression: physical aggression and verbal aggression, whereas the other two relate to aggressive emotions: anger and cognitions: hostility. The AQ uses a 5-item Likert-type scale to score the items. The instrument has high internal consistency (αs = .85, .72, .83 and .77, for physical aggression, verbal aggression, anger and hostility dimensions, respectively; Buss & Perry, 1992).

Raven's Advanced Progressive Matrices Test (APM; Raven, Court, & Raven, 1983) was used as a measure of fluid intelligence. APM is a paper-and-pencil test and consists of 36 items that include a three-by-three matrix of figural patterns which is missing the bottom-left pattern, and eight response options which potentially match a missing one. The score was the total number of correct responses. APM is a non-verbal test and captures the spatial aspect of fluid ability. Because of its high reliability and good psychometric properties this measure has been widely used as a marker of general fluid ability, however some researchers point out that such interpretations should be made with caution (Ackerman, Beier, & Boyle, 2005).

2.1.3. Statistical analyses

First, we correlated the variables used in the study. As men and women might differ in terms of aggressive responses (Campbell, 2006), we conducted a series of regression analyses where, each time, the AQ scale was dependent variable while sex (entered in step 1) and APM score (step 2) were predictors (Table 2). Bonferroni correction was used for alpha inflation.

2.2. Results

The APM was negatively associated only with two scales from AQ: anger and hostility (Table 1). Moreover, all AQ dimensions were positively correlated with one another, which is consistent with previous research (Buss & Perry, 1992).

The regression models were significant in case of physical aggression ($F(2, 311) = 22.53$; $p < 0.001$; $R^2 = .12$), anger ($F(2, 311) = 5.77$; $p < 0.001$; $R^2 = .03$), and hostility ($F(2, 311) = 7.95$; $p < 0.001$; $R^2 = .05$). In particular, men had higher tendency toward physical aggression (beta = .36; $t = 6.70$; $p < 0.01$). This result is consistent with previous findings (Campbell, 2006). Intelligence remained a significant and negative predictor of anger (beta = −.18; $t = -3.30$; $p < 0.01$) and hostility (beta = −.22; $t = -3.97$; $p < 0.01$), after controlling for sex.

2.3. Discussion

The results revealed that cognitive ability was negatively associated only with two aggression-related dimensions: anger and hostility. No correlation between fluid intelligence and external aggression (physical or verbal) might be due to homogeneous sample used in the study. It is possible that, in the group of university students, the individual differences in expressed aggressive behavior were too small to reveal any systematic relationship with intelligence. The inverse association between cognitive ability and anger and hostility is consistent with previous findings (Austin et al., 2002) and may suggest that high level of intelligence helps to efficiently reduce the experience of aggressive feelings and hostile thoughts.

3. Study 2

As fluid intelligence is a broad construct, it would be interesting to identify specific processes of cognitive ability responsible for the reduction of anger and hostility. Many studies examining the cognitive underpinnings of anger showed that cognitive control, and

Table 1
Correlations of Raven's test and Aggression Questionnaire's scales.

	APM	Physical	Verbal	Anger	Hostility
APM		−.03	−.03	−.19**	−.22**
Physical			.32**	.37**	.25**
Verbal				.40**	.37**
Anger					.50**
Mean (SD)	23.80 (5.30)	17.71 (5.43)	14.30 (2.95)	17.70 (5.57)	18.91 (5.98)
Reliability	.88	.78	.57	.80	.79

Note: APM – Advanced Progressive Matrices. Reliability = Cronbach's alpha, except for APM, where reliability was split-half correlations adjusted with the Spearman–Brown prophecy formula.
* $p < 0.05$.
** $p < 0.001$.

Table 2
Regression analyses with aggression related dimensions as dependent variables and demographic variables (step 1) and Raven's test score (step 2) as predictors.

		Aggression							
		Physical		Verbal		Anger		Hostility	
		ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1		.12**		.01		.00		.00	
	Sex		.35**		.08		−.05		.02
Step 2		0.01		.00		.03**		.05**	
	Sex		.36**		.08		−.03		.04
	APM		−.07		−.04		−.18**		−.22**

Note: APM – Advanced Progressive Matrices. Sex coded: men = 1, women = 0.
* $p < 0.05$.
** $p < 0.01$.

inhibition tasks in particular, is one of the most important factors to diminishing anger (e.g. Tang & Schmeichel, 2014). On the other hand, this cognitive function was shown to be highly correlated with intelligence (Kane et al., 2007). Thus, in the next investigation, we decided to see to what extent the three variables may overlap.

3.1. Method

3.1.1. Participants

The study involved 128 students (72 male, 56 female) from various universities in Warsaw. The mean age of the sample was 22.80 years (SD = 2.90). Participants were recruited through local website announcements and advertisements at the universities. One participant was excluded from the study because of responding to less than half of the trials in the cognitive control task.

3.1.2. Materials

Fluid intelligence and aggression were measured with the same methods as in study 1.

The flanker task in the version proposed by Eriksen and Eriksen (1974) was used to capture the inhibition, an aspect of cognitive control. The task required deciding, as fast as possible, if the letter presented in the center of a set of five letters was S or H. The target letter (e.g. S) can be surrounded by congruent (S) or incongruent (H) letters. There were a total of 20 practice trials and 160 experimental trials. Half of the trials were congruent and were randomly presented across the entire session. The final result was calculated by subtracting the reaction time (RT) median of the congruent flanking conditions from the RT median of incongruent flanking conditions. High scores indicate delay in inhibiting response to competing stimuli, and hence poor control. Prior data are quite clear that incongruent flanker stimuli prime the incorrect response, and that cognitive control resources must be used to inhibit this prepotent and incorrect response (e.g. Fan, McCandliss, Sommer, Raz, & Posner, 2002). Flanker tasks have good reliability (in our study .91) and have been proved to be valid measure in neurological (Fan et al., 2002) and social (Wilkowski & Robinson, 2008) studies.

3.1.3. Statistical analyses

First, we correlated the variables used in the study. As only anger was significantly related to intelligence and inhibitory control among the AQ dimensions, we examined the unique variance in anger explained by intelligence controlling for executive functions. At step 1, sex was entered into the regression model followed by the result from the inhibition task (step 2), and the APM (step 3).

3.2. Results

The correlations (Table 3) indicated that intelligence test was significantly related with inhibition, anger and hostility. Moreover, anger was also positively associated with the flanker task. Since higher result on the latter means worse performance, the obtained relationship suggests that individuals higher on anger exhibited poorer inhibition.

The regression model (Table 4) was significant ($F(3, 123) = 3.67$; $p = 0.014$; $R^2 = .08$). Most interestingly, in step 2, inhibition significantly predicted anger (beta = .19; $t = 2.12$, $p = 0.036$); however, this relationship was significantly attenuated when the APM result was added to the model. Specifically, cognitive inhibition became non-significant (beta = .12; $t = 1.28$, $p = 0.201$), while APM was significant (beta = .20; $t = -2.21$, $p = 0.029$) predictor of anger in the final model.

3.3. Discussion

The results of study 2 indicated that higher anger was associated with poorer cognitive control. However, this relationship was no longer significant when cognitive ability was added to the regression model. It is possible that the intelligence-anger relationship may be partially explained by the fact that both variables are associated with a third factor of cognitive control. This result is consistent with much of recent research examining the role of cognitive control in the regulation of state and trait anger. For instance, Wilkowski and Robinson (2008) also found that low trait anger individuals are more efficient in the inhibition tasks (e.g. flanker task) following hostile primes in comparison to persons with high trait anger. Furthermore, Tang and Schmeichel (2014) tested the relationship between individual differences in the capacity for inhibitory control and responses to an emotion induction procedure. Participants first completed a stop-signal task measuring inhibitory control and then underwent an anger emotion induction. Performance on the task predicted emotional responses, such that participants with poorer inhibitory control, reported larger increases in anger following the induction. Regardless of the experimental paradigm, researchers conclude that individuals

Table 3
Correlations between Raven's test, cognitive control task and Aggression Questionnaire's dimensions.

	APM	Control	Physical	Verbal	Anger	Hostility
APM		−.34**	.03	−.01	−.23*	−.24**
Control			−.02	.06	.20*	.08
Physical				.39**	.29**	.32**
Verbal					.43**	.30**
Anger						.59**
Mean (SD)	24.37 (5.42)	40.59 (20.80)	17.54 (6.46)	14.37 (2.77)	17.83 (5.82)	19.62 (5.98)
Reliability	.91	.96	.81	.59	.81	.79

Note: APM – Advanced Progressive Matrices. Reliability = Cronbach's alpha, except for APM, where reliability was split-half correlations adjusted with the Spearman–Brown prophecy formula.
* $p < 0.05$.
** $p < 0.01$.

Table 4
Regression analyses with anger as dependent variable and sex (step 1), cognitive control (step 2) and Raven's test score (step 3) as predictors.

		Anger	
		ΔR^2	β
Step 1		.01	
	Sex		−.10
Step 2		.04*	
	Sex		−.10
	Control		.19*
Step 3		.04*	
	Sex		−.09
	Control		.12
	APM		−.20*

Note: APM – Advanced Progressive Matrices. Sex coded: men = 1, women = 0.
* $p < 0.05$
** $p < 0.01$.

low in trait anger exhibit higher ability to inhibit unwanted reactions, which in turn helps them to successfully down-regulate their negative emotional states (Hofmann, Schmeichel, & Baddeley, 2012; Wilkowski & Robinson, 2010).

4. Study 3

In the last study we tried to determine psychological states that accompany individuals with high levels of anger and hostility while they were solving a demanding cognitive task. Stress is one of the factors increasing the likelihood of aggressive response (Berkowitz, 1993). Thus we were interested whether poorer performance exhibited by high-trait-anger and hostility subjects might be partially explained by increased stress during task performance.

4.1. Method

4.1.1. Participants

The study involved 100 students (62 male, 38 female) from various universities in Warsaw. The mean age of the sample was 23.16 years (SD = 3.26). Each participant was individually tested. Participants were recruited through local website announcements and advertisements at the universities. There were no missing data.

4.1.2. Materials

Intelligence and aggression were measured with the same methods as in study 1.

The Dundee Stress State Questionnaire (DSSQ; Matthews et al., 2002) in the short version (see Matthews & Zeidner, 2012) translated to Polish (Zajenkowski, in progress) was used to assess subjective stress states related to cognitive performance. DSSQ measures three broad factors: task engagement (integrates state constructs that relate to task interest and focus: energetic arousal, motivation, and concentration), distress (integrates unpleasant mood and tension with lack of confidence and perceived control), and worry (a cognitive factor primarily composed of self-focused attention, low self-esteem, and cognitive interference). On the instrument, there are 24 items with 5-point response scales. The internal consistency of the Polish version is high (task engagement $\alpha = 0.80$; distress $\alpha = 0.76$; worry $\alpha = 0.84$).

4.1.3. Statistical analyses

First we correlated all variables from study 3. In that APM, worry, anger and hostility were intercorrelated, we decided to explore the relationship further. Post-task DSSQ score was used since it was suggested this is most representative of state during task performance (Matthews & Zeidner, 2012). In order to test the hypothesis that post-task worry would mediate the relationship between anger/hostility and intelligence, we used the 'indirect' method developed by Preacher and Hayes (2008) which tests for indirect effects by calculating confidence intervals for indirect (mediated) effects. The method uses bootstrapping which provides some advantages to other methods (e.g. the Sobel's test), primarily an increase in power. Additionally, the bootstrap method does not violate assumptions of normality and is therefore recommended for small sample sizes. Sex was controlled in our analysis (by partialling its effect out of worry and intelligence). We conducted this analysis twice; once with hostility and a second time with anger as the independent variable.

4.2. Results

Table 5 shows that intelligence was negatively correlated with anger, hostility and worry in two measurements. Moreover, hostility was positively associated with distress and worry before and after the task, while anger correlated with these stress states in the pre-task assessment, and with worry in the post-task measurement.

The mediation analysis (see Fig. 1) revealed that the direct effect between anger and intelligence (beta = −0.27, $p < 0.01$) was reduced upon the inclusion of the mediator, worry (beta = −0.21, $p < 0.05$), indirect effect = −0.06, $p < 0.05$ (based on the bias corrected 95% confidence interval not spanning zero: lower = −0.15, upper = −0.01). For hostility the direct effect (beta = −0.22, $p < 0.05$) was reduced upon the inclusion of worry (beta = −0.14, $p > 0.05$), indirect effect = −0.08, $p < 0.05$ (95% CI: lower = −0.17, upper = −0.02). The former analysis suggests partial mediation while full mediation for the latter.

4.3. Discussion

Study 3 revealed that the state of worry measured after the IQ test mediates the relationship between trait anger and hostility

Table 5
Correlations of all variables used in study 3.

	APM	Physical	Verbal	Anger	Hostility	Pre-task			Post-task		
						Engagement	Distress	Worry	Engagement	Distress	Worry2
APM		−.15	−.05	−.29**	−.27**	.093	.06	−.32**	.28**	−.04	−.32**
Physical			.44**	.43**	.39**	−.16	.05	.08	−.06	.04	.14
Verbal				.49**	.34**	−.03	.06	.11	−.11	.10	.03
Anger					.51**	−.13	.24*	.32**	−.11	.15	.21*
Hostility						−.24*	.32**	.43**	−.19	.23*	.34**
Engagement pre-task							−.45**	−.09	.61**	−.07	−.12
Distress pre-task								.34**	−.22*	.40**	.30**
Worry pre-task									−.06	.28**	.62**
Engagement post-task										−.23*	−.25*
Distress post-task											.38**
M (SD)	23.15 (5.45)	17.84 (6.20)	14.77 (3.12)	17.20 (5.22)	20.06 (6.20)	21.86 (4.85)	10.63 (4.93)	14.93 (6.25)	22.43 (5.62)	15.15 (4.97)	10.01 (6.03)
Reliability	.87	.82	.60	.84	.78	.77	.75	.80	.84	.70	.83

Note: APM – Advanced Progressive Matrices. Reliability = Cronbach's alpha, except for APM, where reliability was split-half correlations adjusted with the Spearman–Brown prophecy formula.
* $p < 0.05$.
** $p < 0.01$.

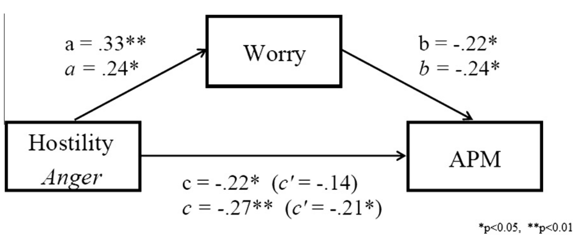

Fig. 1. Relationships between hostility/anger, worry and Advanced Progressive Matrices (APM). a and b are direct paths, c is the total effect from hostility/anger to APM and c′ is the direct path from worry to APM controlling for hostility/anger. Results for anger are in italics. Sex is controlled in both analyses.

and the cognitive ability score. According to Matthews et al. (2002), worry is an index of self-focus of attention and self-evaluation in the performance context. High trait anger and hostility individuals may exhibit higher level of negative thoughts about performance and focused on personal concerns while solving a demanding cognitive test. It is possible that these thoughts interfered with the processing of the IQ test, which in turn might impair the outcome. However, it need to be also acknowledged that the mediation analysis and causal explanation should be taken with caution, since our results are based on cross-sectional data.

5. General Discussion

In the three studies, fluid intelligence was not associated with external aggression and tended to correlate negatively with internal processes related with aggressive behavior. Indeed, a large body of research examining cognitive underpinnings of aggression concerns mainly its internal aspects such as trait anger, that is, individual differences in the frequency of experiencing and the reactivity toward angry feelings, and chronically accessible hostile or negative thoughts (Wilkowski & Robinson, 2010).

The question that we asked further concerned specific processes responsible for the inverse intelligence-anger/hostility relationship. First, we found that cognitive control might be a common substrate of cognitive ability and anger. Subsequently, we observed that high trait anger and hostility participants have increased tendency to worry while solving an IQ test, which in turn impairs performance. As we mentioned above, worry relates to diversion of attention away from the task to process the personal concerns and significance of the task (Matthews et al., 2002). This means that high trait anger/hostility individuals process additional information, irrelevant from the point of view of the task. The irrelevant stimuli may then occupy their working memory space that could otherwise be used to hold relevant information. Studies on working memory suggest that maintaining task irrelevant data negatively influences results in tasks requiring working memory (Vogel, McCollough, & Machizawa, 2005), such as intelligence test.

Yet, the problem of how intelligent individuals use their cognitive control in the regulation of anger and negative thoughts requires further examination. One may wonder whether the mechanism is similar to the one described by Wilkowski and Robinson (2010), who proposed that individuals low in trait anger spontaneously recruit limited-capacity cognitive control resources following the activation of hostile thoughts. Wilkowski and Robinson (2008) found that high trait anger individuals display more pronounced tendencies to evaluate neutral items negatively following a hostile prime; at low levels of trait anger, this effect is significantly reduced. However, this difference was observed only when participants were given unlimited time to complete their ratings. When participants were not permitted sufficient time to recruit and use effortful control, low trait anger individuals exhibited hostility-related priming effects equivalent in magnitude to those high in trait anger. The authors concluded that the inhibition of hostile thoughts is cognitively demanding and resource/time consuming (Wilkowski & Robinson, 2008). One may speculate whether the same mechanism concerns fluid intelligence. Specifically, intelligent individuals may recruit the cognitive control resources when detecting hostile thoughts that in turn reduce their level of trait anger. Future research should examine how individuals with different levels of intelligence process hostile stimuli in various experimental conditions, e.g. with and without time limit. Moreover, in light of the results concerning worry, it would be interesting to compare the cognitive performance of individuals with different level of anger/hostility trait in working memory load condition. In this situation, all participants have their working memory occupied with arbitrary information, hence, no differences should be observed.

Our results have practical applications. Most important, we found that anger is associated with cognitive inhibition and increased worry. Examining possible factors for reducing anger and its consequences seems to be important, because anger increases the likelihood of aggressive behavior (Berkowitz, 1993).

In recent years, there has been significant interest in whether executive functions can be improved via repeated training (Hofman et al., 2012). It was shown that behavioral inhibition methods (e.g. training on inhibitory control such as measured by go/no-go task) can help to deal with impulsive tendencies (Houben & Jansen, 2011). It is possible that such interventions might be also helpful for people diagnosed with aggression or anger control issues. Moreover, our study suggests that high trait anger/hostility individuals' tendency toward increased worry might impair their cognitive functioning. Recent data show that behavioral treatment reduces negative intrusive thoughts in vulnerable individuals (Hirsh & Mathews, 2012).

Several factors may limit our conclusions. Most important, we used only one measure of intelligence. Some researchers point out that it is impossible to identify *g* with any single test; rather, it must be approximated by the aggregation of several measures (Ackerman et al., 2005). Second, we used only self-report measures to assess aggression, thus it would be interesting to explore the link between cognitive ability and more objective markers of aggressive behavior. Moreover, the validity studies of the DSSQ translation are still in progress. Finally, it need to be acknowledged that only student samples (of relatively small sizes) have been tested and further investigation on more specific populations (e.g. offenders) is necessary. Although external aggression and antisocial behaviors have been reported more frequently in offender, as compared to normal population (Ohlsson & Ireland, 2011), the internal aspects of aggressive responses (anger, hostility) seem to be part of our everyday experience (Wilkowski & Robinson, 2010). Therefore, we believe that our results provide valuable knowledge on the functioning of typical population.

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