



# Effects of Neurofeedback Training on Dyslexic Students' Aggression: An Experimental Study

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## ABSTRACT

Our paper describes an field experiment with a pre-test/post-test control group design which investigated the potential of neurofeedback training on perceived control of brain waves and expressed aggression. The study involved 40 dyslexic students (n = 20 randomly assigned to the experimental group and n = 20 to the control group) from 5 learning disabilities centers in the China. During eight weeks, the students in the eight experimental classes learned and practiced the neurofeedback strategy. Data analysis revealed that, the neurofeedback training programs had a positive effect on dyslexic students' aggression. We found support that neurofeedback training can protect dyslexic students from an increase in expressed aggression during the reading words and texts. Furthermore, perceived control of brain waves increased in the neurofeedback group but remained unchanged in the control group.

**Key Words:** neurofeedback, aggression, dyslexia, anger

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## Introduction

### Using neurofeedback for aggression prevention in dyslexic students

Learning disabilities is a common disorder in childhood, and it is related to the problems of students to obtain the skills expected (Lerner, 1997). Aggression levels among dyslexic students are higher during their reading times compared with other students (same age and same IQ) (Kaplan, 2007). Aggression levels of male students are also equal to aggression levels of female samples (e.g. Card, Stucky, Sawalani, & Little, 2008; Smith, Rose, & Schwartz-Mette, 2010). Kaj Bjorkqvist (2017) for example, found significantly equally aggression levels for boys compared with the girls. He stated that, while boys are more physically and girls more indirectly aggressive, boys and girls are verbally about equally aggressive.

Many studies have discussed theoretical models for aggression, which describe the relationship between aggressive factors (e.g., depression, low self-esteem or family conflicts), expressed aggression (as the behavioral reaction to potential aggressive factors with indicators such as violence and anger) and aggression outcomes (e.g., criminal behavior or academic failure) (Nissimov-Nahum, 2009; Coie and Dodge, 1998; Findling, 2003). Studies have shown that the occurrence of aggressive factors is related to expressed aggression (Haapasalo & Tremblay, 1994; Park, Choi & Lim, 2014) as well as aggression outcomes among students (Wang *et al.*, 2013; Park, Choi & Lim, 2014; Kim & Lee, 2008). Furthermore, expressed aggression is related to negative aggression outcomes, and high levels of expressed aggression seem to be a serious issue for many students (Kim & Lee, 2008).

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Park, Choi & Lim (2014), for example, reported a relationship between depression, academic stress, grade (second grade) and aggression in a descriptive study with a middle school student sample: ameliorating negative emotional factors like depression and academic stress predicted decreases in aggression behaviors. Selenius, Hellström & Belfrage (2011) showed strong relationships between aggressive factors and criminal behavior for two samples of patients with and without dyslexia. Other studies pointed at high prevalence rates of aggressive factors, criminal behavior or academic failure among dyslexic students (Karami *et al.*, 2012).

There are different challenges as potential aggressive factors such as short-term auditory memory, rapid naming and decoding dictation that dyslexic students are facing with it (e.g. Osman, 2000; Cornwal & Bawden, 1992). Another source of dyslexic students' expressed aggression is brain waves-related learning disorders, as external aggressive factors, such as poor phonological processing skills (Selenius, Hellström & Belfrage, 2011). Selenius *et al.* (2011) showed that poor phonological processing skills are a significant predictor of anger, which in turn significantly predicts risk of future violence. Neurofeedback strategies might function as a kind of coping strategy to help dyslexic students to adjust to external aggressive factors. In recent studies, neurofeedback was described as a serious issue for dyslexic students (Breteler *et al.*, 2010; Thornton & Carmody, 2005; Becerra *et al.*, 2006). They concluded that treatment programs could play a more active role in helping dyslexic students to make a sense of neurofeedback.

Some studies concluded that neurofeedback strategies play an active role for dyslexic students (Becerra *et al.* 2006; Fernandez *et al.* 2003; Fernandez, 2007), but research concerning the effectiveness of neurofeedback training programs is scarce. We found no intervention study examining the effectiveness of a neurofeedback training programs on dyslexic students' expressed aggression levels. Therefore, the contribution of our study extends the scarce literature on the influence of neurofeedback on dyslexic students' expressed aggression.

Neurofeedback has been described as interventions that aim at achieving an effective function of brain while changing brain waves patterns. In fact, this method recommends operant conditioning on electroencephalography (EEG), stimulate the self-regulation system, and

sustainable changes in brain function (Othmer & Kaiser, 1998). Studies have been shown that neurofeedback training programs have positive effects on behavioral problems and improving cognitive functions (Drechsler *et al.*, 2007; Fuchs *et al.*, 2003; Sonuga-Barke, 2003; Hanslmayr *et al.*, 2005) and expressed aggression (e.g. Enger, 2005; Rimound, Rossiter & Elbert, 2006). In an intensive brain regulation intervention study, Konicar *et al.* (2015) observed reduced aggression after the neurofeedback training of Slow Cortical Potentials (SCPs).

### Earlier studies

Some studies supported the notion of a negative impact of aggression on physical, mental and social consequences (Cook, Williams, Guerra, Kim & Sadek, 2010; Espelage, Low, Polanin, & Brown, 2013; Wang *et al.*, 2013). In a descriptive study, Park *et al.* (2014) showed a negative impact of aggression on social consequences. He stated that aggression in adolescence causes hinders healthy interpersonal relationships and juvenile crimes, and can develop into social maladjustment and criminal behavior in adulthood. While some studies, for example Arnold *et al.*, 2005, don't give evidence for a relationship between criminal behavior or aggressive and dyslexia, Cornwall & Bawden (1992) and Selenius *et al.* (2011) indicated that pre-existing aggressive behavior tendencies may be worsen by dyslexia. In an incarcerated delinquent population, Lewis *et al.* (1980) showed a relationship between poor reading and violence. Also, among the poorest readers, he demonstrated the most violent behavior. Lindgren *et al.* (2002) showed violent crime levels among inmates with dyslexia are higher compared with inmates without dyslexia. Additionally, poor reading ability levels among juvenile offenders relapsed into crime, especially violent crime, are higher compared with non-recidivating juveniles (Harris, Baltodano, Artiles, and Rutherford, 2006). Selenius *et al.* (2011) concluded in their review: 'there is a higher risk of violent criminality in forensic psychiatric patients with dyslexia than in those without dyslexia'.

Neurofeedback-based treatments has been shown to be a predictor of expressed aggression in process models of neurofeedback in the occupational context, with perceived control of brain waves as a mediator between neurofeedback treatment and expressed aggression. Better neurofeedback treatment is expected to lead to more perceived control of



brain waves; more perceived control of brain waves should lead to less expressed aggression and better physical, mental and social consequences. In recent studies, negative relationship between perceived control of brain waves and different indicators of expressed aggression has been supported (Yang, Y. & Raine, 2009; Konicar *et al.*, 2015).

### The present study

In this experimental study, we tested the effects of a neurofeedback training programs on expressed aggression for dyslexic students. We used the variables Physical Aggression, Verbal Aggression, Anger, and Hostility as indicators of expressed aggression to measure aggression using a Swedish version (Lindqvist, Daderman, Hellstrom, 2005) of the self-reporting instrument Aggression Questionnaire (Buss & Perry, 1992). Also, perceived control of brain waves is used to measure brain waves-related outcome (Tansey & Bruner, 1983; Othmer & Kaiser, 1998). Additionally, we used the variable Learning Disorders as expected growing external learning disorders during the reading words and texts (Selenius, Hellström & Belfrage, 2011).

Here, we predicted that neurofeedback would lead to transferable improvement on physical aggression, verbal aggression, anger, and hostility during the reading words and texts. According to the intervention, we hypothesized that the experimental group should show a decrease in physical aggression, verbal aggression, anger, and hostility, while the control group should not.

#### Hypothesis 1:

Growing learning disorders lead to an increase of physical aggression, verbal aggression, anger, and hostility during the reading words and texts.

#### Hypothesis 2:

Neurofeedback training program protect dyslexic students from an increase of physical aggression, verbal aggression, anger, and hostility during the reading words and texts.

#### Hypothesis 3:

Neurofeedback has a positive impact on perceived control of brain waves.

### Method Design

An experimental pre-post intervention study was conducted by means of a survey of students' aggression in which the training programme was the intervention. Participants received an training programme, and the study was

conducted over two time periods, period 1, before intervention, in February 2016, and period 2, after intervention, in May 2016, and the training programme took place between the two (March 2016). Consequently, the reported effects can be attributed to the neurofeedback intervention.

### Neurofeedback intervention

We employed a randomized controlled design with respect to neurofeedback intervention offered by Tansey and Bruner (1983). Many studies showed the positive effects of neurofeedback intervention on expressed aggression (Breteler *et al.*, 2010; Thornton & Carmody, 2005; Becerra *et al.*, 2006; Nazari, 2012). The intervention consisted of 20 sessions, three times for a week, taught each session for 30 minutes and was designed with respect to treatment protocol based on strengthening beta waves (between 15 and 18 Hz) and suppressing delta waves (between 1 and 4 Hz) and theta waves (between 4 and 8 Hz) in location T3 (left brain temporal region).

In this study, our training content developed the main sources related to pronouncing and omitting initial phoneme, pronouncing and omitting latest phoneme, omitting middle phoneme and segmentation tests (Tansey and Bruner, 1983). In the four subtests, first the trainer offered the help words to participants and explained how the test is implemented, and then the training program was implemented. Also, to omit the role of memory and increase the focus and attention of participants, the training programme was carried out with image. We used one-syllable and two-syllable words, and the words were arranged from simple to complex based on the syllable pattern.

In pronouncing and omitting initial phoneme, the trainer asked to say the first sound of the word after naming the image and then remove the sound of the word and pronounce the rest of it. In pronouncing and omitting latest phoneme, the trainer asked to name the image seen and pronounce the last sound of the word. In next step, participants should have removed the last sound of the word and pronounce the rest of the word without it. In omitting middle phoneme, participants removed the middle sound specified by the trainer and then pronounced the rest of the word. In segmentation, the trainer asked to name the



image shown and then to say the word sounds as phonemes into phonemes.

### Participants and Procedure

The participants were dyslexic students from several schools in the North West of China, all in the first weeks of the beginning referral at a Chinese psychiatry clinic. They were from a degree including third, fourth and fifth grade elementary. There were 40 participants, mainly female (about 60%): 20 in the intervention group (M=25; F=31), with a mean age of 10.15 years (SD=5.16); and 20 in the control group (M=21; F=35) with a mean age of 10.11 years (SD=3.41). There were no differences concerning type of study, age, intelligence and prior grade point average between the groups.

Participants in the intervention group learned and practiced the neurofeedback training programme during the period, while participants in the control group learned only developing training courses. They received one-to-one feedback and a report with details of the test results after an intervention. Completion of the length of practice period and reception of the small cards was supervised by the class tutor in the groups. They completed the same pre and post intervention measures for the six variables (physical aggression, verbal aggression, anger, hostility, learning disorders and perceived control of brain waves) directly before and 2 weeks after the intervention.

### Measures

#### Intelligence test

The online version of the WISC\_III (Wechsler, 1991) was used in this study. It consists of a series of subtests performed individually. The test reported Moderate Internal Consistency (MIC) with Cronbach's alpha of 0.89 in all IQ groups (a) overall IQ (MIC=0.96), (b) verbal IQ (MIC=0.95), and (c) practical IQ (MIC=0.91).

#### Learning disorder

To investigate the effect of the neurofeedback programme on dyslexic students, we used the scale learning disorder of DSM-IV (the International Dyslexia Association, 2004). The scale learning disorder reflected the perception of external learning disorders one has to deal with. If any of the participants receives a score higher than 13, he is dyslexic. The reliability and validity of DSM-IV were supported by empirical evidence. Internal consistency for the DSM has been reported, with an alpha coefficient of 0.86.

### Aggression

The subscales physical aggression, verbal aggression, anger, and hostility were used of the Swedish version of the expressed aggression questionnaire as indicator of expressed aggression (Buss & Perry, 1992; Lindqvist *et al.*, 2005). The subscales (physical aggression, verbal aggression, anger, and hostility) measured the internal cognitive-emotional perception of external aggression factors and covered negative aspects of expressed aggression. In the Aggression Questionnaire, the subscales consisted of 29 items. The reliability and validity of the Aggression Questionnaire were supported by empirical evidence (Lindqvist *et al.*, 2005). Internal consistency for the Aggression Questionnaire has been reported, with an alpha coefficient of 0.83.

### Perceived control of brain waves

We measured the perceived control of brain waves with a scale perceived control of brain waves of the Neurofeedback Scale (Tansey & Bruner, 1983). The content of the scale covers strengthening beta waves (between 15 and 18 Hz) and suppressing delta waves (between 1 and 4 Hz) and theta waves (between 4 and 8 Hz) in location T3 (left brain temporal region). We obtained an acceptable alpha coefficient 0.79 at time 1 and 0.81 at time 2.

### Results

We investigated the intervention effect using a two-way MANOVA to improve our research hypothesizes. Figure 1 shows the average scores in the control group, while Figure 2 gives the average scores in the experimental group. Table 2 shows the results for the overall effects of the six different dependent variables (physical aggression, verbal aggression, anger, hostility, learning disorder and perceived control of brain waves).

Table 2 shows a significant time × intervention interaction effect and a significant time effect, but no significant group effect in the overall analysis. According to the table, an increase of learning disorders, physical aggression, verbal aggression, anger and hostility led to the significant time effect. Also, a significant increase of learning disorders has been shown in the control group, but no significant increase for the intervention group.



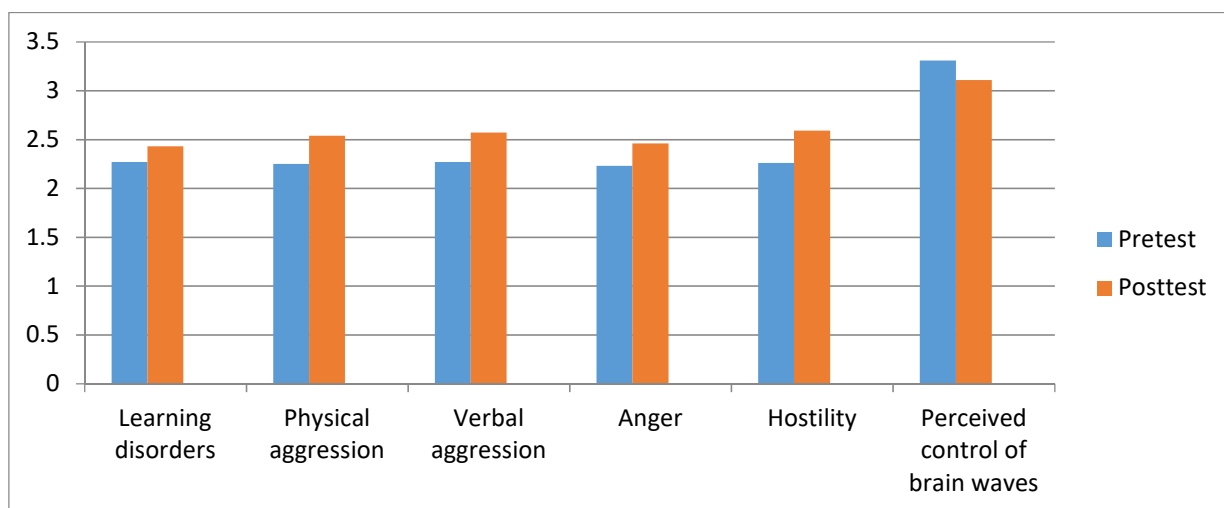
**Table 1:** Sample composition

Dyslexic students characteristic		Frequency			
		Experimental group (n=20)		Control group (n=20)	
Grade elementary	Third	10 (50%)		9 (45%)	
	Fourth	6 (30%)		7 (35%)	
	Fifth	4 (20%)		4 (20%)	
Gender	Boy	8 (40%)		9 (45%)	
	Girl	12 (60%)		11 (55%)	
At time of pretest		M	SD	M	SD
Age		10.15	4.16	10.11	5.23
Intelligence		96.33	5.28	96.19	5.19

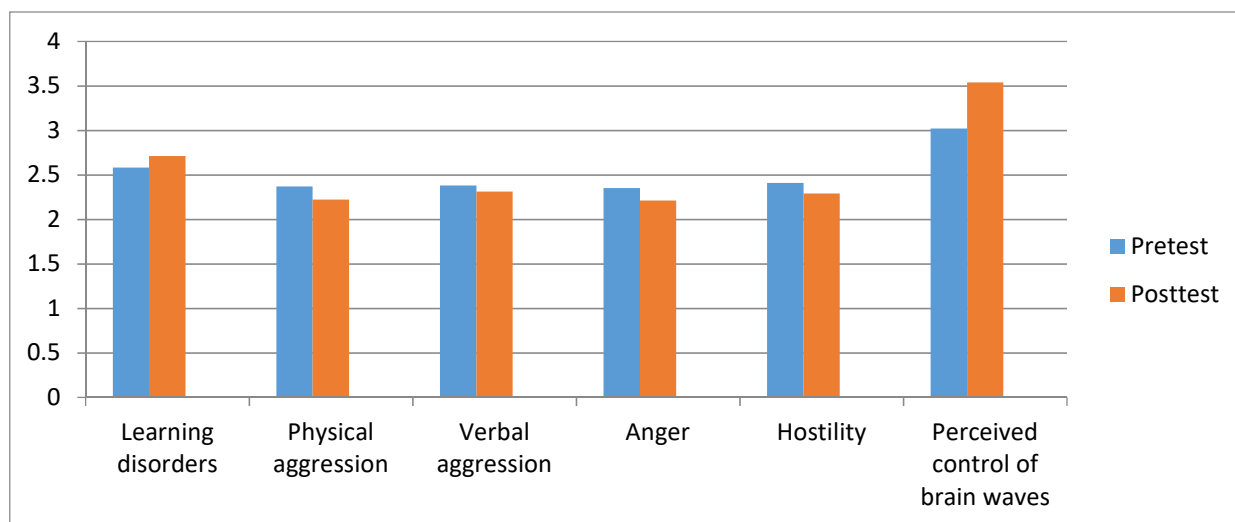
**Table 2:** Mixed design MANOVAs for time (T) × intervention (Int.) interaction.

Variable	Learning disorders		Physical aggression		Verbal aggression		Overall	
	MANOVA	η <sup>2</sup> p	MANOVA	η <sup>2</sup> p	MANOVA	η <sup>2</sup> p	MANOVA	η <sup>2</sup> p
Int.	F(1,39)=1.18	0.01	F(1,39)=0.12	0.00	F(1,39)=0.16	0.00	F(6,33)=0.82	0.01
T	F(1,39)=6.14*	0.03	F(1,39)=8.18**	0.04	F(1,39)=6.11*	0.03	F(6,33)=3.84*	0.02
T × Int.	F(1,39)=0.38	0.00	F(1,39)=7.18**	0.02	F(1,39)=6.42*	0.04	F(6,33)=4.71&*	0.04
	Anger		Hostility		Perceived control of brain waves			
	MANOVA	η <sup>2</sup> p	MANOVA	η <sup>2</sup> p	MANOVA	η <sup>2</sup> p		
Int.	F(1,39)=0.21	0.00	F(1,39)=0.03	0.00	F(1,39)=0.34	0.00		
T	F(1,39)=3.23*	0.01	F(1,39)=6.47**	0.03	F(1,39)=0.53	0.00		
T × Int.	F(1,39)=5.41*	0.03	F(1,39)=7.19**	0.04	F(1,39)=5.46*	0.03		

\* P<0.05, \*\* P<0.01



**Figure 1.** Mean pre- and post-training dependent variables in the control group



**Figure 2.** Mean pre- and post-training dependent variables in the experimental group.



In the overall MANOVA, the reported significant interaction resulted due to a significant interaction concerning physical aggression, verbal aggression, anger and hostility as well as control of brain waves. We observed a significant increase of physical aggression, verbal aggression, anger and hostility in the control group, but no significant increase for intervention group. While perceived control of brain waves increased in the intervention group, no changes occurred in the control group. Our study obtained no interaction effects for learning disorders. With respect to the amount of external learning disorders and expressed aggression levels, at the first time of measurement, there are only a few dyslexic students who experienced high levels of external learning disorders hardly ever (6.2%) and who experienced high levels of aggression hardly ever (10%). Most participants experienced high levels of external learning disorders and high levels of expressed aggression sometimes and often.

## Discussion

### Hypothesis 1

Growing learning disorders lead to an increase of physical aggression, verbal aggression, anger, and hostility during the reading words and texts.

In our study, the reading words and texts at school are marked by a strong increase in external learning disorders for dyslexic students in the control group. It is quite reasonable that short-term auditory memory, as well as brain waves-related learning disorders such as poor phonological processing skills, and other new and unfamiliar challenges are potential aggressive factors for most of the dyslexic students. We hypothesised, that such potential aggressive factors should go along with an increase of learning disorders in the eyes of our participants. The reported results show that hypothesis 1 could be partially supported for participants in the control group, which demonstrated prototypically the expected increase of learning disorders. In the intervention group, a tendency of increased learning disorders was found, but no significant effect. The neurofeedback training programme seems to lessen the increase in expressed external learning disorders. While for all dyslexic students similar external learning disorders occurred in the reading words and texts, the neurofeedback training programme might have been useful for expressing external learning disorders as less threatening and for

developing better strategies for dealing with external challenges.

### Hypothesis 2

Neurofeedback training program protect dyslexic students from an increase of physical aggression, verbal aggression, anger, and hostility during the reading words and texts.

While the reported increase in learning disorders was reflected by an increase in physical aggression, verbal aggression, anger, and hostility in the control group with medium effect size, this increase did not appear in the intervention group. It is a clear evidence for the effectiveness of the neurofeedback intervention on expressed aggression. As can be seen in the control group, as expected, the development without the neurofeedback training programme would be marked by a significant increase in physical aggression, verbal aggression, anger, and hostility. Such increase has not been shown for the participants of the neurofeedback training programme. Consequently, hypothesis 2 could be partially supported. The data suggest that a neurofeedback training programme can be a specific tool to prevent external learning disorders from becoming reflected in higher levels of physical aggression, verbal aggression, anger, and hostility. Such results support former findings showing positive effects of neurofeedback training programmes on indicators of expressed aggression in the previous researches (Breteler *et al.*, 2010; Thornton & Carmody, 2005; Becerra *et al.*, 2006; Nazari, 2012).

### Hypothesis 3

Neurofeedback has a positive impact on perceived control of brain waves.

As described in process models of neurofeedback, neurofeedback strategy might have a positive effect on perceived control of brain waves (e.g. Othmer & Kaiser, 1998). The data of this study give some support for such a conclusion: Perceived control of brain waves increased in the neurofeedback training group. We can result that the effect size can be classified as a weak effect. After the intervention, we did not examine perceived control of brain waves and expressed aggression at different points of measurement with a time lag. Therefore, we cannot prove hypothesis 3 that the attendance at the neurofeedback training programme led to an increase in perceived control of brain waves, which led to a decrease in expressed aggression.

## Limitations and future directions

Our study had a number of limitations, which could induce further research. The sample was restricted to a single source, the participants themselves. To get more insights in the effects of neurofeedback training programme, future research could use multiple source methods and include the peer ratings of neurofeedback training programme pre and post intervention. Another limiting aspect is that, we focused on physical aggression, verbal aggression, anger, and hostility and perceived control of brain waves as dependent variables in our study. Besides these variables the impact of neurofeedback training interventions on academic performance should be examined. In process models of neurofeedback, it is assumed that the use of neurofeedback strategies leads to more perceived control of brain waves, which positively influences performance. Future research could examine these assumptions with experimental intervention designs.

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