Dynamic EEG Mapping as artistic expression
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Abstract: Use of encephalographic (EEG) signals of brain activity can generate dynamic representations of thoughts and emotion when experiencing and creating artworks. EEG responses were produced in reaction to artworks and a recursive reaction to the dynamic representation of the artists own EEG response. These were used to amplify artistic experiences and provide a complementary visual experience in which the observer’s neural reactions to an artwork formed an additional component of the work. Subconscious reactions were made visible and a complex interplay of the observed artwork, reactions to that work, reactions to reactions to that work, and the visual EEG representation itself as an artwork, combined to produce a complex and nuanced artistic experience. The attitude of 53 primary preservice arts education students to arts education was surveyed using the Teaching With the Arts Survey (TWAS) instrument pre and post use of EEG visualisations during arts education studies, and compared to two 53 student control groups in the same course. Improved attitudes to the incorporation of arts education into teaching was shown as a result of using EEG displays to make explicit the effects of holistic artistic experiences.

Introduction

What is the essence of arts education? Dewey (1934, 1958) situated arts education as experiences to be found in everyday life, with the processes and their aesthetic qualities identifying an experience as artistic, and a teacher “measured by his ability to foster the attitude of the artist in those who study with him” (1993, p.288). For Vygotsky (1971) “Art is a method of experiencing the making of a thing, but what is made is of no importance in art” (p.57) and Weschler (1982, p. 186) art exists “not in objects, but in a way of seeing”.

Art education in schools, particularly in the primary years, is often focused not on artistic experience but on skill development, artefact creation, and knowledge acquisition. “Learning the words to a song and singing it along with a recording is not necessarily more artistic than arranging leaves on a paper for a science experiment” (Oreck, 2006) with the often unexplored artistic experience characterised by 1. attention to form and qualities (Beardsley, 1970); Osborne, 1991); 2. connections to feelings, memories and personal experiences (Goleman, 1995; Vygotsky, 1971) 3. a sense of wholeness or completeness of experience (Jackson, 1998), 4. the ability to use multiple forms of expression (Eisner, 1994), and 5. the transformation of a symbolic object or objects (Gardner, 1993). Greater focus on these characteristics permit a more holistic approach to arts education rather than the study of separate skill based disciplines (Oreck, 2006).
Such an approach is dependent however on teachers’ attitudes to the teaching the arts and their preparation for arts education. Teacher disposition to include arts education in their teaching has been found to be largely shaped by childhood experiences and formal training in the arts (McKean, 1999) with “only those few teachers who have artistic backgrounds... having a realistic set of schema's and paradigms for teaching the arts” (Stake, Bresler & Mabry, 1991, p. 318). This presents challenges to teacher education programs preparing teachers to include arts education in their curricula where aspiring teachers often have very limited arts education and artistic experiences.

Compounding the situation further, encephalographic (EEG) brain activity patterns of artists and non-artists show a significantly higher phase synchrony in beta and gamma bands when observing and creating artworks (Belkofer & Knonopka, 2008) and this has been attributed (Bhattacharya & Petsche, 2001) to an ability to see concepts and detail in an artwork and create complex internal representations of such works. This suggests that prior arts education may explicitly allow students to experience art far more deeply than those without a comprehensive education in the arts and highlights the recursive importance of artistic experience in arts education. Without experiences of the arts it is difficult to appreciate artistic experiences, not just logically, but physiologically.

Use of EEG analysis in art therapy is also identifying how our artistic experiences are physiologically received, processed, stored and retrieved (Belkofer & Knonopka, 2008). The emotional impact of such experiences being the result of “dynamic processes created within the socially influenced, value appraising process of the brain” (Siegel, 1999, p. 123) and increasingly identifiable and measurable. EEG measurements are being increasingly used as the basis of interactive artworks (iMal, 2011), using audience biofeedback to generate dynamically responsive artwork from neural activity. All areas of the Arts have been explored using EEG technologies as a medium of interaction, expression or interpretation, visual arts (Matsunaga & Genda, 2005), music (Haill, 2011), dance and drama (Duenyas, 2011). Less use has been made of EEG signals and visualisations themselves as artistic works but examples exist (Smith, 2011).

Study

It was hypothesised that the attitude of aspiring teachers to arts education may be correlated with their association of the importance of artistic experience to student learning - changes to a learners brain. Students used EEG displays of their brain activity while engaging in artistic experiences to directly see how their brain responded to the experience.

A randomised controlled experimental design was used, involving an independent variable of three groups - two control groups and a treatment, with a dependent variable of attitude to the teaching of the Arts. Subjects were randomly assigned to the three groups.

The sample (N=159) comprised students (ages 18 - 37, with a mean of 23) studying to become primary teachers at an Australian university. Their attitude to arts education was surveyed pre-
post using the Teaching With the Arts Survey (TWAS) instrument (Oreck, 2011). Students (n=53) in the treatment group used EEG feedback during artistic experiences to identify if such reflective feedback improved student attitudes to arts education and this was compared to two control groups (each n=53) in the same course of study. TWAS uses a 5-point Likert scale and was comprised of 15 demographic, 8 frequency of use in arts education of dance, music, drama, and visual arts, and 25 attitude to arts education questions. Based on the previous Arts in the Classroom Survey (Oreck, Baum, & Owen, 1999) the TWAS has been validated in several multi-year studies on attitudes to arts education (Oreck, 2011).

The eight frequency of use items describe two general types of arts activities in each of dance, music, drama, and visual arts - 1. active participation in, and 2. exposure to the arts. The 23 attitude items encompass five general constructs identified as important contributors to the implementation of creative and artistic teaching techniques (Gable & Wolf, 1991; Isaac & Michael, 1997) and influencing teaching practices: 1. motivation: sense of importance of the arts in the curriculum and awareness of student needs; 2. concerns: personal, task, and impact; 3. self-efficacy: confidence in facilitating arts activities; 4. self-image: sense of self as creative and artistic individual; and 5) support: sense of autonomy and support from systems for creativity and innovation.

The 65 students in the treatment group each experienced the use of EEG generated neural activity displays while observing and participating in dance, music, drama, or visual arts artistic experiences. Usage ranged from 3 to 6 minutes with a mean of 4.2 minutes, with 1 to 3 experiences per student with a mean of 1.7 measured experiences. Measured experiences included 21 for dance, 42 for music, 10 for drama, and 16 for visual arts. These occurred over a 7 week period of instruction of these art-forms in primary years education.

EEG data was collected at 128 Hz using Emotiv Epoc wireless EEG headsets collecting 14 data channels with two bipolar reference electrodes, spatially organised using the international 10-20 system. This data was immediately displayed in real-time to participants as a heat-map of overall frequency intensity at each of the 14 sensor sites over-layered on a plan diagram of the participants head. In addition, a bar graph display of site F8 (Front Right of the pre-frontal cortex) previously associated with artistic response (Bhattacharya & Petsche, 2001) was displayed showing a sub-band histogram display of Delta, Theta, Alpha, and Beta signal intensities at this site.

The subsequent display provided visual feedback to participants of their neural activity in response to a range of artistic experiences. Students used their brain activity to generate dynamic representations of emotions and feelings as artworks. Works were produced from emotional stimuli, reaction to existing artworks and forms (images, music, dance and tactile examination), reaction to existing EEG artworks, and recursive reaction to the dynamic representations of the artists own EEG artwork.

The stated intent was to encourage participant reflection and appreciation of Arts activities as holistic artistic experiences that make changes to their brain depending upon their emotional
and cognitive responses to the experience. Visual reference to EEG visualisations during these experiences provided a process of explicit reflection on the experience that in turn was made visible, prompting further recursive feedback.

Results

Applying a null hypotheses that there is no correlation between the application of EEG displays during artistic experience (Treatment) and subject attitudes to the teaching of the Arts, a one-way analysis of variance (ANOVA) between the three groups was conducted (Table 1) to explore the impact of EEG display on subject attitude to the teaching of the Arts, as measured by the Teaching With the Arts Survey (TWTA). Subjects were divided randomly into three groups. There was a statistically significant difference at the p < .01 level in TWTA scores (Table 2) between both control groups and the treatment group and no significant difference between control groups. Post-hoc comparisons using the Tukey HSD test (Table 3) indicated that the mean score for Control Group 1 (M = 3.89, SD = 0.58) was significantly different from the Treatment Group (M = 3.96, SD = 0.62). Control Group 2 (M = 3.64, SD = 0.65) was also significantly different from the Treatment Group (M = 3.96, SD = 0.62) but did not differ significantly from Control Group 1 (M = 3.89, SD = 0.58). This results rejects the null hypothesis that there is no correlation between the application of EEG displays during artistic experience (Treatment) and student attitudes to the teaching of Arts.

Table 1. Data Summary

<table>
<thead>
<tr>
<th>Samples</th>
<th>Control Group 1</th>
<th>Control Group 2</th>
<th>Treatment Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>53</td>
<td>53</td>
<td>53</td>
<td>159</td>
</tr>
<tr>
<td>Σ X</td>
<td>191</td>
<td>193</td>
<td>210</td>
<td>594</td>
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<tr>
<td>Mean</td>
<td>3.6038</td>
<td>3.6415</td>
<td>3.9623</td>
<td>3.7358</td>
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<td>Σ X²</td>
<td>719</td>
<td>725</td>
<td>852</td>
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<td>Variance</td>
<td>0.59</td>
<td>0.4267</td>
<td>0.3832</td>
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<td>Std.Dev.</td>
<td>0.7681</td>
<td>0.6532</td>
<td>0.619</td>
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<td>Std.Err.</td>
<td>0.1055</td>
<td>0.0897</td>
<td>0.085</td>
<td>0.0553</td>
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Table 2. ANOVA Summary

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<th>Source</th>
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<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
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<tr>
<td>Treatment [between groups]</td>
<td>4.1132</td>
<td>2</td>
<td>2.0566</td>
<td>4.87</td>
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<td>Error</td>
<td>43.8868</td>
<td>104</td>
<td>0.422</td>
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<td>-------</td>
<td>---------</td>
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<td></td>
<td></td>
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<tr>
<td>Ss/Bl</td>
<td>28.9057</td>
<td>52</td>
<td></td>
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<tr>
<td>Total</td>
<td>76.9057</td>
<td>158</td>
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Table 3. Tukey HSD Test

<table>
<thead>
<tr>
<th>HSD[.05]=0.3; HSD[.01]=0.38</th>
<th>M1 = mean of Control Group 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 vs M2 nonsignificant</td>
<td>M2 = mean of Control Group 2</td>
</tr>
<tr>
<td>M1 vs M3 P&lt;.05</td>
<td>M3 = mean of Treatment Group</td>
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<td>M2 vs M3 P&lt;.05</td>
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Conclusion

Amplification of artistic experiences through EEG augmentation provided a complementary visual experience in which the observers’ neurological reactions to an artwork formed an additional component of the work. Subconscious reactions were made visible and a complex interplay of the observed artwork, reactions to that work, reactions to reactions to that work, and the visual EEG representation itself as an artwork, combined to produce a complex and nuanced artistic experience that was readily identifiable as such to students. The attitude of aspiring primary teachers to arts education was improved and EEG feedback was identified as an effective means of changing student attitudes by making them more explicitly aware of the influence of holistic artistic experiences on student learning.

References


