The Gender Generator: A Brain-Computer Interface for the Evocation of Gender Dysphoria Symptoms

Josh Urban Davis
Dartmouth College
Hanover, NH 03755 USA
joshurban@gmail.com

Abstract
We present the Gender Generator: A P300-based brain-computer interface (BCI) to explore constructions of gender and temporarily simulate for the user the symptoms of gender dysphoria. Despite recent progress towards gender equality, prejudice and violence against queer and transgender people remains prevalent [1]. Trans-humanists gender theorists propose that technology will allow for a post-gender trans-human future [2]. However, it is evident that introducing prejudice into these future technologies is a prescient issue [8]. We explore this problem through a creative lens by designing a BCI user interface with the explicit goal of evoking the symptoms of gender dysphoria. Using a non-invasive P300 BCI system allows us to examine the users conscious and potentially unconscious decisions regarding their gender expression. By doing this, we hope to encourage people who may not experience gender dysphoria to be empathetic to those that do. In addition, we hope this system will bring attention to potential biases against transgender people we may build into this new technology. We conducted an experiment to evaluate the effectiveness of our system as an empathic tool and interactive art installation.
Post-Human Bodies – Post-Human Selves

“Ultimately on both the terrestrial and virtual planes there will be an abandonment of traditional gender expression and the breakdown of gender dimorphism. Genitalia and self will no longer be based on “penis/vagina,” “masculine/feminine” ideals, and transition will not be a shift from one gender to another but from the original human figure to something entirely novel. There will be a countless array of human manifestations; people will be multi-limbed with alternate sensory organs, numerous and interchangeable genitalia, genders that are context dependent and ever varying. Our identities will be identity dependent and ever susceptible to human bias. To explore this, we probe the potential of BCI as an empathic user interface between people who may not experience gender dysphoria and those that do, as well as identify potential biases regarding gender expression that can be introduced into these systems.

The contributions of this work are a P300-based visual stimulus BCI system designed for investigating gender expression (physical representation of their gender) and gender identity (the way a person feels regarding their gender), a dataset consisting of a metric space of gender expression elements in the form of vector graphics, and a user evaluation examining the effectiveness of this system as an empathic tool.

Empathic Technologies
Evidence in the literature suggests that empathic technologies could be effective at reducing prejudice. Oh et al. observed that study participants who embodied an elderly person in an immersive virtual environment (IVE) experienced a greater dissipation in the negative effects of ageism when compared to traditional perspective-taking reading exercises [5]. Similar results have been found for IVE affecting biases associated with race and body image [6][7]. Bailson et al. found that when participants were arbitrarily assigned gender in a social immersive virtual environment, those who were assigned a minority gender performed poorer on an arithmetic task, regardless of their physical gender [8]. Other issues of interface representation have been explored by examining avatar representation in Second Life [9]. Additional evidence in the literature corroborates the effectiveness of empathic affection from various kinds of user interfaces including BCIs. Gilroy et al performed

Author Keywords
Brain-Computer Interface; Gender Studies; Empathic Technology; P300 Evoked Potential; New Media

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI); Miscellaneous

Introduction
The pervasive hostility against queer and transgendered people was substantiated by the largest United States. According to the study, Grant et al. reported that queer and transgender people were nearly four times more likely to live in extreme poverty, making $10,000 or less per year, than the general population. [1]. What’s more disturbing is the report cited that 63% of the respondents “had experienced a serious act of discrimination” and “41% reported attempting suicide, compared to 1.6% of the general population, with rates rising for those who lost a job due to bias (55%), were harassed/bullied in school (51%), had low household income, or were the victim of physical assault (61%) or sexual assault (64%)”.

One solution popular among post-humanist gender theorists speculates that future technological advancements will allow for the dissolution of the gender binary entirely as well as eliminate the oppressive structures associated with that binary [2]. Prosthesis advancements could make transitioning easier and more affordable. The advent of virtual-reality and the internet has allowed transgender people to virtually represent themselves in a manner reflecting their gender identity [3][4]. However, despite the potential of these systems, evidence in the literature suggests that designing empathic technologies must be carefully considered because they are highly

- Laura A. Jackobs [2]
an experimental study with a procedurally generated narrative-based BCI design demonstrating the effectiveness of an EEG neuro-feedback-based approach, showing that subjects can successfully modulate empathic support of a character in a medical drama [10].

**Gender, Bias, Design**
Several works which examining the intersection of gender politics and technology have gained attention in the past decade. Ani Liu presented Brain Controlled Interface for the Motile Control of Spermatozoa which allowed the user to use a brain computer interface to control live human sperm inside a petri dish [11]. *Menstruation Machine* by Sputniko! documented the usage of a device which allowed users to experience the cramping and bleeding associated with menstruation [12]. Though these works investigate the relation of technology and gender, our project distinguishes itself by specifically examining gender non-conforming people.

A clear shift in the treatment of gender non-conforming people is evident with the release of the DSM-V in 2013. From the previous edition, the DSM-IV, the defunct diagnosis of “gender identity disorder” has re-emerged as “gender dysphoria” with a shift in diagnosis criteria from the incongruity between a person’s birth sex and gender identity, to an emphasis on the distress and trauma associated with such an incongruity [13]. Our system attempts to evoke the emotional distress associated with the symptoms of gender dysphoria in order to establish an empathic link with transgender people.

It is because this space of technological oppression is so nebulous that it is ripe for exploration and critique through creative investigations. For this purpose, we have designed a brain computer interface (BCI) which first identifies the user’s gender expression using a P300-based BCI, and then remove a visual catalogue of this expression from the user-interface environment. The user is then asked to construct their gender expression again, without their previously identified primary gender representation present. In this way, the brain is forced to approximate choices of gender expression within a BCI system.

**Brain Computer Interfaces**
Brain-computer interfaces (BCI) are devices that allow a user to communicate yet “do not depend on the brain’s normal output pathways of peripheral nerves and muscles” [14]. This allows a user to control a computer with their conscious thoughts. The two principle methods for BCI systems are invasive systems and non-invasive systems [15]. One of the most widely-used non-invasive system uses electroencephalography (EEG) since these systems are least expensive and least complicated. We use this EEG-based BCI paradigm to examine a P300 event related potential (ERP) described in the next section.

**P300-Based Speller**
The Gender Generator uses a modified P300-Based Spelling system as pioneered by Farwell and Donchin [16]. A traditional P300-based spelling system uses a non-invasive electroencephalograph (EEG) headset to measure the P300 event-related potential (ERP) while the subject performs a spelling task. This task usually involves a grid of flashing characters or symbols displayed on a monitor. The subject is asked to attend
a particular character or symbol and count the number of times the chosen character flashes. Each character on the grid then flashes in random order several times resulting in the target character flashing infrequently for 60ms, followed by a dark-time of 10ms. The P300 brain waveform is an ERP peaking around 300ms after an increase in voltage of about 10µV. This response is triggered by any sufficiently infrequent audio, visual, or somatosensory stimulus that is particularly significant among other routine stimuli. For this reason, counting the flashes around a particular character is a well suited task for eliciting this response.

**Hardware Implementation**

Our system uses the open-source OpenBCI 8-channel Cyton Bio-sensing board which is wireless and transmits data via Bluetooth. Electrodes were placed according to the 10-20 system at positions Fz, Cz, P3, Pz, P4, PO7, Oz, PO8 with references placed on the right ear-lobe and the ground positioned on the forehead [See Figure 1]. The P300 classifier is trained offline using the open-source software interface OpenVibe by employing linear discriminant analysis (LDA). This offline training session is followed by an online session which classifies a user’s P300 response in real time. The interface is built inside the OpenVibe system using a custom Lua framework that receives and categorizes data received from the OpenBCI EEG.A full review of the P300 system is outside the scope of this paper, but is very well documented in the literature [17].

**Interface Design for Gender Expression**

The design design space for this project involves working within a P300 paradigm as a means to explore gender expression. We chose this method because it is primarily visual and allows us to explore user’s conscious as well as unconscious gender expression choices. To do this, we created a metric-space of gender representations divided into 8 categories of gender expression elements: hair, makeup and accessories, facial hair, top body, bottom body, body hair, top clothes, and bottom clothes. These categories were chosen based on Butler’s analysis of gender performativity [18]. Each of these categories contains 12 elements of gender expression in the form of a visual graphic. These elements are presented to the user on a category-by-category basis beginning with the “hair” category and ending with the “bottom clothes” category [See Figure 2]. The user is prompted before each category with the same question: “Which Is You?” with a 10 second delay before the beginning of the category section. At the end of each category, a green rectangle indicates the user’s selection before proceeding to the next category. Once all categories have been completed by the user, the resulting elements selected from each category are compiled into an avatar approximating the user’s gender expression.

As an intentional design decision, we allowed the user to view all 12 of the gender elements of the category throughout the duration of each categorical section. This was done in order to give the user an opportunity to attend to a categorical element that they may not consciously identify as part of their gender expression. By creating this ambiguity, we hope to open room for a qualitative assessment of accidental element selections. This allows us to examine the results of our user evaluation where such incidentals occur and explore the possibility of the user’s mind reacting to elements of their gender identity that are not represented in their
gender expression. This is explored further below in the results of our user evaluation.

After the first avatar’s generation, the system is reset in order to begin a second trial. However, each categorical element from the user’s initial avatar is removed. Thus, each category contains only 11 gender expression elements for the second trial. The entire experiment is now repeated. The goal of successive repetitions of the experiment with the elements of the initial avatar missing is to explore how the brain reacts when the gender expression that matches their gender identity is not available. The emotional impacts of this are investigated in our user evaluation below.

**User Evaluation**

The purpose of this user evaluation is to determine the emotional affect of our system and determine if successive trials with avatar elements removed (as described above) create any emotional stress for the user similar to the symptoms of Gender Dysphoria as described by the DSMV-V [13].

**Participants:**

Our study involved 9 users of various genders and sexual orientations including a FTM heterosexual female, a homosexual cisgender male, two heterosexual cisgender female, two queer males, a gender-queer pansexual, and two heterosexual cisgender males. Each participant filled out a consent form and preliminary questionnaire detailing their self-described gender identity and sexual orientation. All questions on this portion of the questionnaire were optional and the resulting answers were associated with a user ID in order to ensure anonymity and user security. The users volunteered their time and were not compensated.

**Procedure:**

Each user was asked to complete a preliminary questionnaire which includes administrative information, a Positive and Negative Affect Schedule (PANAS) and the Beck Anxiety Inventory (BAI) [19][20]. We chose BAI over other methods (such as the Hamilton Anxiety Rating Scale) because it is a self-reported metric with comparable results [21]. These two metrics were used to form a baseline understanding of the user’s emotional state and have been well documented in the literature for their effectiveness at cognitively assessing distress. The user was equipped with an 8 channel OpenBCI dry electrode soft-cap in the 10/20 format suitable for a P300 experiment. The user then completed a preliminary trial of the Gender Generator system with all 12 gender elements present for each of the 8 categories. This results in the construction of an avatar representing the user’s gender expression. After the completion of the trial, the users were asked to complete a second BAI subset and PANAS questionnaire. We also printed out a copy of the user’s generated avatar and asked the user to indicate which (if any) elements of their avatar did not match their gender expression (physical representation of their gender). We also asked the user to indicate any avatar elements that did not match their gender identity (how the user feels inside regarding their gender). The user then completed two more trials of the Gender Generator avatar construction system with each successive avatar elements removed (as described above). The first trial involved all 12 elements for each of the 8 categories being presented, for their initial gender expression avatar were removed,
resulting in 11 elements for each of the 8 categories. For the third trial, the elements generated from the second avatar were also removed, resulting in 10 elements for each of the 8 categories being presented to the user. Each trial is followed by BAI and PANAS questionnaires. At the end of the 3 trials, the users were asked to complete a final exit questionnaire.

### Results and Discussion

Our results were not highly significant, but did promote an interesting discussion among the participants and indicated a larger user study with some methodology modifications could yield more compelling results. Our preliminary questionnaire resulted in a mean positive affect (PA) score of 28.6 and a mean negative affect (NA) score of 14.2. These results are similar to the momentary means of the PANAS evaluation as reported by Watson et. al [19]. In addition, our preliminary questionnaire resulted in a BAI score of 9.5. These reflect that on average subjects were not anxious at the time of entering the experiment. After completion of the second trial our questionnaire revealed a slight fluctuation in the PANAS and BAI medians, yet remained within the standard deviation of Watson et. al initial results [See Table 1]. We also asked each user to circle on a printout which elements didn’t co-inside with their gender expression. After the first trial, these results were rather negligible except for 3 participants who each had errors indicated on their avatar generation. Two of the users identified as queer males and one identified as gender-queer. These 3 individuals were the only non-binary participants in our study. It should be noted, however, that other participants identified under the transgender umbrella but did not identify as non-binary.

Each user’s avatar elements were then removed for the second trial, after which we administer another PANAS and BAI questionnaire. The results of the second trial indicated an increase in average negative affect as well as an increase in user-identified incongruities in their generated avatar [See Table 2]. The third trial corroborated these results with an increase in average negative affect correlated with increase in avatar incongruities. However, for the 3 members of our non-binary group we observed deviated results. As the incongruity in the user’s avatar generation increased, so too did their positive affectation. Our non-binary participants were the only users to exhibit these results.

### Conclusion and Future Work

Our user evaluation of the Gender Generator demonstrated that as the incongruity of avatar gender presentation increases – so too does the average negative affect score as measured by the PANAS and BAI. As the average negative affect score increases, similarly the average positive affect score decreases. The exception to these results was our subset of non-binary participants who saw an increase in positive affect as the incongruity increased. To further explore these results, we would in the future perform a larger evaluation of our system with an emphasis on comparing binary and non-binary participants. In addition, to decrease the potential for negative affect resulting from study fatigue, we propose to make an associative graph of gender expression elements based on participant feedback. This would allow us during the second trial to not only remove the user’s principle representation elements, but any commonly associated representation elements.

---

**Tabulated Results:**

<table>
<thead>
<tr>
<th></th>
<th>PA mean</th>
<th>NA mean</th>
<th>BAI mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prelim</td>
<td>28.6</td>
<td>14.2</td>
<td>9.5</td>
</tr>
<tr>
<td>Trial 1</td>
<td>30.2</td>
<td>14.8</td>
<td>8.7</td>
</tr>
<tr>
<td>Trial 2</td>
<td>27.3</td>
<td>17.2</td>
<td>15.4</td>
</tr>
<tr>
<td>Trial 3</td>
<td>25.6</td>
<td>20.7</td>
<td>18.7</td>
</tr>
</tbody>
</table>

Table 1: Initial mean of positive and negative affectation and anxiety indexing before the experiment and after each subsequent trial.

<table>
<thead>
<tr>
<th></th>
<th>PA mean</th>
<th>NA mean</th>
<th>BAI mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prelim</td>
<td>27.3</td>
<td>14.6</td>
<td>9</td>
</tr>
<tr>
<td>Trial 1</td>
<td>29.6</td>
<td>15.3</td>
<td>11.6</td>
</tr>
<tr>
<td>Trial 2</td>
<td>33.6</td>
<td>18.6</td>
<td>13.3</td>
</tr>
<tr>
<td>Trial 3</td>
<td>37.3</td>
<td>20.3</td>
<td>15.6</td>
</tr>
</tbody>
</table>

Table 2: Results of positive affect, negative affect, and anxiety index for non-binary participants.
References


15. Guido Dornhege, Jose del R. Millán, Thilo Hinterberger, Dennis J. McFarland, Klaus-Robert


