EDA Quickview:

A new interface for arousal visualization

Elena Agapie Caroline Pires MAS.771 5-11-11 For this project we sought to design a new interface for the visualization of live-streaming physiological arousal data. We hoped to create an interface that was more intuitive and abstract than the currently existing interface, which consists largely of an arousal over time graph that updates as time passes. Our goal was to communicate basic information about arousal status to parents, teachers and caregivers of children with autism, in order to facilitate response to nonverbalized stress as well as better general knowledge of the child's affective state. In creating this interface, our major challenge was to decide what information was the most useful and relevant, and then transform a relatively noisy signal to extract it that information. We used the Affectiva Q sensor, which collects data on electrodermal activity, and developed our final prototype in MatLab and Processing. In order to strengthen our proof of concept, we sought the feedback of two professionals in the field of autism.

BACKGROUND AND SIGNIFICANCE

The autonomic nervous system

The autonomic nervous system is the branch of the peripheral nervous system responsible for unconscious control and regulation of various body functions. Its two main branches, the sympathetic and parasympathetic systems, are antagonistic to one another. The parasympathetic nervous system, whose function is sometimes shorthanded to "rest and digest," activates in times of low activity (although there are exceptions). Its effects include increased flow of blood to the digestive system, decreased heart rate, and constricted pupils. The sympathetic nervous system, more relevant to our discussion, is responsible for the body's "fight or flight" response in situations of high activity, stress, or excitement. Its effects include the release of adrenaline into the bloodstream, increased blood flow to skeletal muscles, increased heart rate, dilation of pupils, and perspiration.

Although heightened arousal can be useful for mobilizing the body in a demanding situation, prolonged activation of the sympathetic nervous system and its stress-response correlates can be harmful. Associated with sympathetic arousal is the release of various hormones by the hypothalamus. Chronic exposure to cortisol, a metabolic hormone released during periods of stress, can have serious negative consequences. In high and sustained doses, cortisol is toxic to neurons in the emotion- and arousal-regulating feedback loop of the hippocampus. Over time, enough exposure can even produce hippocampal withering to such a severe extent that it is volumetrically quantifiable on an MRI. The consequences of reduced hippocampal mass and function include deficits to concentration, learning, and memory (both of which require the genesis of new synapses and/or neurons in the hippocampus), as well a lowered threshold for autonomic arousal (which manifests as increased sensitivity to stress and propensity toward strong emotional response). (for review, see Baron et al., 2006)

Arousal and autism

Anecdotal evidence tells us that individuals with autism often experience chronic heightened anxiety. Temple Grandin describes how, starting at the age of 14, she was plagued with panic attacks: "Any minor disturbance could cause an intense reaction. I was like a high-strung cow or horse that goes into instant antipredator mode when it is surprised by an unexpected disturbance." (Grandin, 2006) For Grandin, the effects of heightened arousal were sometimes positive; they drove her to start a business and become and activist for animal welfare. Yet all too often the anxiety became crippling, causing panic attacks and gastro-intestinal problems. Recent studies concur with Grandin's experience; there is 84% comorbidity for autism and anxiety disorders (Bradley et al., 2004)

Ted Carr's theory of setting events for problem behaviors in autism has direct application to arousal. By traditional logic, problem behaviors (behaviors that are harmful to the individual or to others) occur in response to an aversive event, in anticipation of a desired consequence, or due

to a combination of the two. Carr theorizes that a third variable, the setting event, may mediate whether the antecedent is aversive enough to cause the problem behavior (Carr & Smith, 1995). The setting event may be physical (having to do with the environment), social (related to the presence or absence of certain people), or biological (related to illness, discomfort or fatigue). Studies show that the presence of a setting event can make a normally mildly aversive event more likely to trigger a problem behavior. In essence, the setting event lowers the aversivity threshold required for problem behavior activation. While there does not yet exist empirical evidence linking setting events to increases in arousal, there is a strong possibility that the lowered aversivity threshold correlates with heightened arousal. By this logic, stressful or exciting events or situations throughout a person's day would elevate that person's arousal level, making him or her more alert and sensitive to potential triggers.

For most neurotypical individuals, heightened arousal will manifest itself with outward expressions of excitement or anxiety. These outward expressions facilitate communication of internal state and help others know how to behave around that individual. Because individuals with autism may exhibit a more limited or simply different range of emotional expression, especially if they are nonverbal, it becomes an important issue for parents and caregivers of children with autism to find a way to learn about the child's state of arousal. Such insight may allow parents and caregivers to better know when the child is excited, anxious, alert, relaxed, or even in pain. Especially in cases of chronic heightened anxiety, knowledge of arousal level could help caregivers employ timely relaxation programs.

Monitoring arousal

Various measures exist for physiological arousal, including heart rate variability and electrodermal activity (EDA), which we have exploited in this project. When the sympathetic nervous system activates, sweat ducts throughout the body begin to fill, causing the skin to become more conductive to electrical current. EDA, which refers to the changes in conductance resulting from sympathetic activity, has been proven to accurately and sensitively reflect an individual's sympathetic arousal (Boucsein, 1992). For our project we used two different Affectiva Q sensors: one worn on the wrist that logs data for later download and analysis, and one worn on the palm that streams data live to a nearby computer.

EXISTING INTERFACES

There are several interfaces that attempt to plot EDA data. They all have advantages and disadvantages. One of them is the software plotting offline EDA data from Affectiva. This offers a lot of context on the data and it allows zooming in and out to see details of the day, but it does not work in real time. A second software is the one coming with the real time Q sensor. The advantage is that it shows data in real time and it is good at showing increases in the EDA level. These are easy to observe is watching the interface continuously, but the context is lost after less than a minute when a new set of data is visible. Furthermore, the scale keeps resizing, it is difficult to understand what the value of the arousal means in a small window of data, without a context. Furthermore, Elliot Hedman presented us with a potential data visualization of offline data, showing a window of simulated real time data and the contextual data for a longer period of time. This has been one of our inspiration points. The advantages of this visualization are that shows the real time window along with the historical data. Disadvantages are that we are still dealing with graphs and abstract values. unless someone is used to this type of graphs they this representation might not be very intuitive.

MAKING DESIGN DECISIONS

In the early design decisions we had to consider a lot of aspect of the data we are dealing with, what are the points of interest in this data, what the characteristics of the data are and what population of users we are dealing with. This varies through time and is unexpected. It has increases and decreases in values which should correlate with high or low arousal, but this is not intuitive only from looking at a graph. Furthermore, showing a small section of data might not provide enough context to understand what is happening with the arousal level in general. We considered focusing on increases in arousal over a given period of time (seconds, minutes, hours, throughout the day). This provides very different types of information to a teacher. It can target to different needs: knowing what is happening at the moment, what has been happening with the arousal in the past minutes, or in the past day. We can also envision knowing how ofter the levels of arousal have been changing throughout the day or how fast and how that relates to the current situation. We can envision a teacher needing this information in different contexts. We have also considered understanding the average level of arousal over given periods of time. We would like to be able to relate our data to a baseline of the person's arousal. Different individuals might have different patterns in arousal, and different baselines of arousal. Furthermore these might be different during different days. This is information that if we could visualize might give more context about what the current state of the person is. Given the many variables that the EDA data confines, we decided to focus on sharp increases and decreases in EDA levels, and only afterwards explore more. This would be information that would potentially be of most immediate use to teachers who might want to know if something very sudden is happening to the child they are teaching, and that would not be physically visible.

Furthermore, we thought more about the users we are dealing with. Teachers have limited time to focus on a new data source. They are continuously busy and have to pay attention to a variety of stimuli around them - what the child is doing, taking notes of the child behavior, teaching the child, etc. This was confirmed in the observations we made at the Groden Center visit. So we focused on designing an interface that has some intuitive elements, to which the teacher could just very quickly attend to and perceive, without much effort. This guided us towards finding color schemes or intuitive images to show the arousal level.

In our early conceptions of the first prototype, we sought to visualize some kind of objective arousal level. This would mean representing high and low and a series of intermediary values with a changing display. We had different ideas about how to do this, including a circle of changing diameter and a circle that changed color from blue (low) to red (high) with arousal level (fig. 1). We investigated RGB color representation and discovered how each of those three values would have to change with arousal level in order to get a display that slid smoothly from blue to red. We quickly realized after wearing our Q sensors for a few days that high and low arousal could not map to absolute EDA values, since individual people have different ranges; what is high for one person might be normal or even low for another. And what's more, a person's baseline arousal level—that is, the level where EDA stabilizes when the person is calm and alert—might be different for a single person during different periods throughout the day. We struggled with the problem of how to calculate baseline EDA, essential for determining whether the current EDA was high or low. We knew we would need an algorithm that learned over time, but we also knew a simple average probably would not do the trick. After talking to Akane and Elliott, both of whom have tried to tackle this problem, we decided developing an accurate baseline measure was outside the scope of our project. In order to provide a meaningful and useful visualization without using baseline, we decided to focus on changes in arousal rather than arousal level.

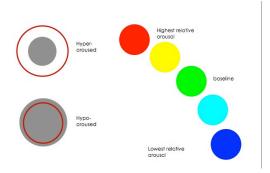
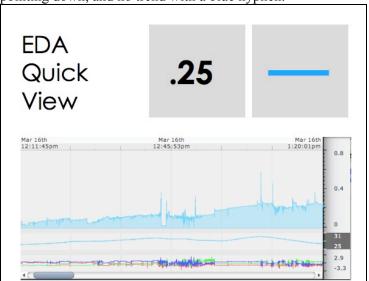


Figure 1. Early conceptions of the visualization: arousal level. Circle scheme (left): diameter of grey circle represents baseline, diameter of red circle represents current absolute EDA. Color scheme: color represents EDA relative to baseline, which is represented by green.

PROTOTYPE 1

We built our first prototype in Microsoft Office Powerpoint in order to prepare the design for testing and feedback before our data processing was complete. Our interface had three dynamic components: an updating graph of EDA over time, a box that showed the raw EDA level, and another box that contained a symbol indicating whether arousal was trending toward a rise, trending toward a fall, or without trend toward either rise or fall (fig. 2). In order to model this interface we used a sample of logged data from a time Caroline visited the doctor's office. We chose this sample for its periods of high and low arousal. There were no calculations involved in this first prototype; we classified periods of rise, fall, and no trend based on visual approximation of the EDA trace. We indicated rise with a pink arrow pointing up, fall with a green arrow pointing down, and no trend with a blue hyphen.



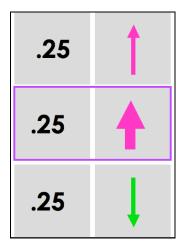


Figure 2. Prototype 1 interface (left) and some examples of other possible EDA-arrow display components (right).

We chose the colors carefully in order to avoid attaching a positive or negative valence to any of the trends; we did not want increase to be red, for example, since rises in arousal can accompany good events, such as increased attention or excitement, as well as bad ones, like increased stress. We did allow decrease to be green, a color with positive connotations, since it usually indicates a

period of relaxation. Each arrow could appear in a thick and thin form: thick indicated rapid change and thin indicated slow change. After thoughtful consideration of our data, we decided to include another component to the display: a purple box that would appear during periods of high lability in the signal. We had noticed in our own data that during periods of heightened arousal, the signal tended to become more jumpy. Since we had no way to indicate "high" arousal in our display, we intuited that it might be a useful second-best to indicate when the signal became labile. A conversation with Professor Picard affirmed our suspicions; she informed us that lability was associated with high cognitive load and with stress. We read a little more on the subject and discovered that most of the literature has focused on categorizing individuals as characteristically labile or stabile in their EDA; relatively few have studied what periods of lability might mean within an individual. We decided that the purple box might provide some useful information, both for caregivers and researchers.

In summary, our first prototype was designed to communicate the following at a glance: how arousal was changing, how rapidly change was happening, whether the signal was stabile or labile, and the raw EDA level (which would be most useful to a caregiver or parent once he or she becomes familiar with the child's usual ranges). The graph was not designed to be interpretable at a glance, but if the parent or caregiver had a little more time to look and wanted more information, the graph could contextualize the current activity. This prototype's graph showed an hour of history.

FEEDBACK WITH DOT LUCCI

In order to gain feedback on our design interface, we met with Dot Lucci, Director of Consultation for MGH/Youthcare. As a former teacher and school psychologist as well as someone who is familiar with the Affectiva technology and works with children and adolescents on the autism spectrum daily, Ms. Lucci was an ideal candidate for testing our prototype. Unfortunately, because our prototype was just a Powerpoint presentation, we could not test it in any kind of real classroom situation. Instead we sought to gain insight on whether our interface was easy to interpret, and whether the information it conveyed would likely be useful to a busy teacher or caregiver of a child with autism.

We showed Ms. Lucci a short orientation, during which we explained the meaning of each of the various symbols. We then showed her showed her several slides, each depicting what the interface would look like at different points in our data sample (from Caroline's doctor's office visit). In an attempt to conduct a semi-controlled experiment, we showed each slide for two seconds and then asked Ms. Lucci to jot down her impressions of the subject's arousal status. Despite our best efforts, the controlled experiment only lasted for about two slides, as Ms. Lucci was very interested in discussing each one. We shifted our strategy to a more holistic, conversational evaluation. Ms. Lucci was initially very absorbed by the graph, and she said that because she was used to working with the sort of graphs that the Q sensor produces, she was more drawn to look at the graph than any other part of the display. She also had a hard time remembering the significance of the colors used, and she did not find the thick-thin system for the arrows intuitive (she thought thick arrow would denote a change that had been happening for a long time). Overall she said the scheme was not overly complicated, but it might take some time to learn.

As for recommendations, Ms. Lucci advised that we make sure our interface conveys gradual as well as temporally isolated rise in arousal. She told the story of a child she had worked with who exhibited subtle signs of growing frustration over the course of two class periods, but only at the end of those two hours did he become truly angry and have a meltdown. While she did not have arousal data on this incidence, she used it to illustrate the point that temporally local changes in stress or arousal don't always give the whole picture. She thought it would be useful to have a separate window teachers could click into that would show arousal trends over different

spans of time. These spans of time would vary by the age of the child; while preschoolers switch activities every fifteen minutes or so, older children may have longer classes. The trends over time would better allow teachers or caregivers to perform the "antiseptic bounce," or preventative intervention before a problem occurs. Ms. Lucci also thought there should be an option to hide the graph, since it might be distracting or overwhelming to some people, and ideally the rest of the display would stand alone during an at-a-glance check. Finally, Ms. Lucci recommended that we make the display more customized to the individual child. A name and photo in the top left hand corner would help the teacher or caregiver associate the information with the child, especially of he or she is monitoring multiple individuals at once. Also, we need to make sure the sensitivity of the arrows is calibrated to the dynamic range of the individual. What might constitute a negligible rise in arousal for an individual whose EDA varies between 0 and 7 might be a significant rise for an individual whose EDA never goes above 3. This last point really made us think, since we thought we had skirted the problem of personalizing when we decided not to work with baseline. We would confront this problem further when we delved further into data processing.

PROTOTYPE 2

The second prototype we developed simulates the process of visualizing EDA data. The prototype consists in a screen that is horizontally divided in two. The upper part of the screen shows real time data streaming. The lower side of the screen shows hours of data and is being updated with the real time data coming in. The prototype also shows the value of the current EDA level. Also, an arrow pointing up or down shows the general trend of the EDA level: whether it is generally increasing or decreasing. More technical details about this will be presented in the section describing how the backend of the interface works.

We decided to include contextual data (a couple of hours of EDA data preceding the current moment). This was due to repeated mentioning of the need to have more context when looking at the EDA data. The advantage of this approach is that teachers would be seeing the context of the current data. The changes in arousal throughout the day might give more meaning to the current data measurements. There would also be disadvantages, as different children might have different patterns in arousal and it possible that the graphs might be confusing in some way. We assessed what the reaction of our participant was to this interface.

EVALUATION AND FEEDBACK OF PROTOTYPE 2

Our primary concerns were to understand which aspects of our interface the user would attend to and why. We also wanted to understand better how the participant was attempting to make sense of the data. We tested our prototype with Jean Deprey, who has experience with working in the Groden Center for children with autism. She is exposed to EDA data on a daily basis.

In the prototype we showed we presented data at a fast pace. The upper screen contained 20 minutes of data and the lower screen contained 2 hours and 20 minutes of data. We did not want to concern the participant with the intervals of data they were seeing. We told out participant the amount of time presented on the two sides of the screen but encouraged them to not think about what the precise range of data they were seeing, but to treat it as real time streaming.

The evaluation of our prototype took part in a couple of steps. The participant was shown several versions of our interface with different data sets. We started with a simple interface showing only the real time stream and the value of the EDA. The second interface contained the real time stream, the arrow indicating increase or decrease in EDA level, and the value of the current EDA. The third interface was similar to the second one but was presented with high fluctuating data. The forth interface included the real time streaming data, the previous hours of

data, the current EDA value and the arrow pointing up or down depending in the increase level of the data. Each of the interfaces was shown with data that was at a fairly constant level and with data that varied in EDA levels. You can see the interfaces presented in Fig. 3.

We chose this gradual revealing of details of the interface to identify whether with fewer details the participant would pay attention more to the graph, the EDA value, or the arrow orientation. Seeing only the final interface would not provide us with all this information. We

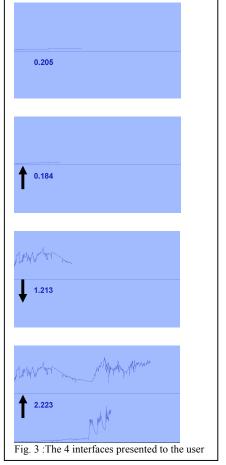
also chose to show different types of data: low EDA, few fluctuations, and higher EDA with a lot of fluctuations. We wanted to see if the type of data we presented the participant with might change the details that she paid attention to in the interface. We will list a selection of observations we received for every interface we presented and what our conclusions are depending on that:

The first interface presented: **real time streaming data**, **EDA value**, **low varying EDA**. In this interface, the participant paid attention to the graph and the value of the EDA. The participant particularly pointed out increases in data. She told us she was paying attention to the values of the EDA. Because these values were slightly changing she pointed out the slight increase in EDA levels. The participant stated she is used to paying attention to the graph and that's what she likes

The second interface presented: **real time streaming** data, EDA value, arrow showing increase in data, low varying EDA. In this interface the participant mentioned she would notice the arrow showing increases and decreases of the EDA level but that she still preferred the graph.

The third interface presented: real time streaming data, EDA value, arrow showing increase in data, high varying EDA. In this interface the participant noticed that the arrow was presenting overall increases in data at a more global level. She wanted it to be more specific, but was also happy that it didn't capture all the fluctuations in EDA. She still preferred the graph.

The forth interface presented: real time streaming data, EDA value, arrow showing increase in data, high varying



EDA, several hours of EDA data. The participant immediately appreciated having the context data from the previous hours. Although she was looking at the same data that she did in the previous interface she pointed out how visible the increase in EDA was based on the contextual data. She found that very helpful in making sense of what the current fluctuations in EDA might mean

Generally, our participant preferred looking at the graph. She mentioned she is working with EDA graphs every day so she is used to looking at that. She also mentioned that if she just glanced at the screen for a very short period of time with the purpose of getting an idea of what the arousal level is, the arrow would be the fastest indicator to notice whether there is an increase or decrease in data. She also stated that if she had a couple of moments she would look at the graphs, and that she would be more interested in the bottom overall graph, because that would offer more overall information about how the arousal has been changing throughout the day. The feedback for seeing both data of the entire day and the real time streaming data was very positive. Our participant really appreciated seeing the context of the EDA levels.

Other details that were changed: in the first interface we presented a colored arrow, green for arousal going down and pink for arousal going up. The participant disliked having colors so we continued in the following interfaces with a black arrow.

DISCUSSION OF PROTOTYPE 2

There are a number of things that we would like to address in the next study.

Experimental Design. We would like to test our interface with users who are teachers, ideally while they work with a child. This will give us a better understanding of what teacher s would pay attention to or what information they would be seeking. In any future testing we will use data that has a real time granularity so that we receive appropriate feedback on how the user makes sense of the data. We also intend to develop different testing approaches, especially for testing while teachers are not working with a child. One of these is to prepare several screens of streaming data. These would be distinct. We would ask teachers to just glance at the screen for one or two seconds and then report on a form what the arousal level was, how fast it was increasing, whether they would be concerned about the arousal they noticed. This would give us a better intuition of what the teacher will observe only from glancing at the screen. We are assuming that in the working environment they have to pay continuous attention to the child and might have only a couple of seconds to glance at a screen. We could attempt the same setting of conditions for a 10 second period, for moments when the teacher would have more time to glance at the screen. We also want to see how different type of data (different fluctuations in arousal, different frequency of increase and decrease in arousal, etc) will affect what information the teacher pays attention to.

Interface. Minor and major improvements will be made. Some minor improvements: adding the axis with the values that the graph is presenting and the labeling for the exact intervals of time presented in the display. An immediate change that we intend to make is to have the arrow tilted at the angle of the increase or decrease in data. This would more be more suggestive in showing the changes in increase or decrease of EDA.

Other more major changes that were suggested in class are to present the streaming data in the context of the entire day with the past sections of time presented at a less detailed resolution. It would be a way to combine the two graphs we are presenting into one. We will explore this possibility. We will also explore different window sizes for showing the real time data to determine how many seconds or minutes should be shown in the real time streaming data section of the interface.

THE BACKEND OF THE VISUALIZATION

The visualization was implemented in Processing. The data that is being plotted comes from files containing real EDA data that has been filtered in Matlab, so that it is presented with less noise. The orientation of the arrow changes based on points of local minimum and maximum in the data. These points are previously computed in Matlab based on the original EDA data and is then exported in a text file that Processing can read and change the orientation of the arrow accordingly.

Determining increases and decreases in EDA levels

Our goal was to determine the general trend of the EDA levels. We wanted to be able to capture whether the EDA level is generally increasing over a period of a couple of minutes, or decreasing. We didn't intend to capture small fluctuations but only the general trend. That is why we started by looking at periods of up to 10 minutes to see how much the levels of the EDA would change. Since the moments of sharp increase in EDA are of particular interest to us we looked at the data we personally gathered with the Q Sensor. For our particular experience a sharp increase in EDA level was followed by a couple of minutes of decrease until the EDA stabilized, or just of

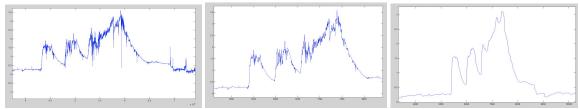


Fig.4: 3 figures presenting initial data, filtered data with 33 size low filter, and further filtered data with a median filter. Each 600 points on the graph represent 10 minutes.

continuous high levels of EDA. In our models we assumed two significant increases in EDA per 10 minutes, or three significant increase in EDA. These can be easily changed, but this is the granularity of the analysis we did currently.

For the data analysis we applied the following procedures. We first filtered the data with a 33 size filter that smoothened the data (Fig. 4). This reduced some of the noise, but our interest was in fitting the data to a curve where we can easily observe the significant changes in general increases and decreases of EDA level. For that we applied a median filter over 100 points at a time, which is about 12 seconds. This smoothened the data significantly. Based on the curve we obtained at this step we tried to fit Gaussian curves over the data or exponential curves. As looking at a long period of time didn't help us fit these curves over the data we decided to focus on 10 minute periods of data, as described before.

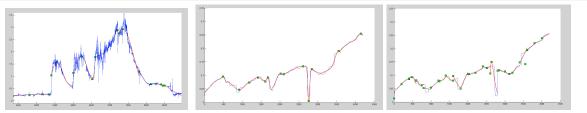


Fig. 5: the first and second graph reflects the data with the local extreme points in the Gaussian fit. The third graph presents an exponential fit to the curves. Each 600 points on the graph represent 10 minutes.

In the first step we attempted to fit Gaussians over 10 minutes of data. We varied the number of Gaussians from 2 to 5. We decided to focus on 2 Gaussians because it fit the perspective of looking at significant events to detect when they are happening. This does not offer a detailed enough granularity on real time data. We plan to increase the level of detail on EDA changes. However, for the purpose of testing our interface and providing data at a faster pace to receive general feedback, we found this approach useful. It allowed us to go through a bigger length of time with our participant. We explored more data and while playing data at high speed, the change in arrow levels corresponded to how often it might change in reality.

We also attempted to fit exponential functions over the data. Since the EDA data is not symmetrical, the exponential would potentially be a better fit. We tried fitting 1 exponential function for every 3 minutes of data. For both fitting we used a the Matlab Curve Fitting Toolbox.

After fitting curves on the data we found the local minimums and maximums for each of the fitting curves. These extreme points were exported in files and the code written in Processing used them for determining when the arrow should point up (a local maximum) or down (a local minimum).

Discussion of data analysis

We only tested the fitting algorithms on a one day data set. On this we think our fitting approach worked well. We were able to determine the significant increases and decreases in EDA levels. However this also captures increases and decreases in EDA level when the EDA is generally constant. In Fig. 5 you can notice these points of local extreme. There is a significant amount of local extremes in somewhat flat data at the beginning of the data set. That should be accounted for when visualizing the data, so that the fluctuations are perceived as somewhat constant. We didn't notice significant differences between the Gaussian fit and the Exponential fit. But this is probably because we tested on very little data. We think that on a longer term the exponential fit is better as it captures the shape of the EDA curve better. Also, we only tested on data that was characteristic one person's EDA levels. This needs to be tested on data coming from several people with different patterns of EDA levels.

Furthermore, there are better algorithms that we can try to determine EDA trends. In the future we could try Exponential Decay Models. Also, for real time data we could use IIR filters. These are options that we need to understand better before we can move in that direction. For the purpose of our proof of concept prototype we resumed to a very basic solution.

One of the immediate goals in data analysis would be to explore different granularities of fitting the data. This implies looking at changes at a 10 or 30 second level, up to 1 or 3 minutes. We will explore how detecting these changes will make a difference in how the changes in EDA are perceived in the visualization.

CONCLUSION

There are a lot of challenges in visualizing the EDA data. Through each of the sections we wrote in the paper we provided a discussion of future work that we envision doing. Immediate changes involve refining the interface and testing it with teachers in an environment that is as similar to how they would use it as possible. This would provide the most feedback on what design changes should be made on this interface. The data analysis is also a challenging part of this project. We would like to perform better detection of the increases and decreases in data. One of the immediate steps is to try different granularities of data to detect the increase in EDA. This could then be immediately tested to see what it's effect is. Furthermore, we would like to do the data processing directly in the Processing programming language so that the flow of the system is simpler. This would allow us to move to a real time version of this interface, where we could explore a new dimension of this visualization and observe new challenges. Furthermore, we need to understand the EDA data better, so that we can make better decisions with regard to how to analyze data, to what are significant changes and how they differ in different individuals. Las but not least, we need to understand our users better and what exactly their needs are. Looking at all these aspects will help us provide an interface for visualizing real time EDA data that offers both context, immediate response to what is happening with the arousal level and a useful tool for teachers.

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