USER-CENTERED DESIGN EVALUATION BY APPLICATION OF

BIOFEEDBACK TECHNOLOGY

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USER-CENTERED DESIGN EVALUATION BY APPLICATION OF BIOFEEDBACK TECHNOLOGY

Whitney Ann Skinner

A Thesis

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USER-CENTERED DESIGN EVALUATION BY APPLICATION OF

BIOFEEDBACK TECHNOLOGY

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Date of Graduation

VITA

Whitney Ann Skinner was born in Dallas, Texas on January 21, 1981 to Peter James Skinner and Cynthia Allen Skinner of Coppell, Texas. She attended all Coppell public schools through High School where she graduated in 1999. She enrolled at Texas A&M University in College Station, Texas and studied Environmental Design in the College of Architecture. On May 10, 2003, she was awarded a Bachelors of Environmental Design with a minor in Art and Architectural History. During a study abroad semester to Castiglion Fiorentino, Italy in her junior year she had the honor of winning a design competition with two other students. The monument, Memory, stands 12 feet tall in travertine marble in honor of those that have been lost to war and terror. This defining moment led her to apply to Auburn University's department of Industrial Design for the post-baccalaureate program and Masters program. On May 11, 2004, Whitney was awarded a Bachelors of Science in Environmental Design. From May 2004 to August 2006, Whitney has been diligently exploring, learning, and researching materials and experiences to include in this thesis document. Because of the great opportunities this thesis work has offered, Whitney will be continuing to study design and biofeedback technologies in the College of Human Sciences while she works towards a Doctorate in Integrated Textiles an Apparel Sciences. Her future goals include additional European travels, possible design consulting and a career in the University setting.

THESIS ABSTRACT

USER-CENTERED DESIGN EVALUATION BY APPLICATION OF

BIOFEEDBACK TECHNOLOGIES

Whitney Ann Skinner

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It is the responsibility of an Industrial Designer to create products that are valuable in usability and aesthetics for the user. Through design evaluation, the designer is able to use techniques of screening out less attractive ideas so that the final result best meets the users' needs. User-centered design evaluation approaches help to minimize the guess work for designers by gathering the user's feedback throughout the product's development. This approach helps to minimize the risk of product failure by channeling the user's preferences during the product development.

There are many design evaluation methods, from criteria matrix, weighting and rating, check list, dot-sticking, to user testing that aim to measure user attitude toward designers' concept sketches, models, or prototypes. These methods capture the conscious physical responses the users make in evaluating the designs. During the translation period, the users' real time responses are filtered to designers through the communication

process. Many inherent problems, such as bias and misinterpretation, associated with communication are inevitable during the process. Therefore, design evaluation techniques are modified to effectively help designers select the ideas that user responds best towards

Biofeedback technologies, used by psychologists for years, provide much more objective results for design evaluation. The Galvanic Skin Response (GSR) uses a psycho-galvanometer to measure the resistance of the skin to the passage of a very small electric current. The magnitude of this electrical resistance is affected not only by a person's general mood, but also by his or her immediate emotional reactions. The change of this electrical resistance is related to the level of cortical arousal. The results from a GSR experiment are a record of the internally experience emotions that a user cannot communicate consciously or physically through other evaluation methods.

This study introduced a new design evaluation method that addresses the physically expressed thoughts and emotions as well as the internally experienced emotional response. Understanding the user's emotional response through a traditional method of evaluation and a biofeedback method allows designers to better understand the user. This method impacts design evaluation and product outcomes with a process that captures a more complete response from the user. Essentially, products evaluated using this new method are likely to be more successful than those evaluated using current methods.

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1. INTRODUCTION

1.1 Industrial Design Background

Industrial Design, also synonymous with product design, refers to the development and creation of sometimes life sustaining, entertaining, functional and mass produced products. The Industrial Design Society of America briefly defines industrial design as:

> Industrial design (ID) is the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer. (www.idsa.org, 2006)

An industrial designer is a problem solver of issues regarding the design and development of products. These problems involve direction and specification throughout the development of the product. An industrial designer solves these problems to ensure that the result is a product that is both satisfactory to the manufacture and the user. The user is an important factor to consider in product problem solving. The product is subject to potential success and failure based on the users' purchasing decisions. The product development process according to *Industrial Design: A Practicing Professional* author, Philip H. Stevens (2002), can be categorized into 10 sequential phases: Conception of a need or idea, Research, Product Specification, Product Development Team, Concept

Development, Concept Refinement, Mock-up and Model Development, Prototype Development, Test Production Run and finally Full Production Begins. As Stevens goes on to explain the industrial designer's function, "The industrial designer creates something and it is his or her responsibility to make it beautiful to look (aesthetics) at and comfortable and safe to use (human factors)" (p. 7). Because the industrial designer has such responsibility in creating products that are as beautiful as they are functional, it is the reactions of the user that can affect the success of the product. However, it would seem that the risk for failure would be greater without seeking the reactions of the user during the development of the product. For the purpose of this study, involving the user is an important factor in the evaluation and development of the product. The Usability Professionals' Association defines user-centered as: "User-centered design (UCD) is an approach to design that grounds the process in information about the people who will use the product. UCD processes focus on users through the planning, design and development of a product." (www.usabiltyprofessionals.org, 2006). This process if used during product development or evaluation would create a product that would ideally meet the needs of the user more than a process where users are not involved.

1.2 Problem Statement

As identified in the design development process, there are phases in the process that define the direction the final product takes. In defining actions taken in the "Concept Refinement" phase, Stevens states, "Criticism of the proposed concept(s) is made by the product development team. Compromises are made and the best concept is refined. With

acceptance of a concept, engineers and industrial designers are free to begin work on the design." (p.8)

The product development team uses current practices of determining the direction of their product based on available trend reports, company identity, user feedback and personal intuition. These practices, however, cannot provide a complete picture for the anticipated outcome. Many factors other than the product's design contribute to the potential success and failure of the product. Involving the user throughout the design phase is one opportunity to reduce potential risk by designing a product with the user's feedback. Current design evaluation methods such as interviews, dot-sticking, weighting and rating and the product development teams own evaluations seem to use communicated responses. It is important to understand the process in which these communicated responses are processed in the brain to further understand how these responses can have a critical effect on design.

The brain processes all information sent to it through messages that neurons carry to it. Inside the brain, the Central Nervous System (CNS) is communicating these messages to the various parts of the brain in which they are processed. The nervous system is composed of the CNS and the Peripheral Nervous System (PNS) and performs four basic functions: gathering information of outside and inside the body, transmitting this information to the specific areas of the brain, processing this information for the right response and sending out any information to the muscles and glands as a response (www.bbc.co.uk, 2006). The areas of the brain are divided into parts that perform certain functions. The Cerebrum, Cerebellum and Diencephalon are major parts of the brain that perform functions related to this study. The Cerebrum is the largest part of the brain in

which several areas within it process speech, thoughts, emotions, skilled movements, touch sensations like temperature and pain and hearing and memory storage. Another important area within the Cerebrum is the area called occipital lobe where visual images are interpreted. (www.bbc.co.uk/science/humanbody/, 2006). Actions like interviews and dot sticking would be processed in the Cerebrum. In addition to the Cerebrum, the Cerebellum is important because the control of muscles, posture and precise movements originate here. The physical action of participating in design evaluation involves this part of the brain. The Diencephalon is a part of the brain that sits beneath the Cerebrum right above the brain stem. This part consists of the thalamus and hypothalamus which are important because involuntary bodily functions and actions occur from the messages sent to it from the body. Sensory nerve impulses send incoming messages to the parts of the brain to interpret and act upon. (www.bbc.co.uk/science/humanbody/, 2006). Understanding how the brain processes information can effect how design evaluation methods are performed because this could influence how the information is processed.

The problem with design evaluation methods where the product development team interprets the physical or verbal outcomes is that the team is only seeing the outcome of how a person has interpreted the product within his or her brain. While this method can be sufficient in determining some kind of result or direction, a process that captures the internal processing of the information could provide an understanding of the user that current methods do not account for. Physical or verbal interpretations or outcomes in design evaluation can not perceive the emotional response that occurs during the design evaluation session. A method that analyzes both the users' physical and internal emotional responses would provide product development teams with a more

clear understanding of the user. This could result in more user-centered designed products and a higher potential for success. In researching design evaluation, it appears that there is not a method that considers these factors. A method that can consider how the brain processes information for design evaluation is needed to aid product development teams produce better products.

1.3 Need for Study

Currently there are so many options to use in determining the selection of a final concept in the Concept Refinement phase that it makes the decision process much more of a risk. These options make it difficult to discern which option provides the best determining factors. The user's physical responses vary from verbal expression of opinion, recorded choices through survey and physical action through processes such as dot sticking. Emotional, or internal responses, can provide another factor in design evaluation.

In both instances, it is difficult to fully understand the responses without the aid of those trained analyzing current methods and without biofeedback monitoring devices. Biofeedback is a process of "...providing real time information from psychophysiological recordings about the levels at which physiological systems are functioning. (www.aapb.org, 2006). This means that the internal processing of information which can result in a form of emotional response, can be recorded using a biofeedback device.

In *The Feeling of What Happens* by Antonio R. Damasio (1999), Damasio states:

> We do not need to be conscious of the inducer of an emotion and often are not, and we cannot control emotions willfully. You may find yourself in a sad or

> happy state, and yet you may be at a loss as to why you are in that particular state now. A careful search may disclose possible causes, and one cause or another may be more likely, but often you cannon be certain. The actual cause may have been the image of an event, or image that had the potential to be conscious but just was not because you did not attend to it while you were attending to another. (p.42).

In concept evaluation, the concept acts as a stimulus that creates an emotion. This emotion is then translated into some display of public understanding with either verbal speech or with non-verbal action. If there is no recording of a user's emotional response, then current design evaluation practices have no way of furthering the understanding of what stimulated his or her responses. A convincing factor for developing a method fully interprets the users' responses is that people are not always truthful. In *Detecting Lies and Deceit: The Psychology of Lying and the Implications for Professional Practice,* Vrij (2000) states that, "People lie for several reasons. First, they lie in order to make a positive impression on others or to protect themselves from embarrassment or disappointment." (p.8). Considering this statement in the use of current design evaluation methods suggests that a person may not translate his or her internal emotional response outwardly in a completely truthful manner. Biofeedback applications can provide methods of recording the internal process of translating emotional responses. These responses can be used by the product development team to make design evaluation decisions that affect product outcome.

This study describes the need for a more clear understanding of how user's process and translate his or her responses to a product during design evaluation. By using

a method such as survey where the user has the opportunity to knowingly translate his or her response and a method of recording the user's internal emotional response can provide feedback for product design that no other single method can produce. The study will also explain the uses of biofeedback technology practices and how the process can provide data that naturally can be integrated into the design evaluation process. The development of a product will demonstrate the use of this new biofeedback technology and survey integrated method and how it can be useful in the design evaluation phase.

1.4 Literature Review

1.4.1 Identifying problem areas within the design of a product

The design of a product is a complex process that involves participants of specific backgrounds in business, engineering, manufacturing and industrial design. The process is intricate with many steps or phases of decision making in order to produce a product that meets the needs of the consumer. Stevens (2000) outlines ten general phases for the development of a product. Each of the phases generalizes the jobs and functions of each participant in the design process. Specifically in the Concept Refinement phase, we find that there is opportunity to make mistakes and areas for improvements.

Whereas Stevens refers to "Concept Refinement" in his book as one of the phases a product passes through in development, this study will refer to the action as Design Evaluation. Design Evaluation is a process of critique. The product development team use processes of selection and comparison to arrive at the best possible solution that is believed to meet the needs of the consumer. These ideas can be presented using a variety of visual methods such as hand or computer generated sketches, or as models that are

either physical or photo realistically rendered using a 3-dimensional computer program. Whether the idea is in drawing form or in model form, through the design evaluation processes, a final idea or concept is selected by the product development team. Each team may use a different type of evaluation process to make a selection from the possible design solutions. The website, www.betterproductdesign.net (2006), provides several methods of design evaluation for product development teams. However, what this website and other resources confirm with their many different types of design evaluation methods is that there is not one design evaluation method that can produce results that would eliminate the need for multiple types of design evaluation.

1.4.2 What is design evaluation?

Participants in design development may contribute in the design evaluation phase by providing their opinion on possible design solutions presented to them. Product development teams may use potential users in requesting evaluation of their product in order to achieve future positive results with the user in the marketplace. User-centered design is about designing a product for the intended user with the feedback of the user throughout the design development phases of the product. User-centered design is a popular movement among design professionals and has significant advantages. Product development teams are confirming a product will be the right one with the user by inviting the user to assist in selecting the right solution.

While user-centered design and the use of design evaluation methods are standard practices in design evaluation by some designers, both *processes* rely on the individual participant's action of expressing his or her opinion. The translation of the participant's

opinion can either be under or over exaggerated and can greatly affect the final solution choice. Because the translation of communication has no measurement, the product development team must use caution in relying on such opinions.

1.4.3 Different processes in design evaluation

Both qualitative and quantitative methods can be helpful in providing data that can provide useful information to the product development team. All of the methods are intended to select a clear solution that the product development team can further develop. However, with each method used, there are advantages and disadvantages. Some typical examples of methods used in design evaluation are weighting and rating, dot-sticking, questionnaires, and focus groups.

In the use of weighting and rating as a design evaluation process, www.betterproductdesign.net, states that it is: “The simplest and most commonly used form of concept selection. Easy to understand and apply, but demands reliable information to be truly effective.” In this process, important features are listed with weights assigned to each feature. The scores are then calculated and typically present a numerical *winner*. However, the website reminds potential users of this process that the numbers are subjective and arbitrary and do not provide a qualitative evaluation.

Another design evaluation process that, www.betterproductdesign.net, presents is called dot sticking.

The dot sticking approach is a good selection tool, when there a wide array of potential or competing ideas as well as a large number of stakeholders. By

> allocating each stakeholder with a number of sticky 'dots', they can allocate one, some or all of them to their preferred choice. (2006)

Dot sticking is a non-verbal form of communicating opinion. However, while there is measurement of the number of dots an idea may receive, there is no further understanding of the opinion of the individual who placed the dot on the selected idea. This form of design evaluation may be quantitative, but without questionnaire or interview follow-up, it lacks qualitative results that could have assisted the product development team in furthering the development of the product in a way that was more user-centered.

Questionnaires can be a useful design evaluation process by offering both quantitative and qualitative results. However, they cannot provide a measurement of a person's true feelings towards the concepts they are evaluating. According to DeFleur, Kearney and Plax (1998),

> Structured questionnaires have advantages and disadvantages. Critics maintain that highly structured questionnaires lead participants lock-step through a series of rigidly posed questions, reducing their answers to categories and boxes. As a result, the participants' more subtle meanings, feelings, and perceptions are either lost or distorted. (p. 429)

Most questionnaires limit the possible response a user can make. This is because evaluators must use one of many question types and scales in order to produce a measurable data result. With a questionnaire using either type of question and scale measurement, a product development team does not get the opportunity to understand the opinion or mindset of the user. While verbal communication is not involved, the

information the user provides the product development team, is subject to the same translation as is verbal communication. This type of quantitative data has limited applications into possible changes a product development team can make that would create a more user-centered product.

The focus group is a qualitative research method that can be used during the design development phase to help the product development team. Christopher Ireland (2003), defines the traditional focus group in his article, “Qualitative Methods: From Boring to Brilliant”, as:

> A gathering of 10 to 12 consumers who are led in a tightly scripted discussion by a trained moderator, usually for about 2 hours. Originally used for any topic or purpose, they are now recommended primarily when you want to generate ideas and/or expand understanding without needing to reach consensus. (Ireland, pg 24).

This type of group interview is used to assist the product development team in either understanding consumer reactions or to help them understand ways to improve their existing products.

> One of the common uses of the group interview is in the development of new products. In an early stage of new-product development, occasionally the technique of determining consumer reactions and objections to existing products can help lead to new-product modification. Early checking of reactions to a new-product idea (concept testing) through the group method may also be useful in gauging reactions to a new product. (Blankenship, Breen, Dutka, 1998, p. 141)

While Blankenship, Breen and Dutka state the above from their book, *State of the art Marketing Research* that a focus group can be useful, Thomas L. Greenbaum (1998), states in his book, *Handbook for Focus Group Research* that: “Many focus groups are intended to learn what is wrong about products or service in order to make the appropriate changes to improve it...The mistake here is that the regular users of a product or service are normally quite satisfied with it and have relatively minor dissatisfactions. (p. 62)

The problem with both statements is that the product development team or the participants using the findings from the group study are evaluating the content of the verbal expression. The participant is then bringing his or her own understanding and bias to the statement to arrive at a conclusion of what has been said. “The biggest analytical mistake that people make is to enter the research with a preconceived bias and to listen for inputs from group participants that confirm their belief. Unfortunately, this mistake is quite common in focus group research.” (Greenbaum, 1998, p. 68)

Bruce Crandell (1999), in his article, “To Focus Group, or not to Focus Group”, on www.decisionanalyst.com gives examples of reasons to perform focus group research. “There’s nothing quite as powerful as actually seeing and hearing what someone else truly thinks about your product or service. Additionally, groups are often videotaped, allowing observers and others to review them later on.” (www.decisionanalyst.com, 1999).

When a product development team uses the information gathered from focus group research, they are able to make assumptions from what they have witnessed and translate those into results that may or may not be apparent in the designed product. The

problem again with focus group research is that it makes the product development team translate verbal communication into what they need at that point of the design development. If the consumers who participated in the focus group propose the color blue for the product but also believe it should have a different appearance and the product development team translates the information as needing to make their product blue, they may or may not have positive results with the user in the marketplace. The product development team relies on the communication between focus group participants which is not an accurate form of measurement needed to confirm the product will be user-centered and have positive results with the user in the market.

All of these design evaluation processes provide some kind quantitative and qualitative result that the product development team can use to further the design development process. However, these results can not provide a recorded measurement of the user's true thoughts and emotions toward the ideas being evaluated.

1.4.4 Why do product development teams use design evaluation?

Baxter provides necessary insight into the importance of understanding the consumer in product design with his statements regarding how orienting the product's design and development to be user-centered. His book also suggests that the consumers' buying habits will be effected by the designs of products when user-centered products begin to be more available and understood that the product has been designed using user feedback.

In one of Baxter's statements "Product development must be fundamentally and comprehensively customer oriented." (p.26), it would seem that in order to achieve this,

design evaluation must accurately insure that the developing product is in fact customer oriented. Success depends on the consumers and their reactions to the product. If a product development team can use design evaluation methods to increase success with the consumer, then the product development team is more likely to choose concepts that are in line with a consumer's positive reactions. By using gathered information from design evaluation to discover which ideas appeal most to users and what will be accepted by the user, the product development team can then design a product that is most in line with those thoughts of the user. Product development teams need this information in order to reach their target audience. By involving the user in the design evaluation phase to gather such information, the product development team can better understand how well they have reached their audience, or how much more work they need to do in order to appeal to them. Additional work may include revisiting the scope of the project including product specifications or revising minor concept details in a way that may be more understandable. Either way, the product development team needs to demonstrate an understanding of the user's wants and needs so that in the evaluation phase, the user can understand what is being communicated.

1.4.5 The significance of design evaluation in designing user-centered products

Using design evaluation is significant in creating user-centered products. Because users' reactions to the products can affect a product's success, both usability and aesthetic value are important factors to evaluate. Don Norman, an author of evaluated consumer products and co-founder of the Nielson Norman Group, a product and service

consultancy has the following to say about product design: “Good design means that beauty and usability are in balance. An object that is beautiful to the core in no better than one that is only pretty if they both lack usability.” (www.jnd.org, 2002). If the product development team can implement methods to find the balance Don Norman describes, then a product’s success should be an attainable goal. However, the method in which this balance is achieved must be able to capture the user’s needs. Product success can be achieved using a method that implements user-centered product design evaluation throughout product development. The reactions the users are able to provide through evaluation methods should be the key to the product’s success.

1.4.6 Identifying opportunities for potential risk and success

Baxter’s text also lends insight into the necessity to evaluate goals the product development team should set and understand. The designer’s role in creating successful products is partially dependent on how well they understand the audience they are designing for as well as an understanding of the market.

> Setting clear and realistic targets for new products provides the vision of what that product must achieve to be successful. The most important targets are those demanded or wished for by customers...Designers who fail to set targets will indeed ‘see no evil’ but they also will fail to see what they must achieve in order for the new product to succeed. (p. 4)

A designer must use a design evaluation method that can best understand the consumer in order to alleviate the product development team’s risk for failure in the development of the product. Norman (2001) in his essay “Applying the Behavioral,

Cognitive, and Social Sciences to Products" states, "Design is a complex business, not only because the products themselves are complex but because of the complexity of people and their needs."(www.jnd.org, 2001). This statement is significant in that design evaluation becomes even more important. Each phase of development such as drawing, rendering and modeling become opportunities for implementing user-centered design evaluation. These opportunities to gather users' responses would give the product development team a better indication of how the consumer might possible react to the product once developed. Emotional responses could provide the necessary tool to reduce the potential for risk and increase the potential for success.

1.4.7 Using design evaluation to reaffirm the concept is valuable to the consumer

In the early design development phases, targets, goals and specifications are set that identify the consumers' needs and desires in the products they use. Design evaluation that involves the users in a way as to record their emotional responses, in chart form will assist the product being developed in meeting the customer's satisfaction. With so many methods of design evaluation it appears that there are few that can capture a consumers' emotional reactions. Methods that do not account for emotional response cannot completely represent the user's true intent. For example, with methods such as group interviews, designers must extract and interpret responses which can have a potentially problematic effect on the design of a product. A design evaluation process that confirms product value and meets user's desires and needs by using recorded emotional responses

in real time will help designers create customer-oriented, user-centered, successful products.

1.4.8 Design evaluation criteria

In order to enhance the current practice of using design evaluation methods, criteria must be presented to understand how product development teams could integrate a new process that provides a complete response from a user. The arguments in this paper have presented several of the needs for a new evaluation process.

Criteria for this new evaluation process must consider multiple areas of the brain that process information and the responses that result. Because the results are both external and internal, methods that capture both results are necessary. A survey has the ability to capture the external response and a GSR test has the ability to capture the emotional response that takes place inside the brain and body. An advantage to this new evaluation process will be that the product development team can better understand the users and apply their responses to providing successful user-centered products. Product development teams could use the new, more comprehensive method, in every phase of design evaluation, from concepts to physical models, to best gain access into possible changes they need to make based on the responses of the user. The users' responses would aid product development teams in understanding how well they have met their goals of reaching and appealing to the user. Advancements in Biofeedback have created the basis for this study. This Biofeedback based design evaluation has the potential to provide a more clear understanding of a user's preference towards products.

1.4.9 What is biofeedback?

Biofeedback is an important tool in capturing emotional responses. This kind of tool for design evaluation can also be defined as:

> Biofeedback is providing real time information from psychophysiological recordings about the levels at which physiological systems are functioning. Biofeedback does not need to involve the use of computers, electronic devices etc. For example, a mirror is a perfectly good biofeedback device for many aspects of gait retraining. Electronic biofeedback devices are designed to record physiological functions non-invasively. Most record from the surface of the skin. The information recorded by surface sensors is frequently sent to a computer for processing and then displayed on the monitor and/or through speakers. The person being recorded and any therapist or coach who may be present can attend to the display of information and incorporate it into what ever process they are attempting to perform. The device does not send anything directly back into the person being recorded. (www.aapb.org, 2006).

Biofeedback can also be used to help people who may have certain medical conditions ranging from headaches to high blood pressure to paralysis. These people, with the aid of therapists, are able to train their bodies and improve their condition based on the biofeedback signals they receive. Biofeedback dates back to the 1960's when it became a term associated with the training of the body based on brain activity, heart rate, muscle impulses and other bodily functions. Some biofeedback techniques and practices have a longer history dating back 100 years.

Biofeedback devices as mentioned above do in fact range from extremely complicated and uncomfortable for the user to simple non-evasive hand held devices. All devices have the potential to gather feedback that can contribute to helping the user.

Neurofeedback is a specific term associated with the study and training of brain activity and function. This is an important biofeedback method that has gained popularity among design related disciplines. Neuromarketing is a new term in which scientists are studying to understand the buyer better. By studying the brain, they are able to better understand which parts of the brain process *buy* and *want* and *need*. According to an article by Carrie Peyton Dahlberg for the *Sacramento Bee*, she quotes the following:

> As hard as merchandisers try to fathom customers, behavior remains so hard for businesses to predict that, 'from their point of view, consumers are like some kind of random, finicky cat,' said Colin Camerer, a professor of business economics at the California Institute of Technology.
>
> 'Neuromarketing is kind of like interviewing the brain," he said. "Instead of just asking people what they want, you go right to the brain process.' (February 6, 2004).

The process of neuromarketing is similar to the process needed for a new design evaluation method. Instead of asking people whether they like the idea or not, design evaluation needs to go right to the source, the brain. Currently, neuromarketing involves the use of functional magnetic resonance imaging, or fMRI machines. These machines are large, heavy, loud and uncomfortable machines that do not fit in with the criteria the new design evaluation process wishes to take. With the discovery of biofeedback methods and the data gathering techniques, the following defined area of GSR (GSR)

testing could prove to provide valuable data. This data will allow product development teams to understand the user's true reaction to pictures, models and questions without the need for a verbally communicated answer.

1.4.10 What is GSR?

GSR is a biofeedback method that is able to measure skin resistance. According to Peter Shepard (2006), Transformational Psychologist and author of articles on the website, www.trans4mind.com, has the following explanation of how GSR is a biofeedback method:

> The most advanced layers of the cortex, unique to Man, link to the thumb and forefinger especially, and there is a further complex physiological response which occurs when the forebrain is aroused. Changes in Alpha rhythms cause blood capillaries to enlarge, and this too affects resistance. (www.trans4mind.com, 2006)

The connection between the brain and forefinger can provide understandable results when the GSR test is conducted. A psycho-galvanometer was an early tool that measured the skin's resistance through a small electrical current through the fingers. Over the course of the last 25 years, advancements have been made in understanding GSR and what causes the change in the skin's resistance.

> It has been known for decades that the magnitude of this electrical resistance is affected, not only by the subject's general mood, but also by immediate emotional reactions. Although these facts have been known for over a hundred years and the first paper to be presented on the subject of the psycho-galvanometer was written by Tarchanoff in 1890. (www.trans4mind.com, 2006)

In design evaluation, having the ability to measure a user's emotional reactions through GSR would transform the ability to design better products for the user. As an example of how GSR testing and design evaluation could interact to produce results, a user would only have to have their forefinger connected to small electrodes and when a question or picture is presented, the user only has to have an emotional reaction. The psycho-galvanometer would be able to understand the significance or degree to which the user responded. If the user was asked the question of "do you like this" to several concepts, the product development team would be able to understand which concept the user responded to with the most reaction. This procedure meets criteria of reducing possible user bias by eliminating verbal response. It also keeps the user comfortable and in a setting that is non-evasive, unlike the use of fMRI machines in nueromarketing. GSR testing has promising use in transforming design evaluation.

1.4.11 How can GSR aid design evaluation?

GSR is a process that can measure a user's reaction to presented stimuli. In the case of design evaluation, the stimuli are concepts the product development team needs evaluation on. Whereas old methods of design evaluation do not offer recorded emotional response data to base decisions on, there is the opportunity to use the GSR biofeedback method as a way to accomplish this. The GSR tests provide recorded data without the use of externally transmitted responses. This test records the emotional response a person interprets internally when asked questions or presented with visual material. Traditional forms of evaluation gather the external expression and translation of responses that a product development team can then translate into decision making material.

Understanding both kinds of responses gathered through design evaluation can allow the product development team to make decisions. GSR can aid this process with the emotional response data that it captures.

1.4.12 Potential outcomes for use of GSR and or in design evaluation The use of GSR when incorporated into Design Evaluation could reduce the risk of the product development team's potential for failure. Baxter (1995) confirms the need to invest in the early stages of development. "Of all the stages in new product development, the most important are the initial stages." (p. 26)

By investing in biofeedback techniques that provide measured data throughout the design evaluation phase, the development team will reduce the possibility of needing to make changes to the design in the later phases of design development. If biofeedback processes are used throughout various stages of design evaluation such as drawings, renderings or models, each decision will have recorded reactions of potential users to help the product development team base their decisions on. Emotional responses from consumers as a basis for decisions should provide success for the designer and in the marketplace.

1.4.13 Conclusions

The product development team can now utilize biofeedback as a method to aid design decisions. Understanding the emotional responses from potential product consumers will aid in the reduction of failure among these consumers. The feedback that these users provide through externally and internally transmitted responses will help

transform the way in which products are designed for users. The goal of incorporating both a traditional method and a new method for design evaluation is better products for the consumer and a degree of success for the designer. The use of biofeedback that gets into the internal processing minds of users will begin to change potential buying habits and design trends. Designers should see this movement as a way to better meet the needs of the consumer and the biofeedback methods as one way of understanding the why of buy and the minds of the consumer. The combination of design evaluation methods that provide feedback for product development teams that no other single method can provide can change current methods and current market products. The possibilities for this study are optimistic and extensive, but have the potential to create a foundation for future development and changes in design evaluation.

1.5 Objectives of Study

- To gather all necessary information from books, periodicals, CDs and Internet sites on Design Evaluation, Market Research, Communication, GSR, CNS and PNS
- To identify common current evaluation methods
- To formulate a new design evaluation method using biofeedback devices
- To set up a preliminary test using the biofeedback devices to test which device or combination produces the best measurements
- To identify and design MP4 players to be used as the concepts to be evaluated
- To identify a select group of students to evaluate the chosen designs and to have their evaluations measured using biofeedback devices
- To chart the findings of each student's evaluations and decipher the supporting value to the design evaluation method

- Develop and use a survey to gather voluntary data from users following the biofeedback design evaluation experiment
- To produce papers to be published containing this new concept of design evaluation
- To produce a final documentation that completes the Thesis requirements required by the graduate school at Auburn University

1.6 Definition of Terms

Biofeedback

- Biofeedback is a term associated with the training of the body based on brain activity, heart rate, muscle impulses and other bodily functions. Methods of biofeedback include Electroencephalogram (EEG), and Electromyogram (EMG). Some simple biofeedback techniques and practices have been available for over 100 years.

Central Nervous System (CNS)

- The Central Nervous System is part of a person's nervous system in which a body's responses are voluntary and controlled such as muscle movements and conscious decision making.

Cerebellum

- The second largest part of the brain. This area controls muscular movement, posture and precise movements.

Cerebrum

- The largest part of the brain. This area controls functions such as speech, emotions, touch sensations and memory storage among other specific functions.

Concept Refinement/Design Evaluation

- The phase in the development of a product in which ideas are continually refined through methods of evaluation until a final idea or product is the result.

Design Development Process

- The process of developing a product. The design of the product can go through several processes before production and made available to the public.

Diencephalon

- Part of the brain that is located just above the brain stem. Contains the thalamus and hypothalamus regions that transmit various sensory impulses in and outside the body to specified areas of the brain.

Product development team

- The team of professionals including engineers, designers, users, business professionals and anyone involved in the development of a product.

Galvanic Skin Response (GSR)

- An example of a biofeedback method that is able to measure skin resistance through a connection of electrodes to the fingers. Devices can provide recordings or audible indicators to the state of the person's reactive levels to stimuli. Emotional responses such as fear, anger, and love can be detected through devices, although they can not be specifically identified.

Industrial Design

- Industrial design (ID) is the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of

products and systems for the mutual benefit of both user and manufacturer. (www.idsa.org)

MP4 Player

- An electronic device in which mpeg 4 video files can be played. Similar in nature to a MP3 player that plays mpeg 3 audible files.

Peripheral Nervous System (PNS)

- The PNS comprises other part of the Nervous System that controls involuntary functions. These functions include monitoring bodily temperature and response to emotional stimulus.

User-Centered

- User involvement in the design and development of a product with a focus on meeting the needs of the user.

1.7 Assumptions

Assumptions are factors that this study uses to support the need for research and further investigation. Each following statement is an assumption based on research.

Product development has many phases and can be modified at any instance of design. During Concept Refinement, all design evaluation processes and methods will be performed. No complete, whole body response measurement process is currently in use for the selection of a final concept. Biofeedback would provide measurement of reactions from the peripheral nervous system while surveys would provide measurement of reactions from the central nervous system. Biofeedback equipment will not frighten or be uncomfortable to the user. The user will not know the individual results of their

evaluation. The visual survey used in conjunction with the biofeedback technology will be based on a nonscientific organization process and will need refinement. The process of presenting concepts to the user during biofeedback evaluation can also be applied to the presentation of models or functions. It is also assumed that the data generated cannot provide a concrete answer towards understanding the user's reactions. It is also possible that there are additional methods of conducting the study sessions that could impact the results of the study. For this study, it is assumed that the results generated are a step towards gathering a whole reaction from the user.

Additional assumptions that are not based on research include the potential to have great effect on the design and biofeedback communities. This research will be conducted in a neutral setting on the Auburn University campus. This thesis work could have potential to expand into additional areas of research and expand into allied areas of design. It also has value that could impact the commercial markets as a way of impacting methods of design evaluation.

1.8 Scope and Limitations

1.8.1 Scope.

- The biofeedback methods utilized will only be methods that have been proven to provide the desired results of measuring and recording response to stimulus.
- The equipment used will only be the basic units that will provide the best, most usable and understandable results. Expensive equipment is not necessary to achieve the same results.

- It is the opinion of the author and advising faculty that the illustrating concepts of MP4 players as of June 2006 represent a product that is not as widely used in the United States yet but is an established product in the UK and Asia. The concept evaluation of this product will provide feedback that would be similar if a new market product were being introduced.
- Auburn University students will be invited to participate. There is no statistical data used in the formation of this experimental group used as evaluators of the MP4 player concepts.

1.8.2 Limitations.

The limitations imposed on developing and completing the research is as follows:

Cost

- The cost of some of the more advanced Biofeedback equipment is too expensive for use in initial testing. Testing using less expensive equipment will produce the same results but possibly without detailed graphics or extensive software interaction.

Demographic of Groups

- No personal information and background on the participants will be collected. Because of this, it is impossible to know the demographic background of each participant and how that can affect the outcome of the research.

Understanding of Technology

- The Biofeedback technologies used are basic and understandable. However, because no professional training in using these devices took place, results from

the individual sessions may not be fully actualized. As well, composition of the surveys in conjunction with the way the equipment works may produce varied results.

Product Production

- The design process demonstrated in this study is an example of what design professionals may duplicate in practice. The product produced in this study, because of technology limitation, can only reach the level of pre-prototype.

1.9 Procedures and Methods

Step 1

- Information from books, periodicals, CDs, and Internet sites on design evaluation methods and biofeedback technology, practices and information supporting the areas of the brain used in evaluation are needed to support this research topic. In addition, an understanding of a product area and target audience to study also needs to be identified.
- Research will be conducted using library search engines for books, periodicals, and CDs that will assist in gathering supportive materials that identify a niche area within design evaluation that needs improvement. The Internet searches will also help to understand complex information regarding Biofeedback. The internet will also aid in identifying the ideal product that meets the needs of this study.

Step 2

- Identify the ideal product to use as an example during design evaluation. Gather information on existing products and sketch using Photoshop and a wacom tablet,

ten existing products and ten new products of my own design. This will help in providing a choice of 20 products that are all presented in a similar manner. These sketches will be used in the first round of testing using biofeedback technologies.

Step 3

- By identifying GSR as the best technology to use in the design evaluation process, it is important to locate a GSR product that will be accommodating of both budget and level of understanding.
- Conduct preliminary testing using a prepared timed PowerPoint presentation with the GSR device. Make changes based on feedback from initial test.

Step 4

- Identify students for participation in study. Invite students to participate in four to five study sessions during the development of the product. Each session will aid in the development of the final product.

Step 5

- At each session the student participates in, the student will come into the office and will have his or her fingers connected to the GSR devices. He or she will then proceed to watch a timed PowerPoint Presentation of the prepared materials. When the PowerPoint concludes, the student will be given a picture survey to fill out. The picture survey will ask for the student's reactions in number form to the concepts in the PowerPoint Presentation. Each session should not last longer than 10 minutes. The student is free to leave upon the conclusion of the session.

Step 6

- Following the completion of all the sessions, the charts will be saved into JPEG format to present in an Excel Spreadsheet. Each GSR chart will be matched with numerical values of the picture survey. The picture survey results will be averaged to establish a numerical winner. The study will begin with 20 concept sketches and will then proceed to five computer models. The numerical results will present the top choices for the next session. The third session will present three computer rendered models and three prototypes. The results from the third session will conclude with one final model. The final session will present the final model, both computer generated and in final prototype form. The participant will have the opportunity to evaluate the final model in comparison to a successful product currently on the market. This comparison product will also be computer modeled and prototyped to present a similarity in quality.

Step 7

- Present final conclusions to both groups and Thesis committee. Turn in final documentation of Thesis for Graduation.
- Create a presentation of all the work from generated sketches through final model, including user reactions generated through GSR and visual survey. The Thesis committee will evaluate the presentation and research prior to the Thesis submission by the graduate school. If approval is given, prepare the final documentation according to the graduate schools standards and submit to the graduate school by given deadline

1.10 Anticipated Outcomes

This research depends on several factors. Each anticipated outcome is dependent on the previous outcome. Below are the anticipated outcomes in the order in which they are projected.

1. Through research on design evaluation, a new method for evaluation will be formulated
2. This new method for design evaluation will include biofeedback procedures for gathering feedback and an existing survey method
3. Biofeedback devices will be tested to insure their accurate measurement of reaction to design concepts
4. It is projected that the biofeedback devices and method for testing using design concepts will produce data that corresponds with a traditional survey method. The result will be a whole reaction produced from the central nervous system and the peripheral nervous system
5. The selected experimental group only represents members within the target audience; however, no statistical or personal background information is collected.
6. The results will produce only one view of how collecting information from the CNS and PNS correspond in the area of design evaluation

1.11 Deliverables

This research will result in a one model for using biofeedback for design evaluation. Several products will result from the completed research and experiment. These include the following.

1. One method for using biofeedback devices in regards to design evaluation.
2. A complete set of MP4 Player drawings, 3-D computer models and details of function renderings.
3. A test environment with biofeedback devices in a setting that is neutral and comfortable to the evaluator.
4. Data from all of the participants in graph form to provide a visual for the varying degree in differences.

1.12 Speculations

This research is possibly uncovering a new area of combining existing methods into a process that provides a complete picture of user reactions. This could have both positive and negative effects on society. First the positive affects being the creation of products that the manufacturer knows the consumer will react positively to and purchase. This effect could prove to have a tremendous effect on trends. If the consumer begins to have heavy influence on the aesthetics of the product, then products may begin to have very similar features. This research could also affect the consumer's purchasing habits if this procedure were to be used with every consumer product. Consumers may begin to plan their purchases specifically to the release dates of products. Some consumers currently practice this habit in regards to electronics, but this habit could extend to the next blender. This could also be a negative effect. The economy is powered by the consumer and changes in the consumer's habit could effect the economy's strength. Another possible negative affect and consequences could be that after all this research and the proof to which we provide with testing, is that no one is interested in using such

technology and reasoning to change the way they conduct design evaluation. These possibilities could all have different outcomes given a difference in the Limitations.

2. SESSION 1 EXPERIMENT

2.1 Preparation

There are four design evaluation sessions that relate in this study to four idealized phases of the design process. The first session is the most crucial because it is not also the results that are important but also how the session is designed. Experiences learned from each session can have a significant impact on the outcome of the experiment.

2.1 Participant Recruitment and Involvement

Each of the design evaluation sessions was set up with the participant in mind an in meeting the requirements set by Auburn University Institutional Review board for Research involving Human Subjects. The participants were in the age group of 19-27yrs of age and the likely target user of a media device such as an MP3 music file player. These participants are Auburn University Students and have schedules that include classes and possible work and organizational activities. Taking these considerations into account, a time limit of no more than 10 minutes was set to increase the potential for participation. 20 non-design University major participants were recruited to participate in the study. The ten males and ten females were of varying ages within the constraints of 19-27yrs of age and of varying majors and interests on campus. Some of the participants were previously known by the principle investigator.

2.2 Experiment design

The first session contained the beginning design phases for the development of an MP4 video file player. 20 MP4 player sketches were prepared in advance for the integration into a presentation for the first session. Based on an initial understanding of the GSR process of capturing real time responses to stimuli, it was important to create a presentation of the material in a manner that allowed direct correlation to take place when the session was complete. The GSR software has the ability to record the session and recall the chart at a later time. The material was prepared in a PowerPoint Presentation with rehearsed timings. These timings would later be recalled to correspond to the GSR recorded chart.

This first session presentation began with a very simple introduction to the project, what design project would be evaluated, and some instructions to follow once the sketches were presented. The first minute included pictures that were intended to measure the individual's emotional levels of response to stimulus. Each of these sets of pictures was intended to evoke emotions of sadness, anger and a neutral resting state. However, in preliminary testing, it was found that the color images were distracting from the sketches that followed. It was also observed that the individuals had no noticeable emotional response to the variety of pictures. It was decided to change the pictures to black and white and replace the pictures that were potentially negative for pictures that were more positive and or neutral. These changes would bring the person to a neutral state of emotional arousal which provided better results when the participant began to view the 20 sketches.

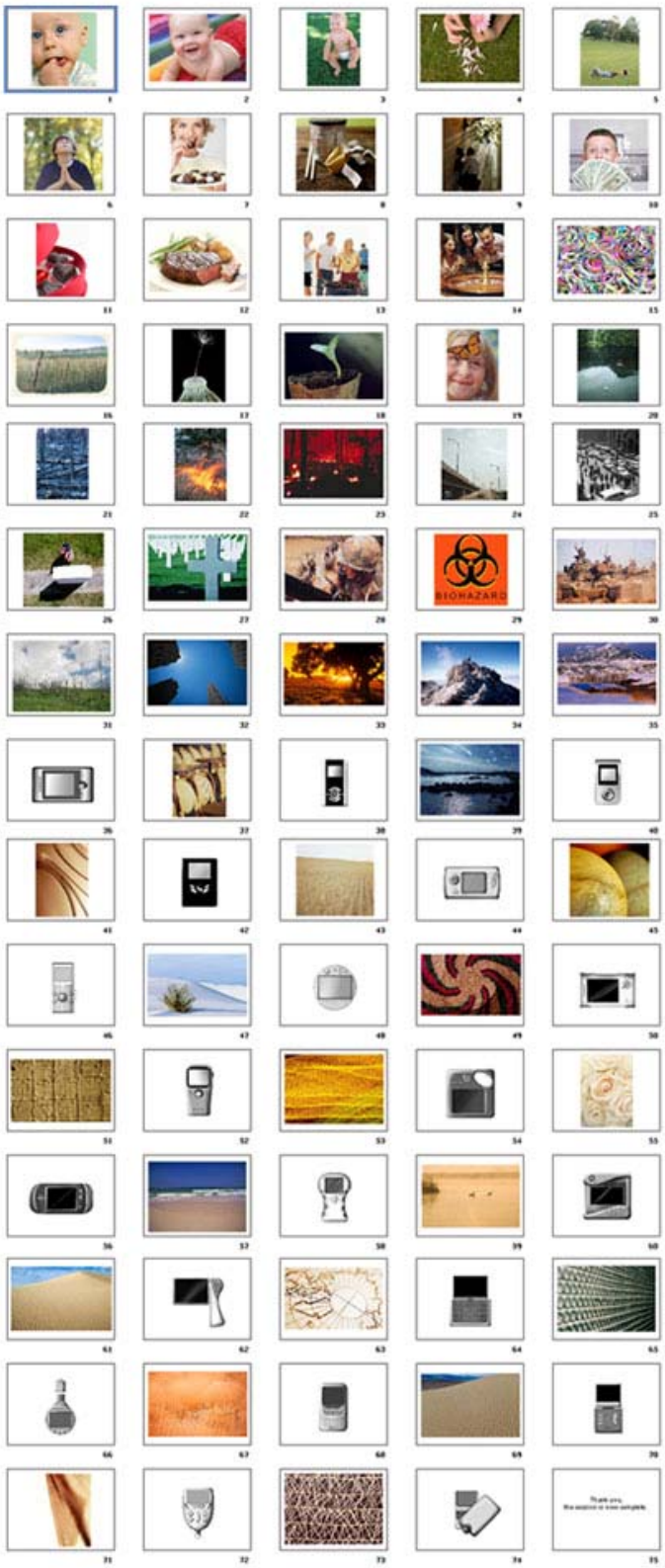


Figure 2.1 - Preliminary Session 1 PowerPoint Presentation

Figure 2.2 - Actual Session 1 PowerPoint Presentation

The 20 sketches were done in a similar manner to ensure that no one sketch was more visually appealing than the others. Ten of sketches were of existing MP4 players that are popular around Europe and Asia and the other ten sketches were of the researcher's design. By providing a combination of potential products to choose from, it would be interesting to see the results of which were most preferred, existing or potential products. In the presentation, the 20 sketches follow a series of neutral pictures. Then, the sketches are shown for approximately five seconds. In preliminary testing, neutral pictures were place in between the sketches. However, this was changed because it increased the time and, even though neutral, they had little to no effect on the reaction to the following sketch. These pictures were deemed pointless and were eliminated from the series of sketches.

A picture survey of the 20 sketches follows the GSR session. The participant is asked to assign a value to each of the 20 sketches. The first 5 sketches and their rankings are presented in the picture survey format in Figure 2.3.

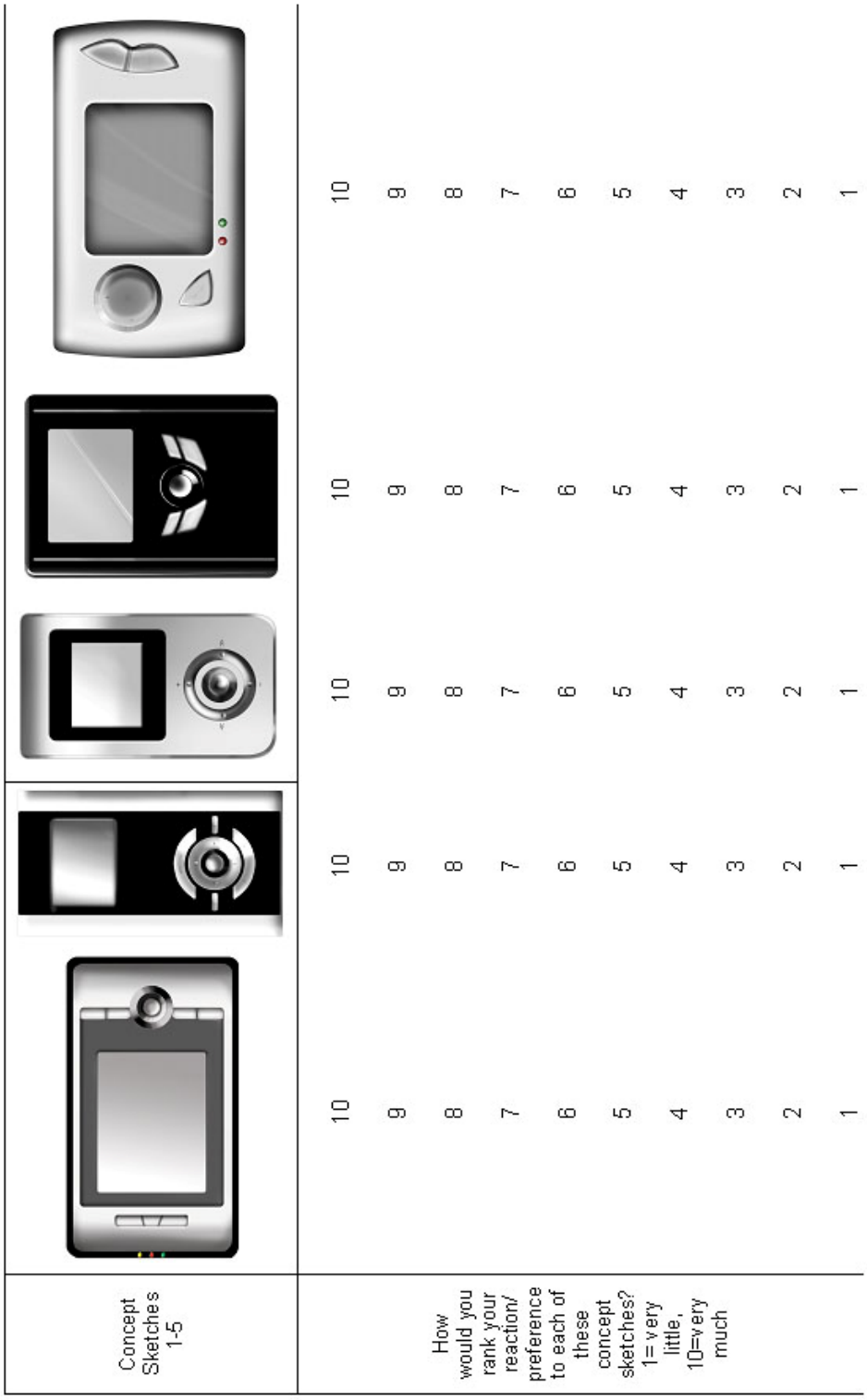


Figure 2.3 - Session 1 Picture Survey Example

2.3 Anticipated Outcome

1. It is anticipated that it will be unknown if the participant owns or has had experience with a media device such as an MP3 player.
2. It will be unknown the activities or conditions that the participant encountered or participated in prior to arriving at the session. It will also be unknown the participants stress level, emotional state or physical ailments at the time of participation. These conditions can all have effects on the participant's ability to respond to the stimulus.
3. It is projected that the design of the session in which the 20 sketches are presented is designed in the best way to derive at a response from the participant.
4. It is anticipated that the material needs to be presented as quick as reasonable possible so that the participant does not become bored.
5. Each participant's GSR chart of responses to the first session is expected to be understandable enough to provide a result.
6. The anticipated outcome from the participant's picture survey is expected to correspond to the responses on the GSR charts.
7. It is projected that the five sketches that are preferred the most based on the results of the GSR charts and picture surveys are each different and unique.

2.4 Deliverables

1. A Microsoft PowerPoint Presentation including the above mentioned changes to the presentation of sketches.
2. 20 different sketches of MP4 players

3. 20 GSR charts, 1 from each participant
4. 20 picture surveys with results marked from each participant

2.5 Actual Findings

Each GSR chart and coordinating picture survey for each participant was analyzed and recorded. After each participant's results were recorded, the data was looked at as a whole and analyzed. The findings from the picture survey were easily understandable. Each participant was able to provide numerical winners. The GSR charts were more difficult to understand. Results from individual participants varied. For example, in the portion of the survey where the sketches are presented, at the top of each slide is a question that asks if the participant would like to own this MP4 player? The participants were instructed to respond silently to this question. It was thought that by responding with a "Yes, I would like to own this MP4 player" or "No, I would not like to own this MP4 player", there would be a clear response shown on the GSR chart. For some individuals, there was no noticeable response and for some, there was. Below are two charts that represent participants with no noticeable reaction and one with clear, noticeable reactions to the stimuli.

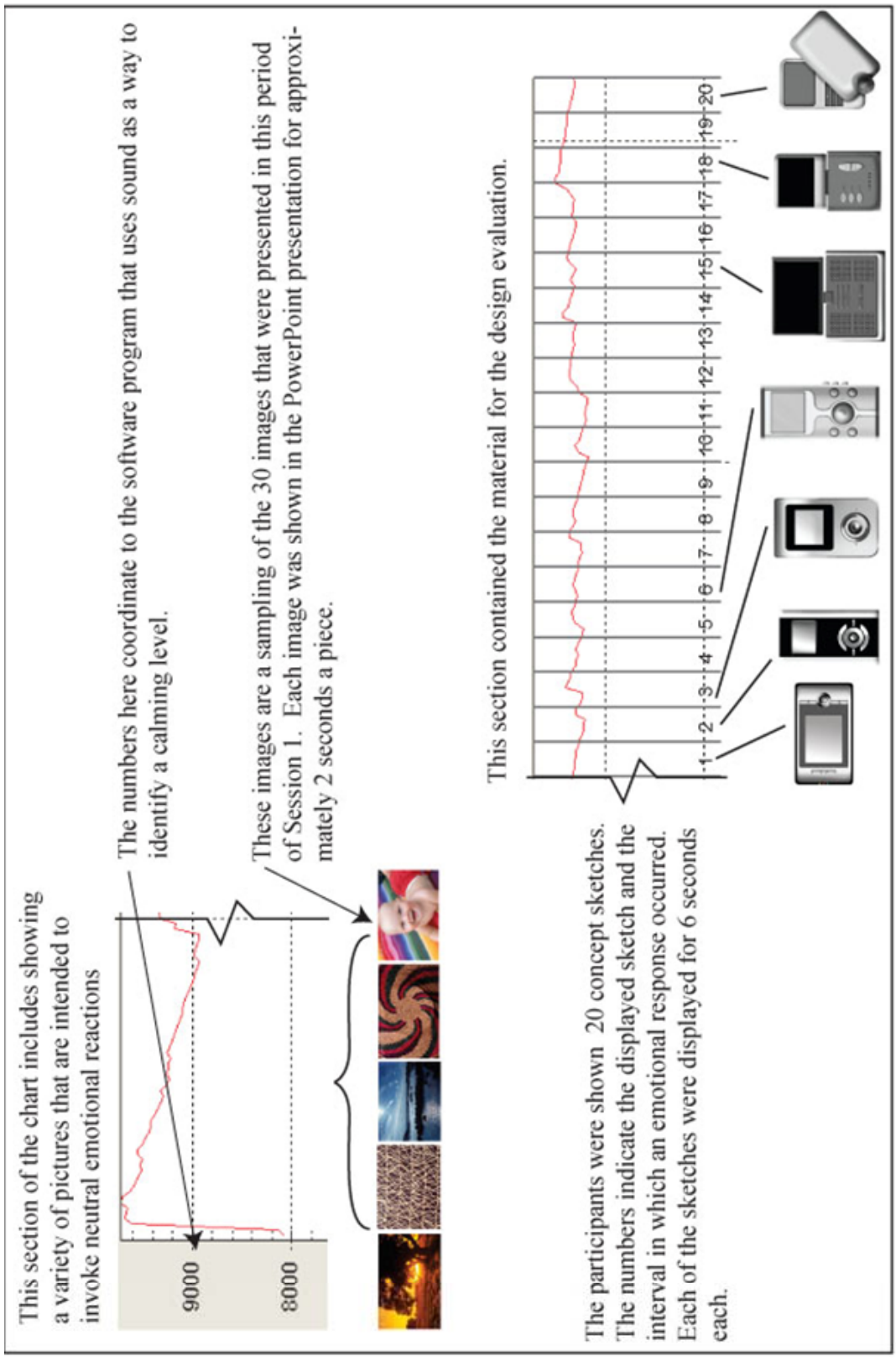


Figure 2.4 - Session 1 GSR Chart Dissection & Explanation

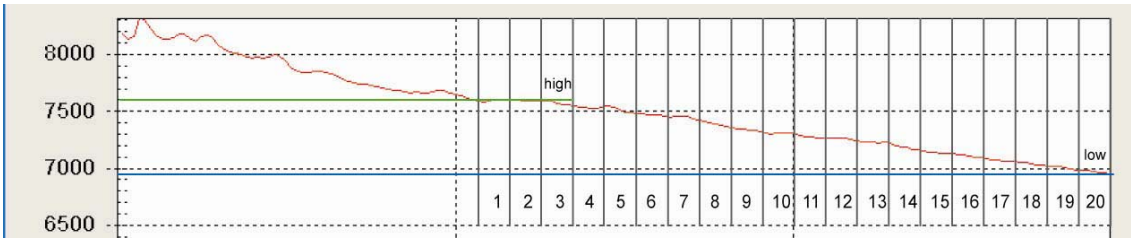


Figure 2.5 - Session 1 Chart Example

This chart shows that at the beginning of the session, the participant's emotional reaction levels were raised. As the session progressed, the individual became more relaxed and therefore his or her emotional reaction levels decreased. This had a direct relation to his or her ability to respond to the stimulus. The amount of time in which the participant was exposed to pictures via the same medium (the computer screen) could possibly have affected his or her ability to respond because he or she had become bored with the stimulus. No data was able to be collected from this particular chart. The participant's picture survey was the only way to understand his or her preference to the material.

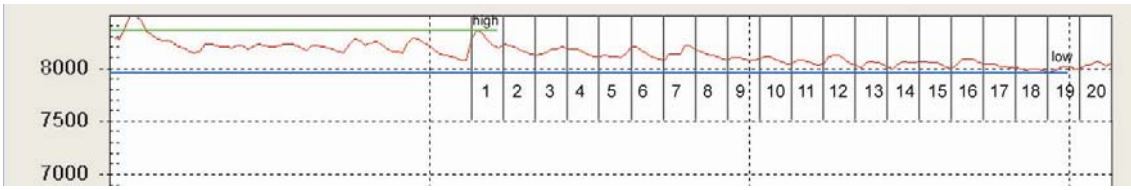


Figure 2.6 – Session 1 Chart Example

This participant was clearly aware of the stimulus and was able to maintain emotional reaction levels. The bars separating the numbers indicated the time period the participant was viewing the particular sketch. It is easy to view this chart and speculate which sketches the participant had the greatest reaction to. In understanding the GSR's abilities, it is known that it is impossible to understand if the greatest reaction is a positive or negative reaction. The GSR is only able to record emotional reactions. However, when comparing the GSR chart to the picture survey, it is then possible to understand how positively or negatively the participant reacted to that particular sketch.

The GSR and picture survey results from Session 1 were interesting. As stated previously, it was unknown whether or not the participant had any previous interaction or ownership of a media device. It is believed that the majority of the participants did in fact own a popular MP3 player and this affected their initial decisions. Refer to the similarities noted in Figure 2.8 to see the first product of preference has Apple Ipod design influences. In figure 2.7, the numerical data gathered from the picture surveys places each sketch in an order of preference.

Session 1 Preference Averages :	**5.9**	**8.2**	**7.2**	**4.4**	**4.8**	**6**	**4.4**	**3**
Order of Preference (Concept #):	**2**	**3**	**18**	**6**	**1**	**15**	**20**	

3.5	**3.9**	**3.4**	**4.9**	**4.1**	**3.1**	**3.8**	**5.7**	**2.8**	**5.5**	**6.1**	**3.8**	**5.7**
5	**11**	**17**	**4**	**7**	**9**	**12**	**8**	**10**	**13**	**14**	**19**	**16**

Figure 2.7 – Session 1 Data Presentation

Data is presented is order of averages from participants' scores. The second row in the figure places each of the concepts in order of its numerical average beginning with the concept that received the highest average of scores.

Session 1 Most Preferred Concept Sketches						
1	2	3	4	5	6	7
						

Figure 2.8 – Session 1 Concept Sketch Results in Preference Order

These are the results from averaging the participant's scores are represented in visual form. The process of averaging was done as one way of sorting through the numerical data gathered from the visual surveys. While this is only one method of data analysis, the development of the products used this form as the main form due to time constraints.

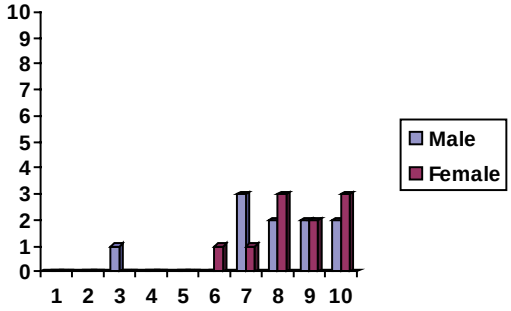


Figure 2.8 – Concept 2

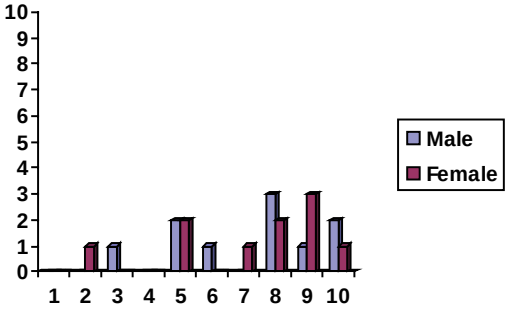


Figure 2.9 – Concept 3

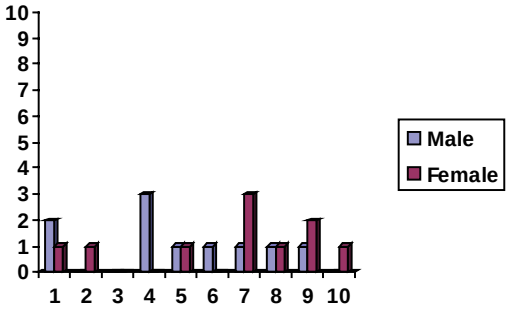


Figure 2.10 – Concept 18

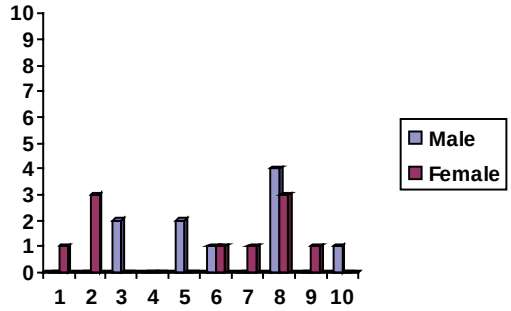


Figure 2.11 – Concept 6

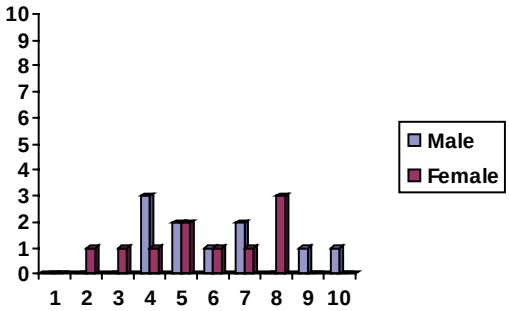


Figure 2.12 – Concept 1

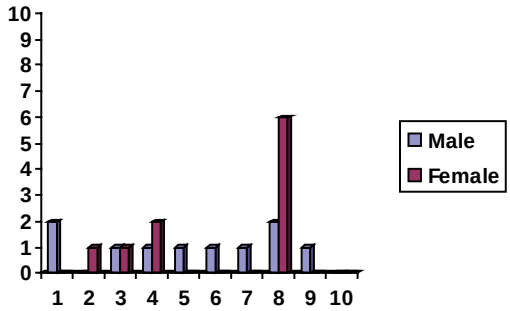


Figure 2.13 – Concept 15

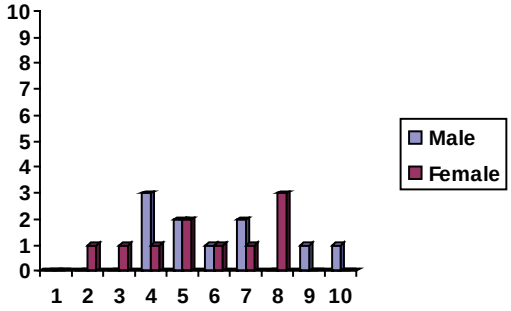


Figure2.14 – Concept 20

These bar graphs are numbers from the seven concept sketches that received the highest averages. These numbers came from the scores both male and female student participants gave during the picture survey.

In the figures 2.9-2.14, each of the top 7 concepts identified in Figure 2.8 by averaging were further analyzed by separating votes of the female participants from the men participants. While the individual figures represent the similarities and difference in scores per concept and per men vs. female, the numbers the concepts have in common represent the top 7 concepts most preferred. Further investigation using numbers by gender could lead to interesting research. However, because this study focuses on the development of the technique, gender specific product development was not included.

2.6 Discussion

There were many conclusions that were drawn from every aspect of this first session. These conclusions were positive in helping to create a more complete experiment. The introductory pictures seemed to be neither simulating nor relaxing and only added to the time in which the participant was shown images. The lack of changes in material presentation contributed to the lack of stimulation. Because of this, the Session 2 PowerPoint presentation was changed by eliminating the introductory images and by changing up the time and images the participant would see. The selected sketches provided a variety of options to further develop in Session 2. However, there seemed to be an overwhelming response to the first sketch. Memories and associations to the Apple Ipod had an impact on their emotional response to this sketch. Overall, the results from the first session uncovered the need to see the experiment through to conclusion to be able to fully understand the impact that this experiment has on the design development of a product.

3. SESSION 2 EXPERIMENT

3.1 Preparation

Based on the conclusions of Session 1, many aspects of the experiment were changed to ideally positively effect the participant's ability to provide understandable GSR results. As well, the seven sketches were furthered developed into computer generated models in which their pictures would be integrated into the PowerPoint Presentation and picture survey. The results from this session would be another phase in the design development of the MP4 player product.

3.2 Participant Involvement

The same participants from session 1 participated in session 2 to provide continuity of results. The practice of using the same participants over the course of the product development is not unusual. Because these participants provided results for the development of the five concepts in session 2, it was important to continue to seek their feedback into the following phase of the product evaluation.

3.3 Experiment Design

Session 2 presented the next phase in the design development process. Based on the outcome from Session 1, the seven sketches were revised into five computer generated models. Pictures of the models were incorporated into a PowerPoint

Presentation for the purpose of monitoring the time in which the participant views the material. Figure3.1 shows each of the concepts.

Figure 3.1 - Session 2 Concepts identified by their model letter and the order in which they are presented in the PowerPoint presentation.

This presentation prepared the participant with a scenario to better help he or she visualize the product. The participants were instructed that they would be going to Best Buy to purchase an MP4 player. All the players had the same features and were the same price. For the purpose of capturing results through the GSR device, the participants were to base their decisions on the designs of the products. The beginning of the presentation did not present any questions for the participant to answer. This was different from Session 1. Instead they were shown the pictures of each product first. Then after viewing all of the pictures, they were presented with the questions of deciding which product they preferred the most and would like to purchase. This was followed by five slides that showed one picture of each product and asked this question at the top of the page. Asking the question near the end of the session after the participants had seen all of the products helped to establish a better opportunity for he or she to have a more clear response. Having seen each of the products earlier in the session, the participant has the opportunity to form a response in advance of answering the question which MP4 player he or she prefers the most. Because of how the GSR device works, the participant might have a reaction to a product that he or she did not know they preferred. The use of the picture survey helps to establish a better understanding of the response that the GSR chart displays. Refer to Figures 3.5 -3.7 for a more detailed illustration of participant GSR charts.

Figure 3.2 - Session 2 PowerPoint Presentation

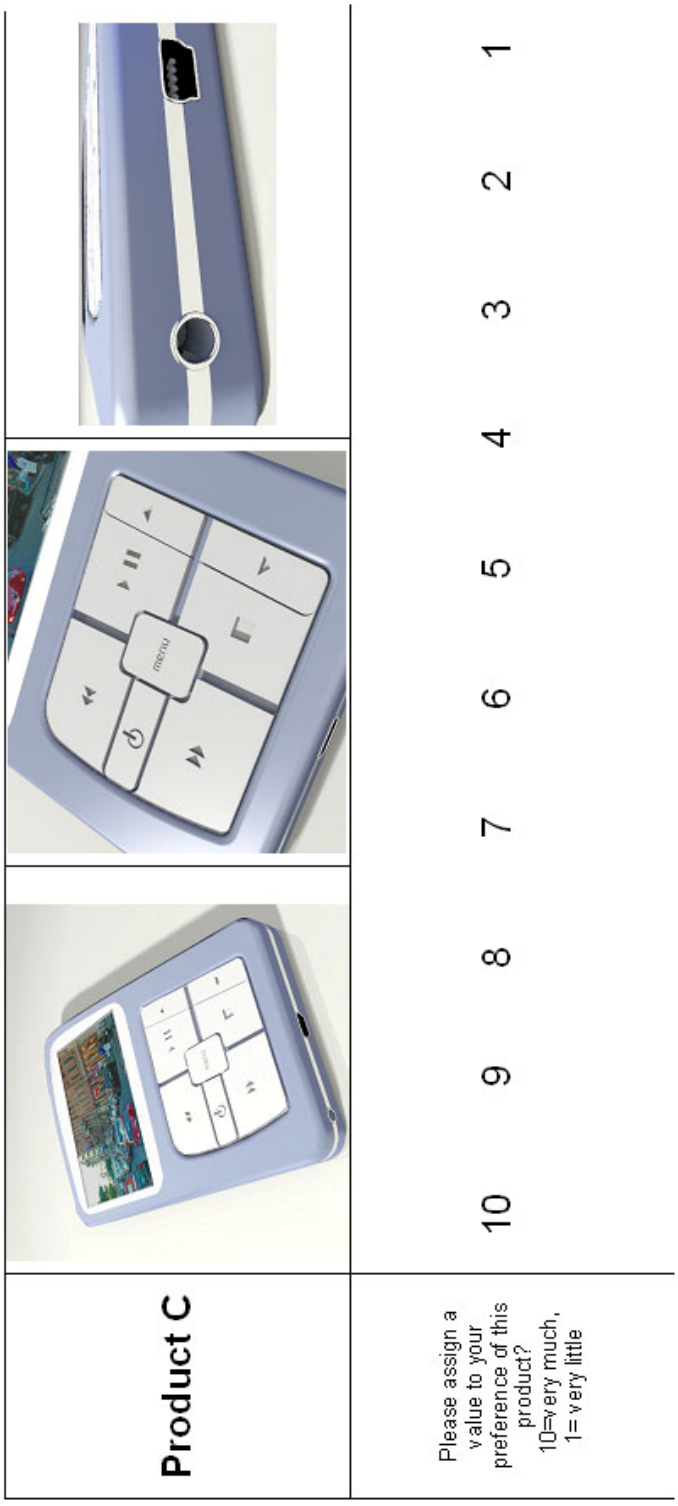


Figure 3.3 – Session 2 Picture Survey Example

3.4 Anticipated Outcomes

1. It is anticipated that any speculations made from Session 1 will enhance Session 2 and will increase the opportunity for a more successful outcome.
2. It is anticipated that the participant will be more relaxed going into Session 2 since understanding the procedure.
3. It will be unknown the activities or conditions that the participant encountered or participated in prior to arriving at the session. It will also be unknown the participants' stress level, emotional state or physical ailments at the time of participation. These conditions can all have effects on the participant's ability to respond to the stimulus.
4. It is projected that the design of the session in which the five computer generated models are presented is designed in the best way to arrive at a response from the participant.
5. It is anticipated that the timings prepared for the presentation of the materials is in the best interest of the participant and for the experiment.
6. Each participant's GSR chart of responses is expected to be understandable enough to arrive at a result.
7. The anticipated outcome from the participant's picture survey is expected to correspond and support the responses from the GSR chart.
8. It is projected that the three models most preferred will be revised into three enhanced computer models and subsequently, three urethane foam prototypes.

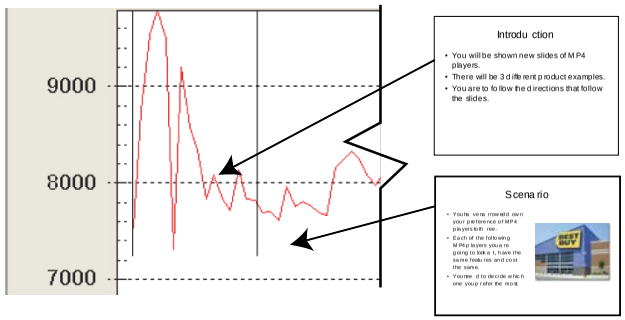
3.5 Deliverables

1. A PowerPoint Presentation including the five computer generated models.
2. Five computer generated models with additional pictures of the models' details.
3. 20 GSR charts, 1 from each participant
4. 20 picture surveys with results marked from each participant.

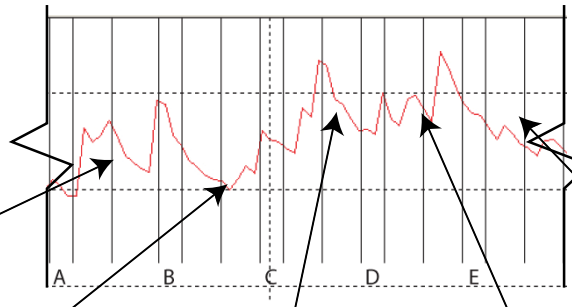
3.6 Actual Findings

The GSR charts and picture surveys provided interesting results. The first result was that most participants, who showed very little reaction to the stimuli in Session 1 were more responsive in Session 2. This could be because they were more prepared for the procedure, more excited about the content or because of some unknown factors that could have contributed to their elevated emotionally reactive state. The changes that were made in the layout and order of questions might also have contributed to the participant's ability to respond at the given time.

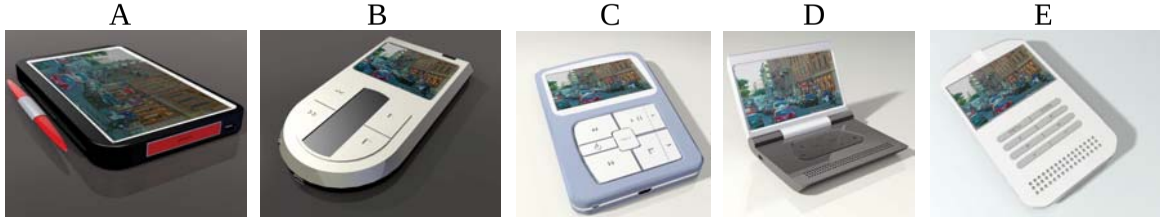
Figure 3.4 – GSR Chart Dissection and Explanation

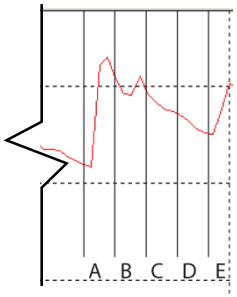


The is session began with an introduction and a scenario intended to help the participant visualize and think about the concepts as actual products they have an opportunity to purchase. This process was intended to invoke an emotional response to each of the 5 concepts.

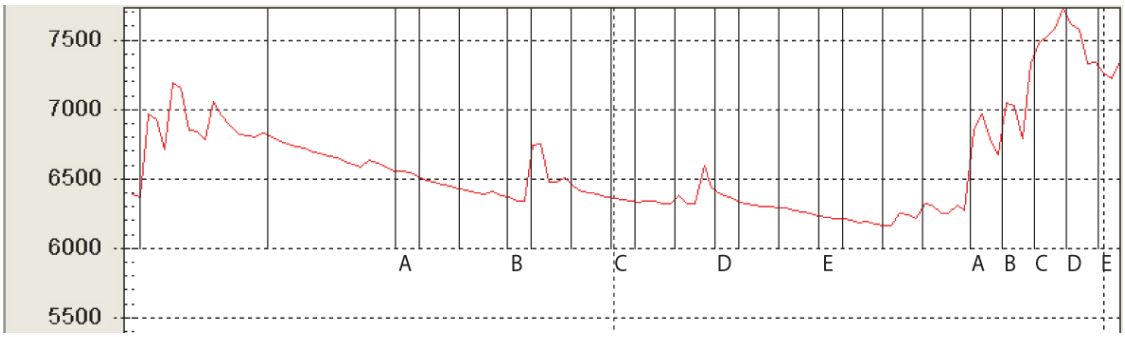


Each of the 5 concepts were presented over 2 slides. The first slide introduced the product followed by a slide showing the product details.





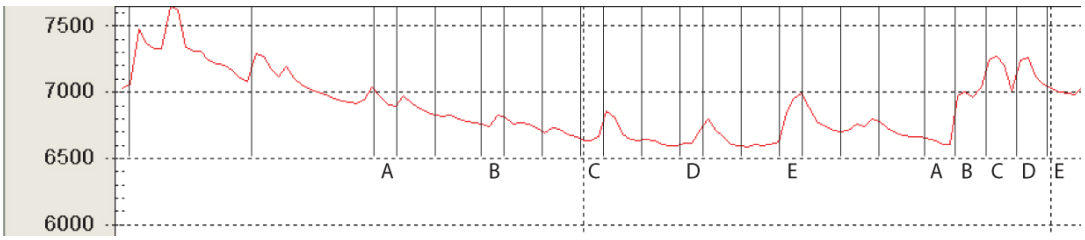
In the final section of the session, the participants were instructed to choose a product from the 5 that they had seen. Then, each concept is shown for 4 seconds asking “Is this the MP4 player you would like to own?” This was intended to evoke a yes or no answer.



Product picture questionnaire: Products A-E	**A**	**B**	**C**	**D**	**E**
Individual ranking of preference on a 1-10 scale, 10= very much, 1= very little	4	7	9	6	3

Figure 3.5 - Session 2 GSR Chart & Specific Picture Survey Results

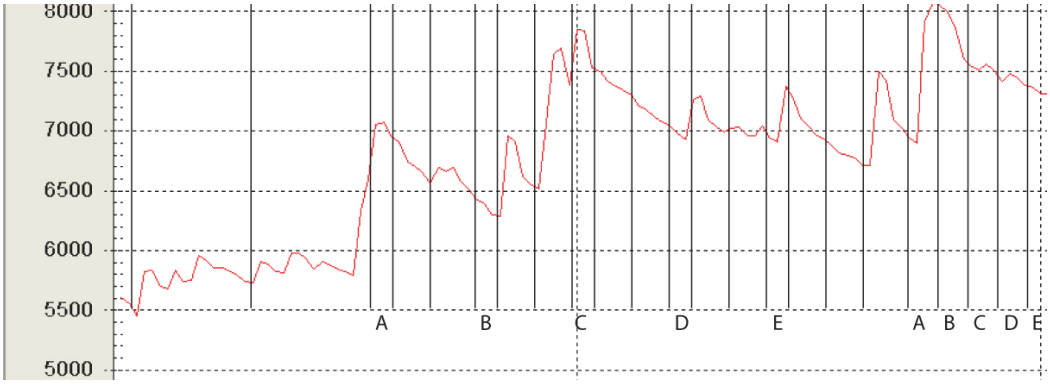
This GSR chart shows the vertical bars that separate the time periods in which information was being shown to the participants in the PowerPoint Presentation. The letters correspond to the model shown at that time. This chart and survey results shows clear reactions during the time that the participant viewed Model B and C. In the latter portion when being asked the question, the participant had the greatest reaction to Model C. When comparing the results from the chart with the survey, the participant clearly preferred Model C.



Product picture questionnaire: Products A-E	**A**	**B**	**C**	**D**	**E**
Individual ranking of preference on a 1-10 scale, 10= very much, 1= very little	6	6	8	10	8

Figure 3.6 - Session 2 GSR Chart & Specific Picture Survey Results

This is another interesting outcome from Session 2. This participant, according to the picture survey results, highly favored Products C, D and E. When comparing these results with the GSR chart, it is easy to see that the participant had an emotional response to each of these products when viewing them the first time. When analyzing which product she preferred the most, it then becomes difficult because it appears that she equally preferred Product C and D. Although, one might interpret the dip in Product C and the rise in Product D, as changing his or her mind. This would correlate with the picture survey results. However, it is again impossible to discern what kind of emotion or thoughts the participant might have been having at these times.



Product picture questionnaire: Products A-E	**A**	**B**	**C**	**D**	**E**
Individual ranking of preference on a 1-10 scale, 10= very much, 1= very little	1	6	8	7	10

Figure 3.7 - Session 2 GSR Chart & Specific Picture Survey Results

In this participant's chart, the participant was able to have a wide range of emotional reactions. Outside or unknown factors may have contributed to this participant's ability to respond with a variety of degrees. The picture survey results indicate that the participant preferred different products more than the ones the chart reflects as more preferred. It would seem that the participant was stimulated the most by the features of product B. However, the participant peaks when seeing Product C. Again, when asked which product the participant preferred the most, it might appear that A or B is most preferred. Because of these difficult anomalies, it is difficult to arrive at an outcome based solely on the chart alone. This is why the picture survey is so important.

Each GSR chart was analyzed for its most preferred product based on the emotional responses the participant had. The order of the preferred products was then compared to the analyzed picture survey results. The results are seen in Figure 3.8 Averaged data was again used to determine a numerical winner in a short time period while comparing the chart level reactions. Followed by figures 3.9 – 3.13 are the analyzed breakdowns of men and female votes for these 5 concepts.

Preference Averages :	**5.1**	**6.05**	**6.4**	**7.6**	**6.2**
Product Order of Preference	**D**	**C**	**E**	**B**	**A**
Product Order of Preference based on Chart Level Reactions	**C**	**B**	**D**	**A**	**E**

Figure 3.8- Session 2 Analyzed Results: Row 1 is the averages in Model order (A-E) presented to the participant. Row 2 shows the order based on the averages that the products are preferred. Row 3 shows the order of preference based on chart analysis.

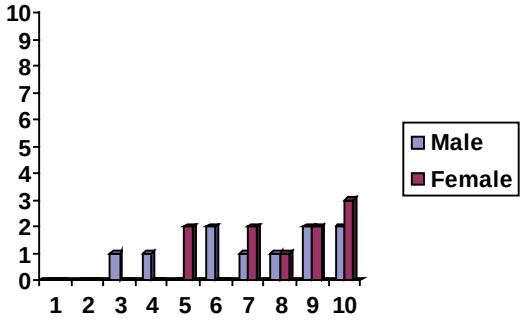


Figure 3.9 - Concept D

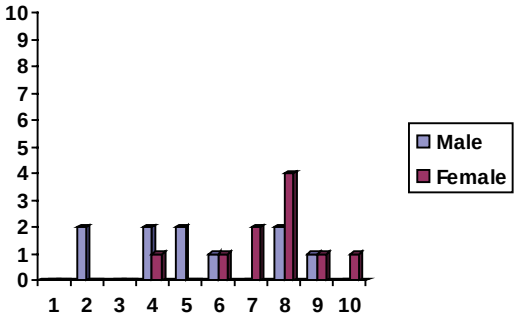


Figure 3.10 - Concept C

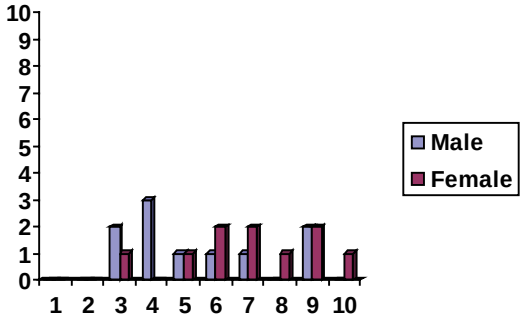


Figure 3.11 - Concept E

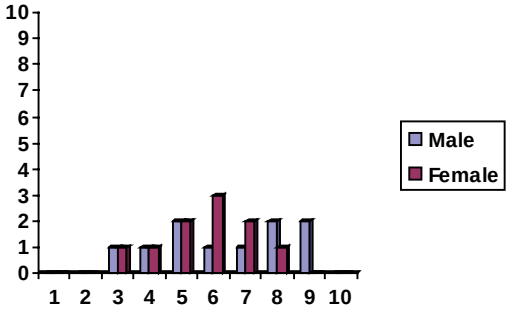


Figure 3.12 - Concept B

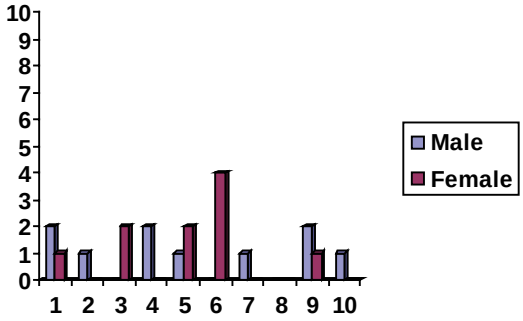


Figure 3.13 - Concept A

These bar graphs are numbers from the five models in order of the averages they received, highest to lowest. These numbers came from the scores both male and female student participants gave during the picture survey.

The picture survey provided a numerical number to average out for a result. The "Preference Averages" is the "Product Order of Preference". Products D, C and E were the top three most preferred products based on the picture survey. Determined from the emotional reactions the participant's GSR charts displayed, Products C, B and D were most preferred. Product E appeared to have very few emotional reactions therefore making it appear that it was not as preferred. However, a problem in the setup of the experiment left no room for any other reactions to occur after viewing product E, making it impossible to see if the participant's reactions would have increased. This problem could have affected the ability to read from the GSR charts a preference for this product. Figure 3.14 represents the top three concepts in both orders according to the initial results.

Session 2 Picture Survey Results in Order			
Session 2 GSR Chart Results in Order			

Figure 3.14 - Session 2 Results in Visual Form

These three products would be further revised as computer generated models and pre-prototypes for Session 3. Based on the design features of these products, it was in the best interest of the participants to incorporate the features of Products B and E into one of the three products for Session 3. Products C and D would continue to be revised in Session 3.

3.7 Discussion

As with Session 1, there were many things learned from the changes incorporated into the experiment and from the participant's behaviors as well. Conclusions drawn from Session 1 were integrated into the Session 2 PowerPoint in hopes of creating more understandable data. It seemed that this presentation kept the participant stimulated and interested in the experiment. Asking questions at the end of the session allowed the participant to really experience the product, think about the product, and then make a decision. In most instances, the participant showed a clear response during this last section of the session. In this last section, it was clear to understand if the participant was responding to the question of "Is this the MP4 player you'd like to own?" In Session 3, a similar approach with the material and questions will be applied to the PowerPoint Presentation. It is possible that product color could have affected the outcome of the results. In Session 3, color choices will be integrated to understand if this has an affect on the results. Session 2 was successful because emotional reactions were clearer than in Session 1. It is hopeful to see if the format of Session 2 can be revised to accommodate the materials included in Session 3 and if Session 3 will be as successful. Again, in conclusion, it is important to continue seeking answers to the development of this process as it is the end result of the evaluation of the product.

4. SESSION 3 EXPERIMENT

4.1 Preparation

To prepare for Session 3, results of Session 2 were analyzed and revised using the computer modeling program, Rhino 3D. Pictures of the three models were made for the slide show presentation and the file was saved so that it could be used by the computer aided 3 Axis Router to cut the models out of urethane foam. This technique can create quick 3-D models that help with better understanding the user relationship with the product.

4.2 Participant Involvement

The same 20 participants continued to provide their feedback through Session 3. Keeping the same participants throughout the study is important for continuity and because the results may vary because of different views, beliefs and backgrounds if different users were involved.

4.3 Experiment Design

Two additional features were added to Session 3 in order to try and better understand the user's reactions as well as test the possibilities of using a different presentation of material to see if that affected the responses. First, the user interaction

with the pre-prototypes had to be added into the setup of the slide show. This would also have to include the ability for the GSR device to capture the response during the interaction. Color was thought to have affected the results in Session 2. Color choices would be added to see if the participant is drawn to a specific color and to eliminate the possibility that color is a factor in this phase of design evaluation. Figure 4.1 shows the concept models as they will be first presented to the participants in the PowerPoint presentation shown in Figure 4.2.

Product A	Product B	Product C
		

Figure 4.1 - Session 3 Models used in PowerPoint Presentation

Figure 4.2 - Session 3 PowerPoint Presentation

Midway through the presentation after all the models have been presented through the images, the participants were given the opportunity to interact with the pre-prototypes. Figure 4.3 shows the pre-prototypes the participants were given 30 seconds each to interact with. During the time in which the participant is interacting with the model, their reactions are still being recorded using the GSR device.

Product A	Product B	Product C
		

Figure 4.3 - Session 3 Pre-Prototypes made of urethane foam

At the end of the presentation, each model is presented with 5 color options. The participants were asked to answer the question of which color choice they prefer and when that color choice appears, to answer “Yes”. Options for model color are represented in Figure 4.4.

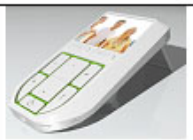
A					
	Black	Gold	Light Blue Metallic	Blue Black Metallic	Silver White
B					
C	Black 	Gold 	Light Blue Metallic 	Blue Black Metallic 	Silver White 
	Black	Gold	Light Blue Metallic	Blue Black Metallic	Silver White

Figure 4.4 - Session 3 Model Color Options Presented in PowerPoint presentation

Each session is followed by a picture survey. The picture survey for Session 3 asked participants, in addition to assigning a preference value to each of the products, but also to select the color they most preferred.

Figure 4.5 - Session 3 Picture Survey Example

4.4 Anticipated Outcomes

1. It is anticipated that Session 3 will be more successful than previous sessions in capturing and understanding user reactions due to the interaction with the pre-prototypes and the addition of color choices.
2. It is anticipated that the participants will have greater reactions to the three urethane foam prototypes than the pictures because the process involves additional senses. During the time periods in which the participant is handling the prototype, it will be difficult to discern their response due to do noise that can contribute to the participant's reaction levels increasing.
3. In viewing the three urethane foam models it will be impossible to allow enough time for the participant to come back to a neutral state before viewing the next pre-prototype because every individual will have a different amount of time to resume a neutral state.
4. The addition of color choices is expected to produce similar results as the last question portion of pictures from Session 2 because the presentation of the question is identical.
5. In conclusion of Session 3, it is anticipated that the results will yield one product that both the GSR chart and the picture survey convey is the strongest among the three choices.

4.5 Deliverables

1. A PowerPoint Presentation including the three computer generated models.
2. 3 Urethane Foam Models produced using a 3 Axis Router

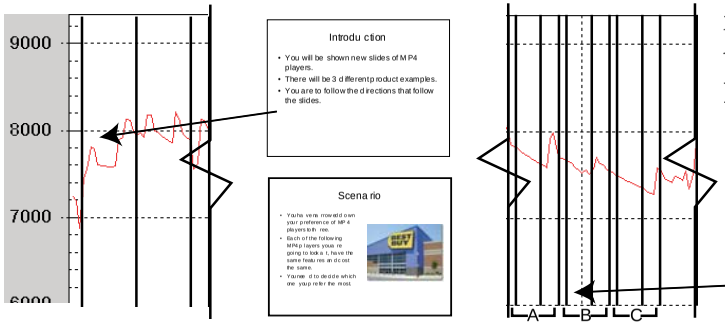
3. Three computer generated models with additional pictures of the model's details.
4. 20 GSR charts, 1 from each participant
5. 20 picture surveys with results marked from each participant

4.6 Actual Findings

While the beginning of the Session 3 presentation was very similar to Session 2, the results began to become difficult to understand once the participants interacted with the pre-prototypes. All of the participants had some kind of increase in response when they saw and or touched the first pre-prototype. This level of response mostly remained during the time they were interacting with the pre-prototypes. Their response levels decreased when the presentation continued and the question that they choose a color began. The color portion of the presentation was expected to yield a result that would better assist the design development process. Ideally, if the participants are able to responds to pictures and answer a question, then they should be able to respond to a color and answer a question of "yes, this is the color I prefer". Unfortunately, this period of choosing a color did not produce clear enough results to completely understand which color was most preferred through the GSR charts. The picture survey, however, had clear results from which to draw conclusions. Figures 4.7-4.9 are examples of GSR charts from Session 3.

Figure 4.6 – GSR Chart Dissection & Explanation

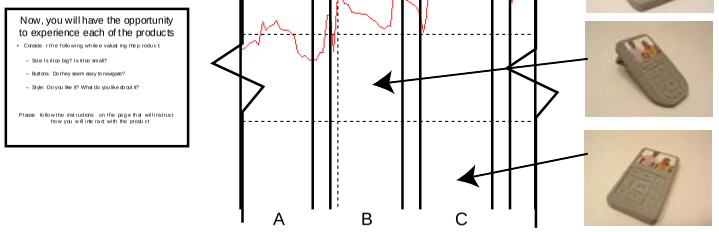
This is the introduction section of the chart that includes instructions and a scenario for the participants to consider.



This section is the first introduction to the session's products. Two images of each product are shown for 7 seconds then 5 seconds. The vertical lines indicate the time in which the product images were shown and the response that occurred during these times. Below are the images of the products that were used in the PowerPoint Presentation.

A B C

This section was new to the format because it included the opportunity to interact with the pre-prototypes made of urethane foam and finished to a similar quality. Each participant was instructed when to interact with the product and when to put it down. The interaction time was for 20 seconds followed by a 5 second blank slide.



The final section asked the participant about their color preferences. Each product was shown in 5 different colors for 5 seconds.

black gold lt. blue dk. blue white

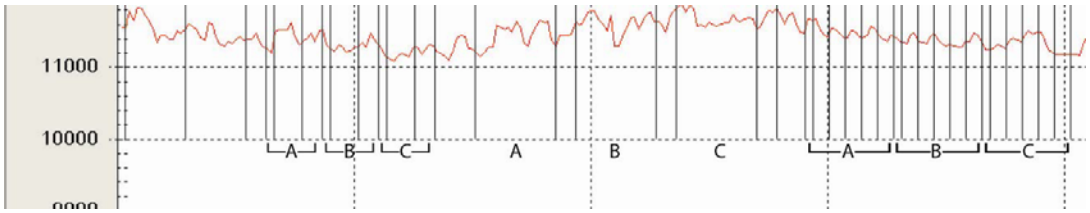


Figure 4.7 – Session 3 GSR Chart

The design of Session 4 included three opportunities to evaluate the design of each of the three products. The opportunity presented each of the three products individually with details about the product. The second opportunity was the interaction period in which the participant could touch and feel the urethane foam pre-prototype. And the third opportunity consisted of five pictures of the product showing that product in five different color options. In the first set, this individual was actively responsive to each of the slides shown with the different products. When seeing the product for the first time, the participant responded more than after seeing the second picture of the same product. During the interaction period, this participant is as equally stimulated as when they began the session. The third section asked the participants to respond yes to the color they preferred on each of the three models. This participant remained active into this last section. Factors contributing to these results could be explained as being stimulated by the material or from outside unknowns. This participant's results were difficult to understand because of so many equal reactions. It was difficult to understand which reactions truly corresponded to preference.

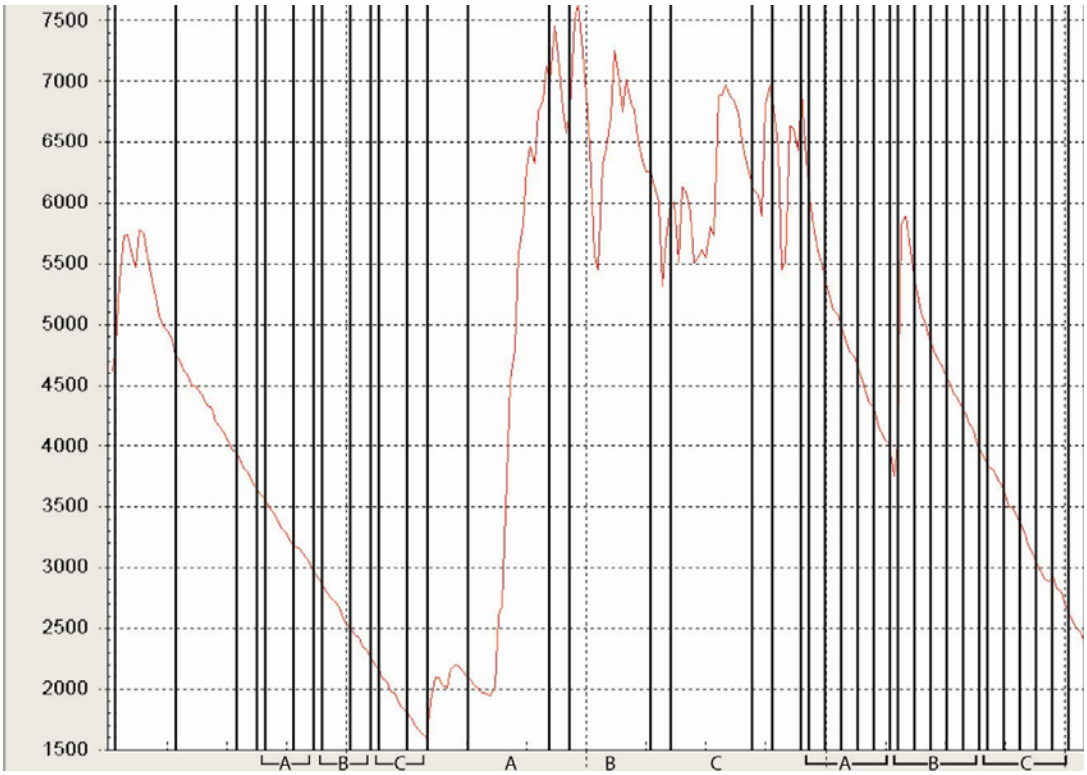


Figure 4.8 – Session 3 GSR Chart

This participant has a wide range of emotional response. The first set of pictures of the product does not provide enough stimuli for the participant to respond with a reaction. However, during the interaction period, the participant has a strong reaction to seeing the pre-prototype and touching it. It would appear that the participant preferred product A over the other two products because of the decline in reactions. During the color portion of the survey, the participant responds highly to Product A and B both in the color black. Although there are clear reactions to specific portions of the presentation, it is still difficult to understand what kind of stimulus is needed for a person who has a higher range of emotional response.

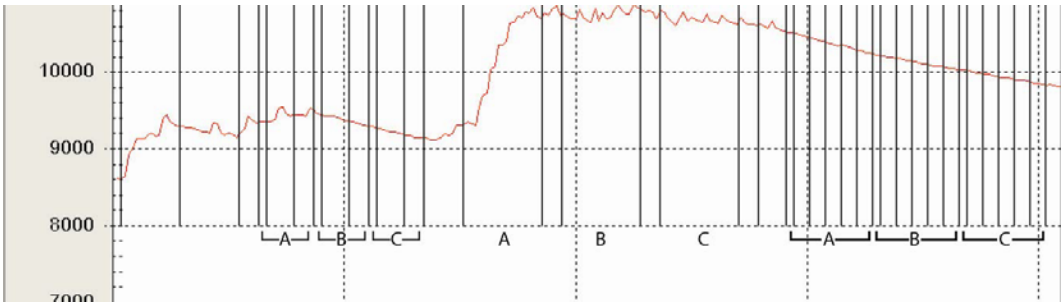


Figure 4.9 – Session 3 GSR Chart

This chart reflects a participant who shows little to no response to stimuli in multiple contexts. The participant shows a little response in the beginning of the presentation but it is not clear if the participant is truly responding to Product A or simply adjusting his or hers anxiety levels to his or her normal state. During the second section, the participant is reactive to touching and feeling the pre-prototype but shows very little range in response. During the color portion of the survey, the participant does not provide any indicator that the color option pictures are enough stimuli for a response. Another contributing factor could be boredom or an inability to become emotionally engaged to a subject matter such as this.

Each of the charts provides enough results to conclude that product A is the most preferred product among the choices. The only results that the color options provided came from the picture survey and not a combination of both the picture survey and the GSR chart. The GSR chart data was insufficient in providing clear responses to the color preferences. The preferences of the participants are outlined in Figures 4.10. In Figure 4.11 shows the actual numbers of votes per model per color received from the picture surveys.

Preference Averages :	**7.05**	**6.5**	**5.4**
Product Order of Preference	**A**	**B**	**C**
Product Order of Preference based on Chart Level Reactions	**A**	**B**	**C**

Figure 4.10 - Session 3 Results from Averages & GSR Charts

A					**B**					**C**				
black	gold	light blue metallic	blue black metallic	silver white	black	gold	light blue metallic	blue black metallic	silver white	black	gold	light blue metallic	blue black metallic	silver white
4	0	7	4	4	4	1	4	5	5	2	5	4	1	7

Figure 4.11 - Color Preference Results from Picture Surveys

Figures 4.12 – 4.14 are the analyzed breakdowns from men and female who participated in the experiment. This data is helpful in understanding where the numerical data and averages come from.

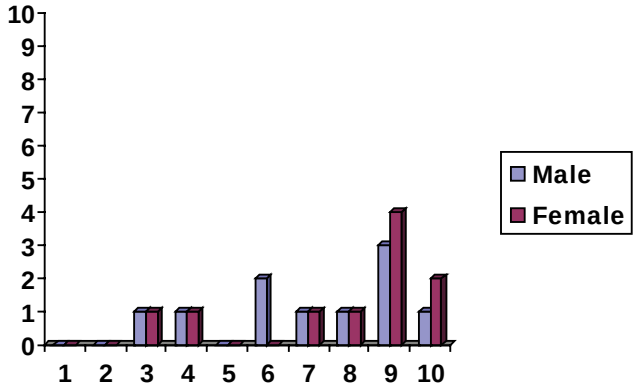


Figure 4.12 - Concept A

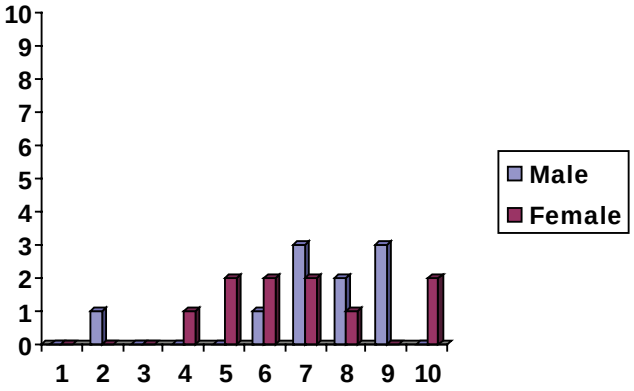


Figure 4.13 - Concept B

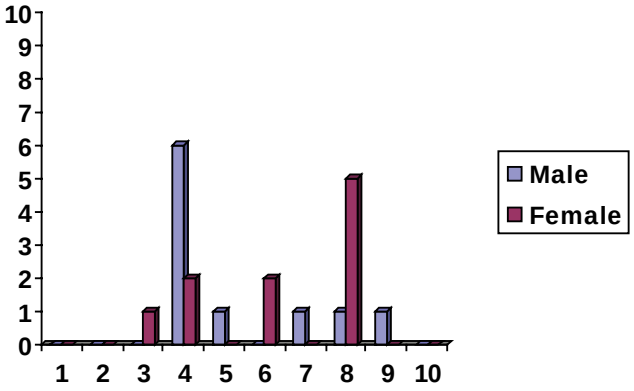


Figure 4.14 - Concept C

These bar graphs are numbers from the three models and urethane foam pre-prototypes in order of the averages they received, highest to lowest. These numbers came from the scores both male and female student participants gave during the picture survey.

Many factors could have contributed to the lack of findings such as placement in the presentation. After achieving such a high level of response from interaction with the pre-prototypes, the pictures no longer provided enough stimuli to measure a positive response from. As well, the length of time could have contributed to the inability to responds. Based on both the GSR charts for preference to product and the picture surveys for color preferences, the results as represented in Figure 4.15 are the order in which the ideas will be developed into 1 final concept prototype. Male and female participant votes were separated and analyzed for confirmation and to check for differences in preference. The charts confirm that Product A was equally preferred by both sexes while Product C had extreme differences in the females vote vs. males votes. Again, looking at the whole procedure instead of the individual differences in gender preferences is what this study is about. Further investigation into gender differences is recommended for future studies.

Product A	Product B	Product C
		

Figure 4.15 - Session 3 Model Results in order of Preference and Color

4.7 Discussion

Session 3 was a critical experiment phase for both this study and in the development of the product. Based on the conclusions of this phase, Product A will be developed as the final product and tested in Session 4. It can also be concluded that a silver white color was preferred more than any other color even though for Product A, the color light blue metallic was most preferred. In design, sometimes compromises must be made in order to satisfy the majority of the consumers. In this case, a silver white color will be used as the color for the final product. Drawing on the conclusions of the experiment design, the incorporation of the interaction with the product will still be included while a smaller number of questions will be asked afterwards. In addition to testing the responses to the final product, a current on the market comparison product will be added to draw a real result from the responses the participants have in Session 4.

5. SESSION 4 EXPERIMENT

5.1 Preparation

Using the results from Session 3, the final product was further revised into a concept prototype. A popular MP3 player with video (MP4) playing capabilities was identified to use as a comparison product. This comparison product featured similarities to the appearance and function of Product B from Session 3 which was also highly preferred by the users. It was modeled using the same computer modeling program and produced using the same process as the final concept prototype to keep quality features consistent. The two concept prototypes are presented in Session 4 in a similar format to Session 3 where the participant interacts with the products.

5.2 Participant Involvement

Session 4 is the last session that the participants are asked to schedule and attend. The final feedback helps to conclude the experiment with either validation or contradiction of the design development process for the MP4 player created through the feedback delivered over the course of three sessions.

5.3 Experiment Design

The PowerPoint Presentation set up included an almost identical format to Session 3. Eliminated from the presentation were color options. The color options yielded little to no consistent results by being included in the presentation. This presentation concludes with the final concept prototype with a current market product with similar features. This use of a “new product” (NP) and a “comparison product” (CP) both shown in Figure 5.1 intends to bring about a conclusion that this experiment can be used with comparison products once the product being developed has been finished.

New Product	Comparison Product
	

Figure 5.1 - Session 4 Final Prototype (New Product) and Comparison Product

Pictures of the products in scenarios of use were included in the PowerPoint shown in Figure 5.2. These pictures were taken to assist the participant in visualizing using the product. The presentation also included a period to see, touch and visualize using the product. Additional time was added to the presentation to allow the participant more opportunity to resume a neutral state before being exposed to more stimuli. Notice

the blank white slides included in the presentation. These blank slides were included to provide a mind clearing time for the participant to relax.

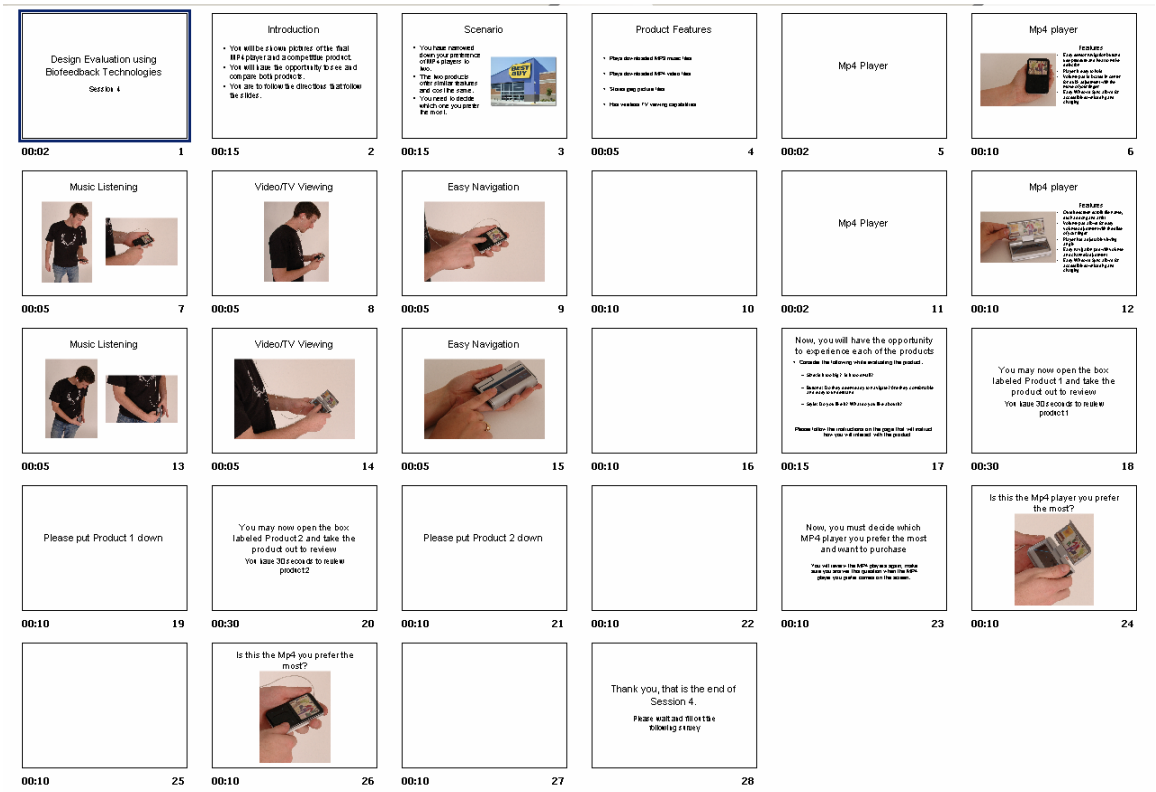


Figure 5.2 - Session 4 PowerPoint Presentation

The final survey as shown in Figure 5.3 followed the same format as all the previous surveys but included a box for the participants to check if this was the product they most preferred. Although the results should be reflected in the numerical value they assign to the two products, the action of choosing the product is something that is important for the participant to do. This final survey is the last step in conducting the experiment.

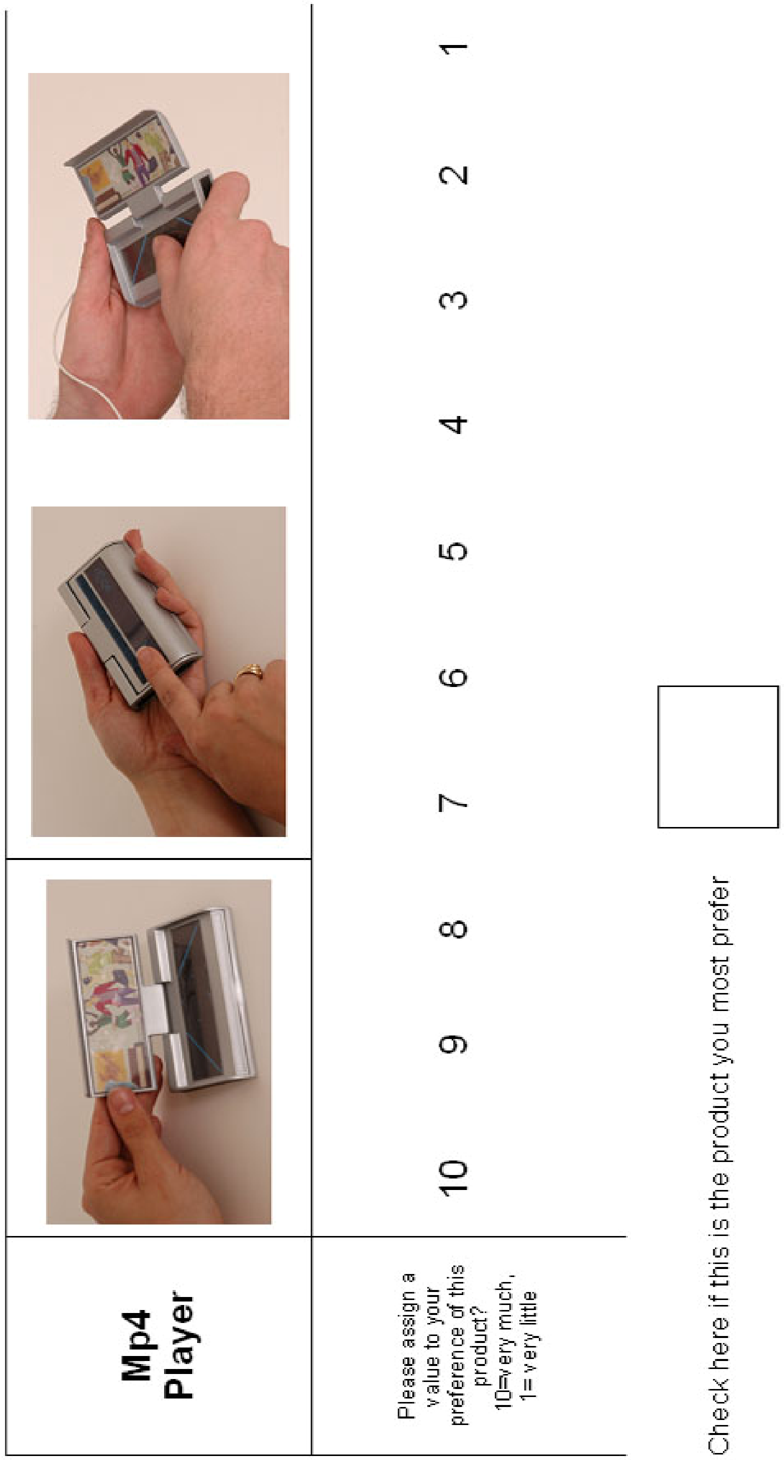


Figure 5.3 – Session 4 Picture Survey Example

5.4 Anticipated Outcomes

1. In this final session, it is anticipated that the participant's anxiety will no longer be about starting the experiment but finishing the experiment.
2. The comparison product chosen is intended to provide as close to an opposite of the new product developed through the experiment. This is to test to see how well the designer understood the results of the experiment.
3. It is anticipated that the participants will be closely split between the two products since the comparison product has similar features to two of the previously evaluated products in Session 3.
4. The two products are produced using similar processes to keep quality consistent. It would be assumed that the current market comparison product would be most preferred if it were purchased from a local retailer and was a working prototype in comparison to the concept appearance model form of the NP.
5. It is projected that the participants' responses will closely correspond to the results they indicate on the picture surveys.
6. By switching the product first seen after 10 participants, it is anticipated that the product seen first will be most preferred.
7. In conclusion of the experiment, it is anticipated that this final session will include observed improvements from previous sessions and that Session 4 will be the best example of how to conduct future experiments.

5.5 Deliverables

1. A PowerPoint Presentation including the new product and the comparison product
2. Two products representing the new product and the comparison product produced in ABS plastic using a Fuse Deposition 3-D Modeler
3. Detailed pictures of the two products and shots of them in “use”
4. 20 GSR charts, 1 from each participant
5. 20 picture surveys with results marked from each participant

5.6 Actual Findings

Session 4 is a conclusion to the previous sessions representing the development of an MP4 video playing device. Created for the purpose of comparison, the CP, provides a product of similar features to the NP in order to produce some kind of measurable results. The participants approached this session anxious to be finished with the experiment rather than excited to contribute their feedback. This was due to a time constraint that affected most university students. Figure 5.5 shows the anatomy of the Session 4 GSR chart.

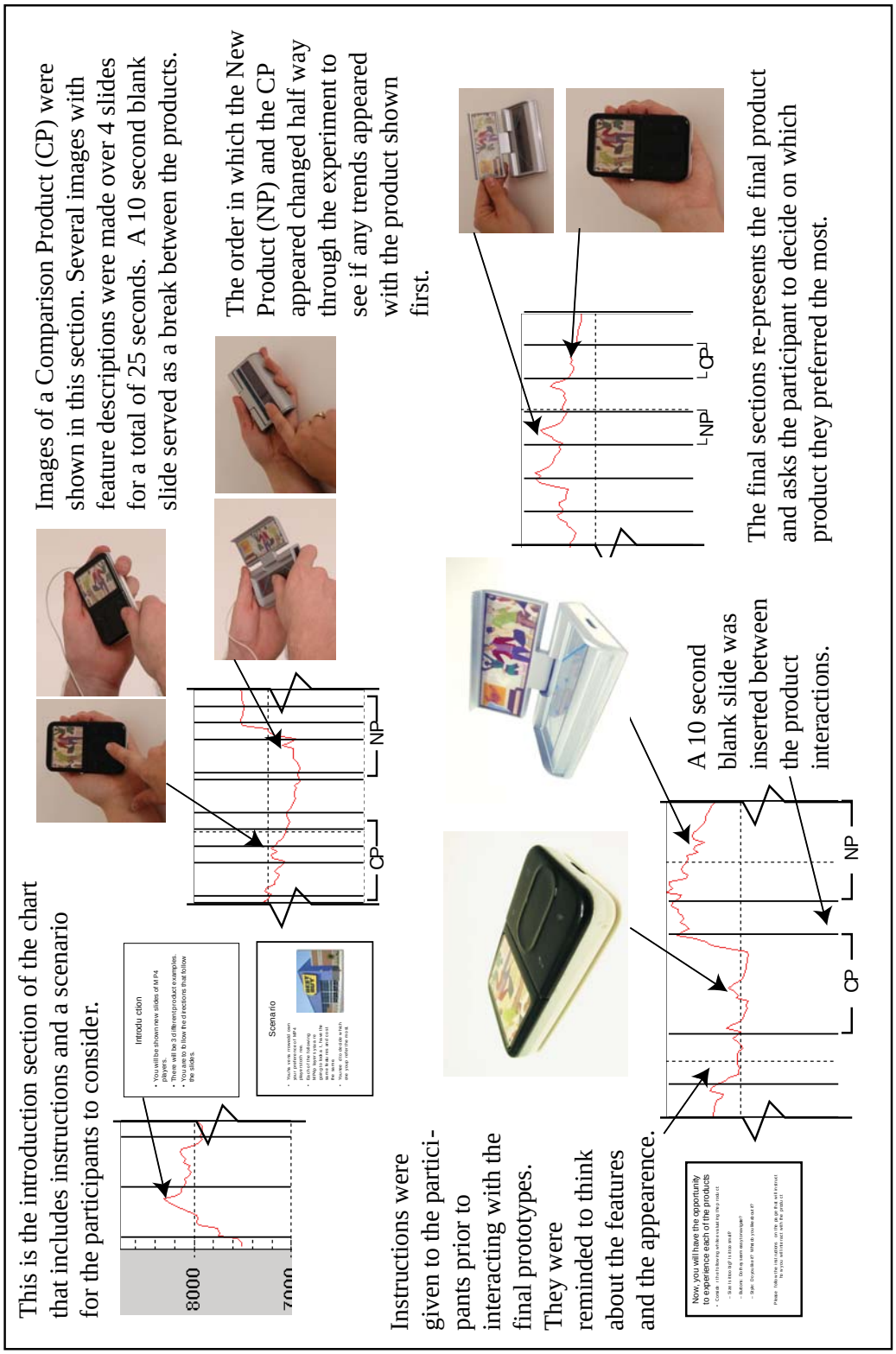


Figure 5.4 – Session 4 GSR Chart Dissection & Explanation

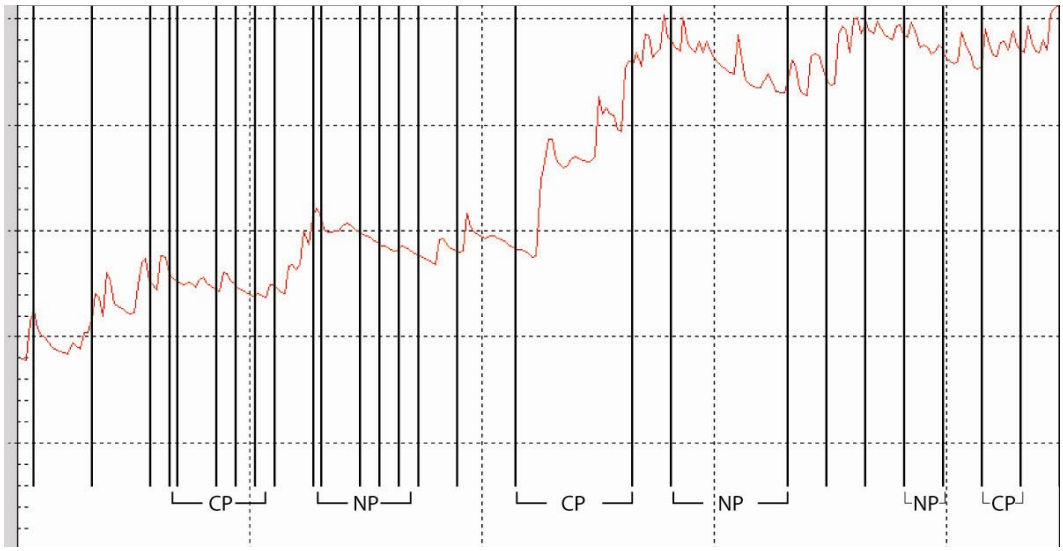


Figure 5.5 – Session 4 GSR Chart

This example shows the consistent reactions throughout the session. Even more convincing is how the picture survey results match the parts of the chart that show the strongest emotional response. This participant felt more strongly for the NP than the CP. In the picture survey the participant assigns a 9 to the NP and a 6 to the CP. In the chart, the NP has the strongest responses in the first section, second section and the strongest response in the section where the participant is asked to decide which product they prefer the most. This participants prefers the NP even though he or she was shown the CP first.

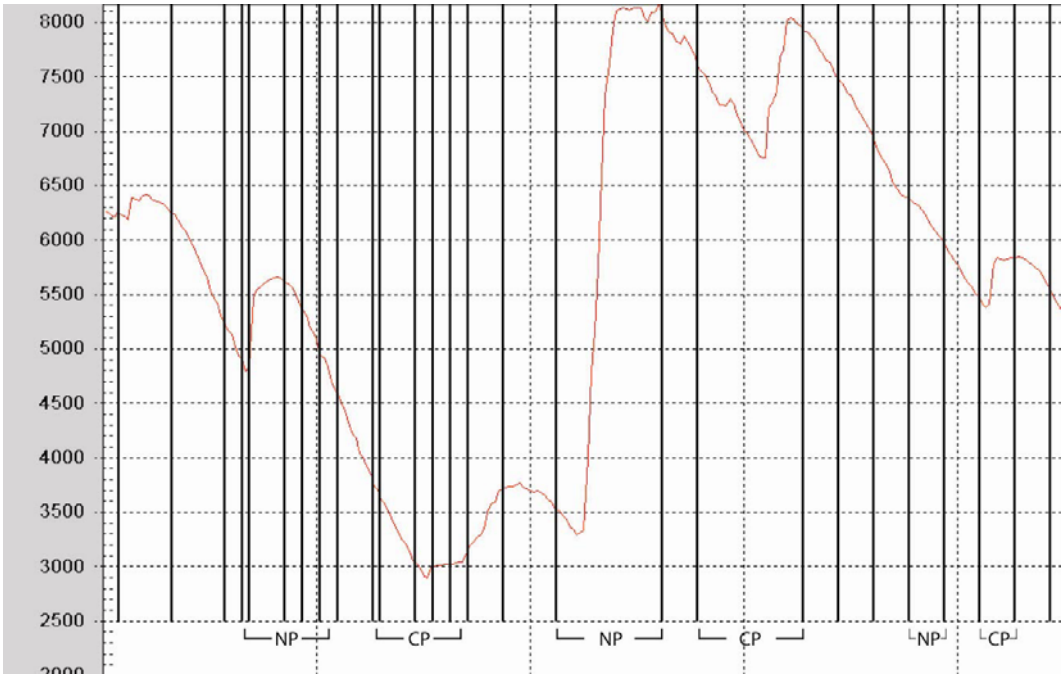


Figure 5.6 – Session 4 GSR Chart

This example of a wide range of emotional responses is a good example of seeing the specific time and material that provided the stimulus. In this example, the NP is clearly a stimulus the participant is responding to in two of the three instances of viewing the product. In this example the participant is viewing the NP first before viewing the CP.

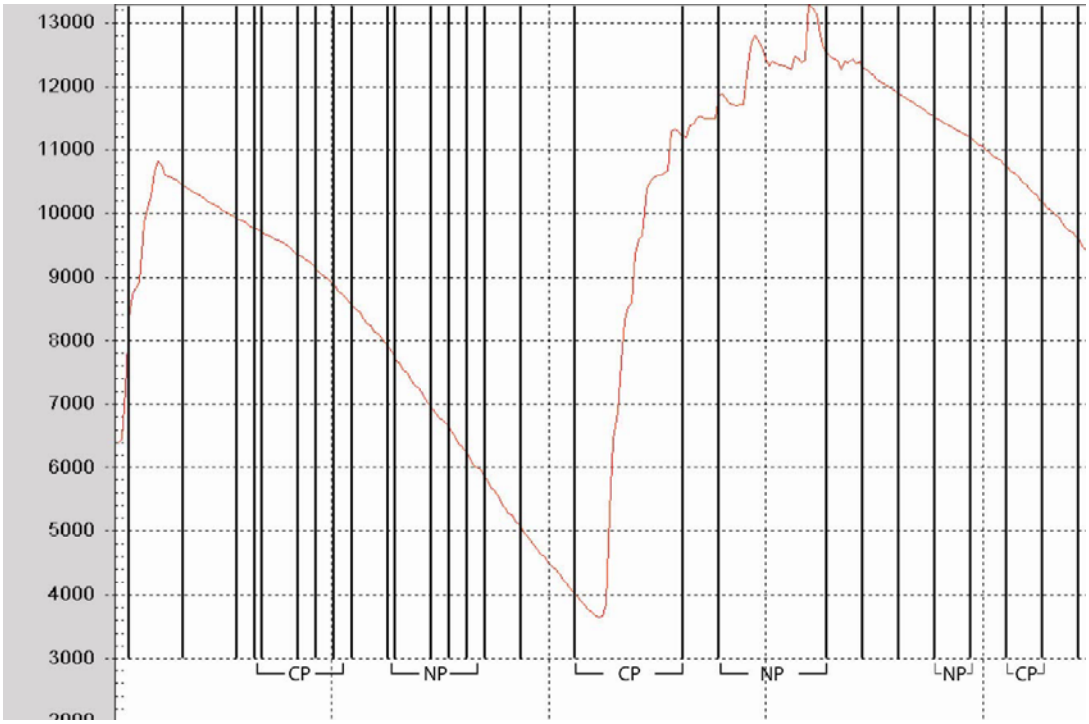


Figure 5.7 – Session 4 GSR Chart

While this chart shows a wide range of emotional response, it also shows a lack of response during periods where stimuli is being provided. The participant responds in the interaction period but not in the viewing or deciding periods. This participant states in the picture survey that he or she prefers the CP. This could possible be because the CP was shown first. It is unclear if this participant would have preferred the NP if it had been presented first.

In ten of the twenty participants' charts, the product they prefer the most is understandable. In the other ten GSR charts only speculations can be made as to which product the participant preferred. This is due to either a lack of response or equally strong responses for both products. According to the picture surveys and the numerical data presented in figure 5.8, the NP was preferred more than the CP by a very narrow margin.

Preference Averages	**7.45**	**7.3**
NP (New Product) Preference	**11 out of 20 participants prefer the NP**	**9 out of 20 participants prefer the CP**

Figure 5.8 - Session 4 Numerical Results

In figures 5.9 – 5.10, the analyzed breakdown of male and female participant votes demonstrates the differences and similarities of preference the two sexes had. For the New Product, female preferred it more strongly than males. In the Comparison Product, there were more equal preferences among the sexes.

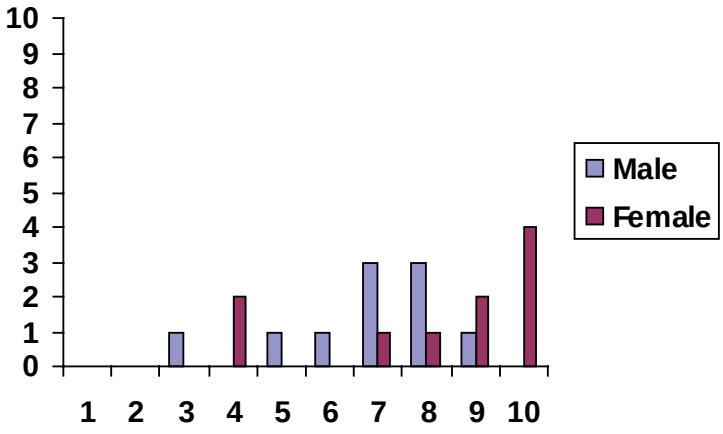


Figure 5.9 - New Product Participant Scores

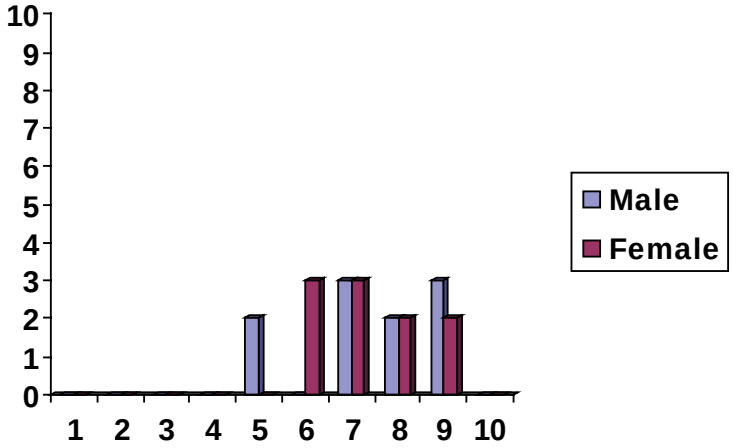


Figure 5.10 - Comparison Product Participant Scores

These bar graphs are numbers from the New Product and Comparison Product prototypes. These numbers came from the scores both male and female student participants gave during the picture survey.

It is difficult to know exactly why the participants did not have a wider preference range for the two products. Another difficulty is determining which product had the most success, the New Product because of the averaged numerical data, the number of participants that stated they preferred it over the Comparison Product, or the value in the number of female vs. Male that preferred it? All of these factors, aided by the use of the biofeedback technology, point to the New Product as being most preferred over the Comparison Product.

5.7 Discussion

This final session concluded with results that are definitive and yet many things to question such as why the margin of preference is so small. What factors contributed to this? What could have been done differently? Of the ten participants who were shown the NP first, six of them preferred the NP over the CP. Of the ten participants shown the CP first, five of them preferred the CP over the NP. This result provides inconclusive evidence that the product shown first will be more strongly received than the product shown second. However, as a guide, this practice can only prevent the possible occurrence of the first product being preferred in all instances. Just about half of the participants in this final session were active throughout the final session. This means that they were actively responding to the stimulus throughout the session. This is a positive conclusion to an experiment that looked to create a process to use design as a stimulus and measure that response to stimulus through the Galvanic Skin Response.

6. EXPERIMENT CONCLUSION

6.1 GSR Chart Type Analyses

The design evaluation process yielded a final concept prototype as a result of conducting the study. However, the most important results are those that can be found by analyzing the GSR chart results for any trends of similarities, differences and or points of interest. Very clearly, three broad categories of charts emerged from the sessions. The qualities and descriptions of each of the categories are described in figure 6.1.

Type A	The participant is actively emotionally responsive throughout the session. The chart results can sometimes be clouded by the amount of responses and the equality in strength of the responses. Participants who produce this chart form are easily stimulated by this subject matter.
Type B	Participants who produce Type B charts have a wide range of emotionally responsive levels. Visually, they have downward lows with immediate upward highs. They may or may not be reactive during these lows and highs making some results difficult to understand.
Type C	Type C charts are difficult to read because the participant has provided little to no response to any of the areas stimulus is provided. There are more male respondents than females in this chart category.

Figure 1.1 -GSR Chart Type Analysis

The charts were analyzed by gender and by session. The results provided some interesting results to draw more conclusions from for the design and incorporation into future studies.

6.1.1 Type A Charts

In each session, approximately one half of all respondents were emotionally responsive to the material presented throughout the session. Figure 6.2 and 6.3 are examples of charts from each session that visually confirm this chart type. The two charts from each session aid in the understanding that in more than 1 occasion, there were charts that supported the groupings of like type charts especially after the trend in chart types appeared in analysis. As stated in Figure 6.1, the characteristics of a type A chart is the presence of emotional responsive activity to the given material in the Session. These types of respondents are ideal for studies such as this because they lend the most information to the research phase of the study.

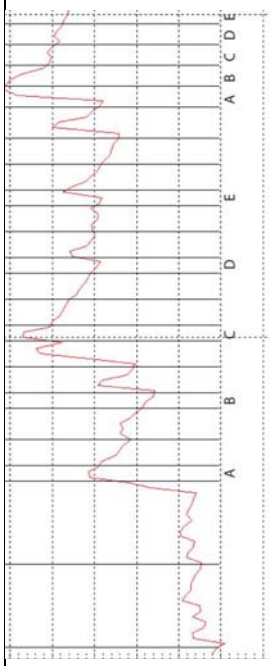
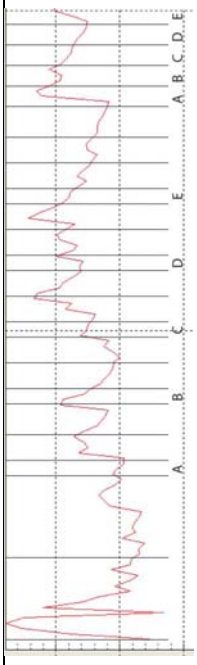
Session 1 Type A Chart		
Session 2 Type A Charts		

Figure 6.2 – Sessions 1 & 2 GSR Type A Chart Samples

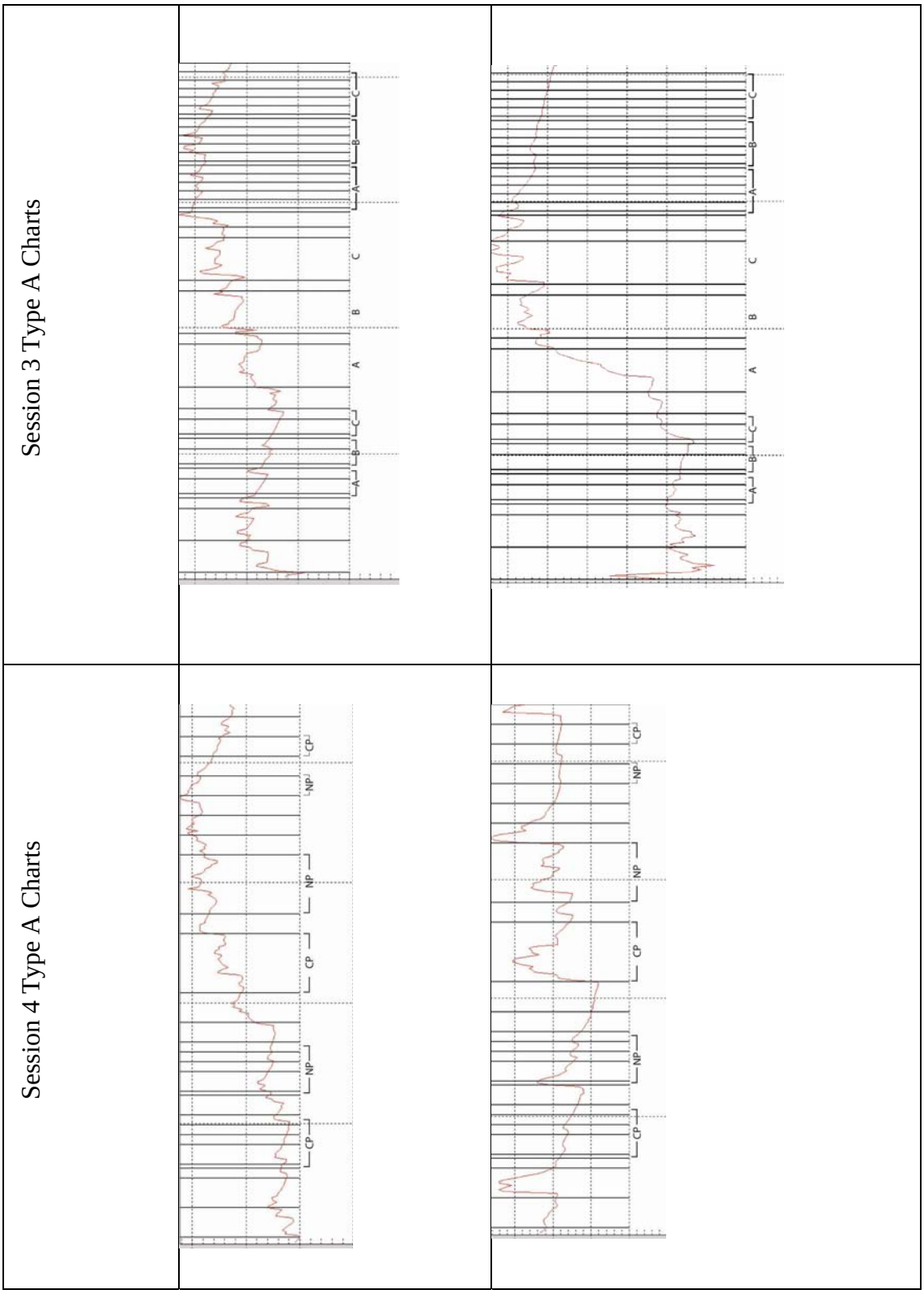


Figure 6.3 – Sessions 3 & 4 GSR Type A Chart Samples

6.1.2 Type B Charts

GSR Type B Charts are a representation of participants who respond to the stimulus with a wide range of emotional response. These charts typically are larger in height due to the drastic change in response levels. Most of these participants are the ability to respond to stimulus quickly and specifically. These charts are usually much easier to analyze due to the specific responses. It is also easier to observe the times that the participant is not as stimulated by certain areas of the experiment versus when they are. Figures 6.4 and 6.5 are samples taken from each of the sessions that illustrate the Type B Chart. Participant's who produce these types of charts are also good participants to have in the study because their responses are more easily understood and can help provide valuable assistance to product development team.

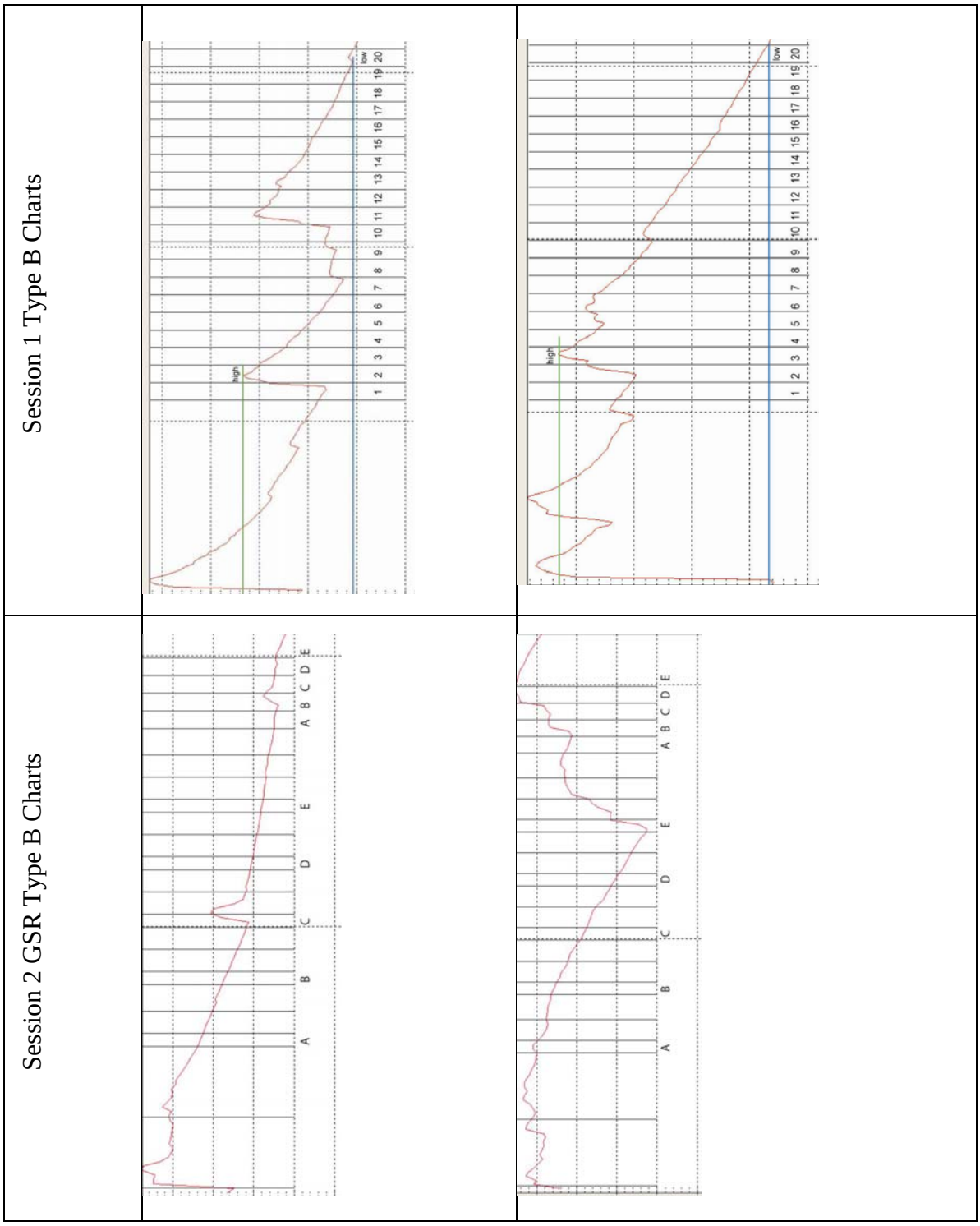


Figure 6.4 – Sessions 1 & 2 GSR Type B Chart Samples

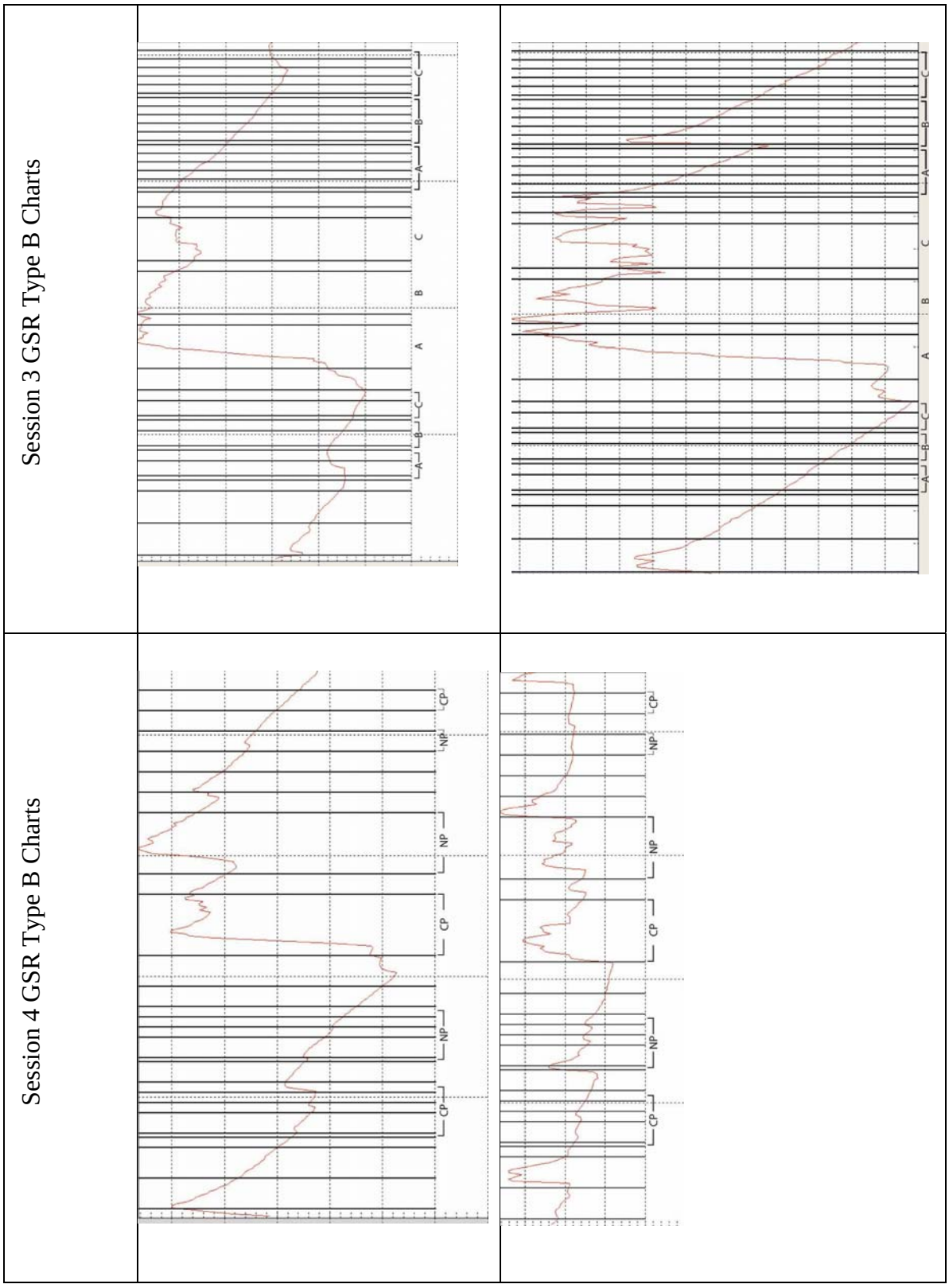


Figure 6.5 - Session 3 & 4 GSR Type B Chart Samples

6.1.3 Type C Charts

GSR Type C Charts visually appear to have the lack of emotional response represented by a flat line in a downward motion as shown in Figures 6.6 and 6.7. These charts are especially difficult to analyze due to the inability to see any specific point of emotional response. The few responses that occur on a Type C chart are useful but can not be dependable. Typically the majority of these charts begins with some form of response and might possibly end with some response. Early response is likely to relate to anxiety connected to the experiment rather than any form of stimulus. These charts are undesirable in design evaluation because they cannot provide any positive data. It is possible that these participants are engaged and feel stimulated but through the process of GSR do not provide any visible stimulus. This is a secondary reason why combining this form of evaluation with a survey can be useful. However, if possible, eliminating the potential for this type of chart would be most desirable in designing future studies using GSR.

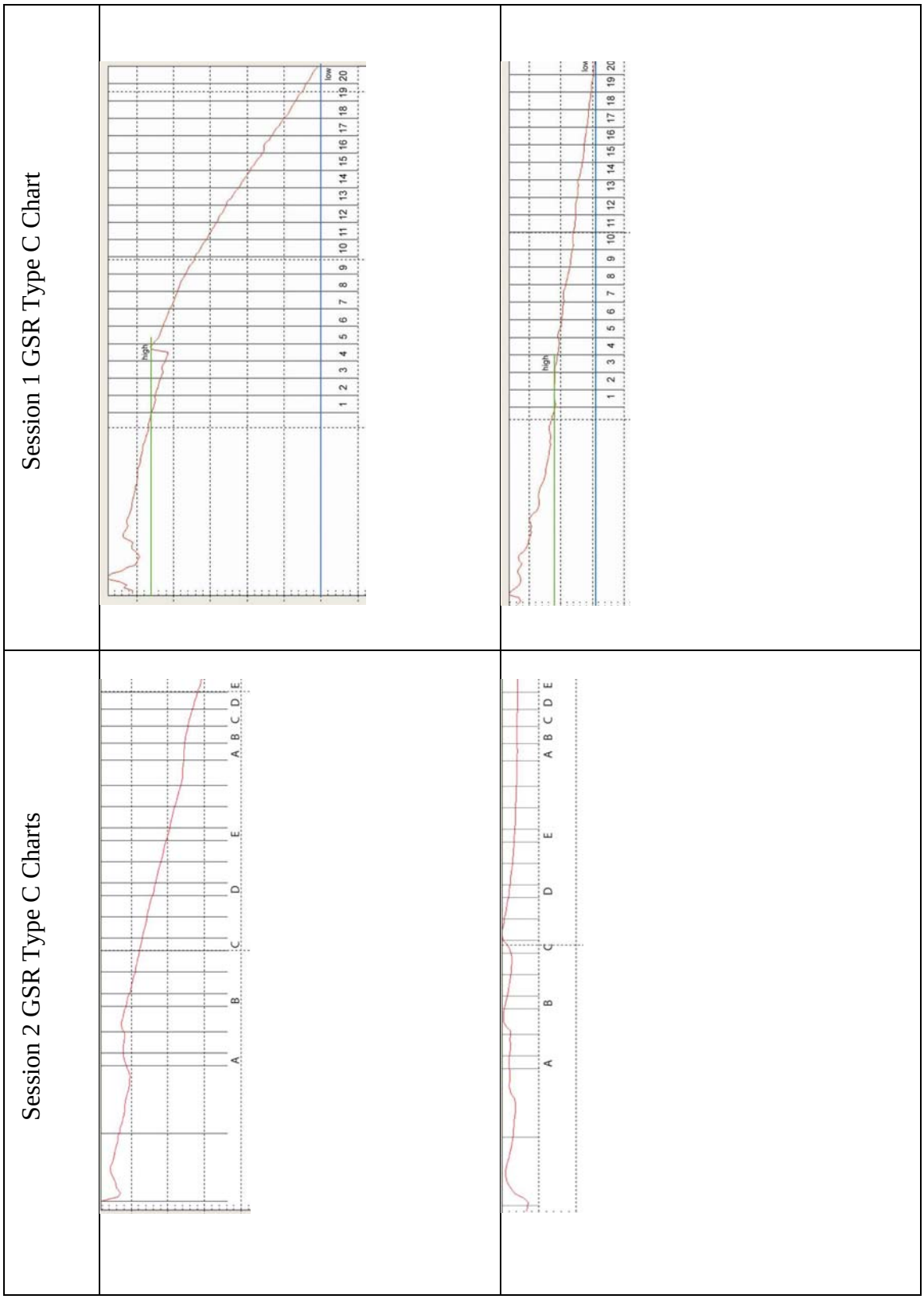


Figure 6.6 – Sessions 1 & 2 GSR Type C Chart Samples

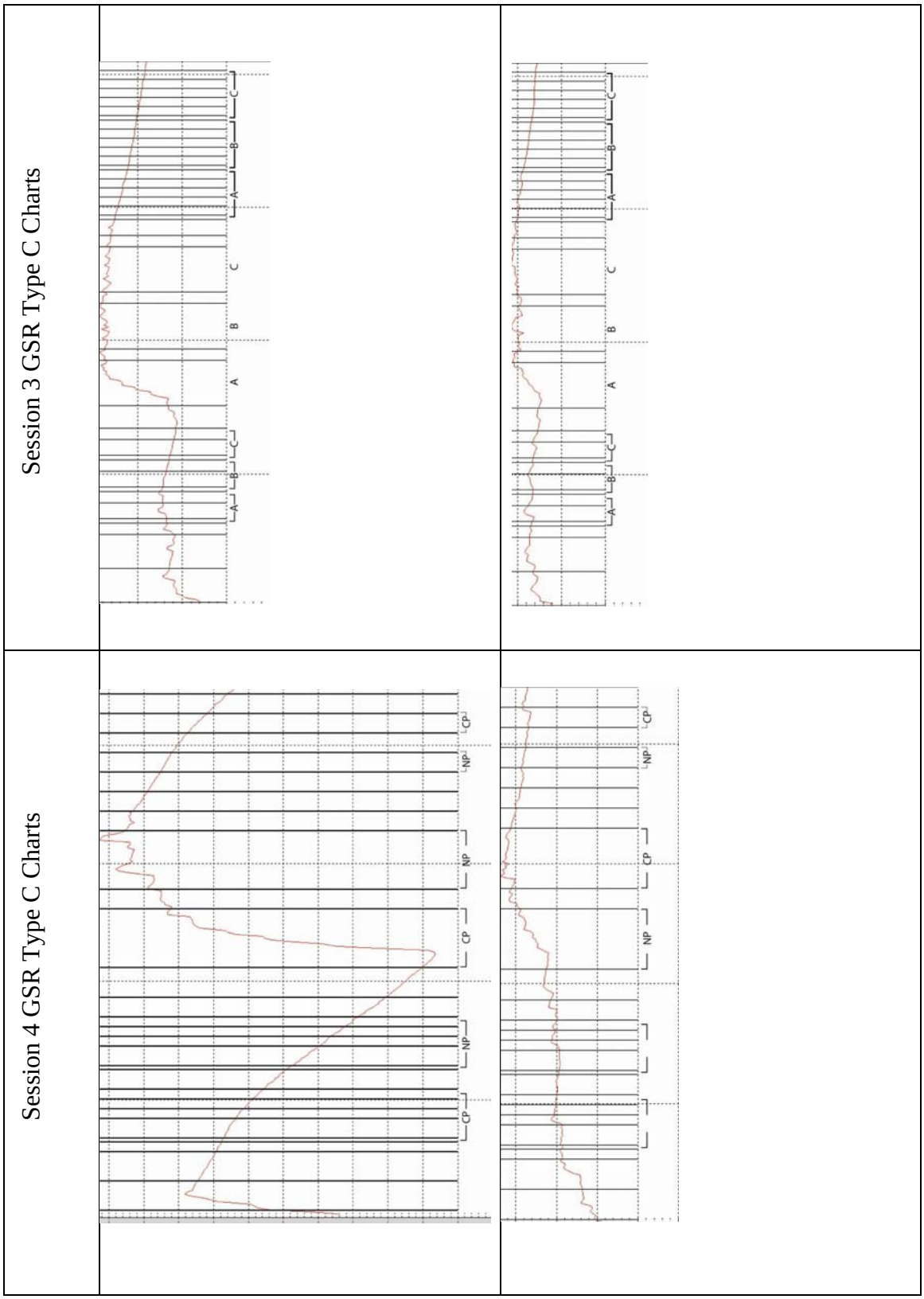


Figure 6.7 - Sessions 3 & 4 GSR Type C Chart Samples

6.2 Chart Conclusions by Session

6.2.1 Session 1 Chart Conclusions

In the analysis of the GSR charts and the creation of Chart Types, it was also important to analyze for any trends among who these charts were produced by. Figure 6.8 shows the number of Male and female participants who produced which type of chart.

Female Participants	Type A (4)	Type B (4)	Type C (2)
Male Participants	Type A (5)	Type B (1)	Type C (4)

Figure 6.8 - Session 1 GSR Chart Type Numerical Analysis by Gender

Many factors affected this first session and, consequently, the results. Anxiety and nervousness in starting the session affected at least half of the participants. This affected every chart type by first making the person more emotionally aroused by the situation therefore causing them to be reactive during the session. This behavior likely produced a Type A chart. Another factor is that because of this raised emotional state, it increased the participants' ability to experience a wider range of emotional response. For the male participants, it likely brought about a completely opposite response. Males are characteristically less emotional and even at an aroused level, it corresponds well to the increasing fall in emotional response, a Type C chart.

6.2.2 Session 2 Chart Conclusions

Session 2 produced interesting results because these charts are characterized by the wide range of emotional response. Because of this, it was possible for a person to have a hybrid of responses that include remaining responsive throughout the study to long downward motions indicating no response mixed with wide ranges of response to specific stimuli. Figure 6.9 shows the number of male and female respondents and their corresponding chart type for Session 2.

Female Participants	Type A (2)	Type B (4)	Type C (1)	Hybrid (2)
Men Participants	Type A (3)	Type B (4)	Type C (3)	Hybrid (0)

Figure 6.9 - Session 2 GSR Chart Type Numerical Analysis by Gender

In session 2, the participants were more aware of the procedure which likely helped to reduce any anxiety previously experienced. This probably increased the shift in male respondents having a wider range of emotional response. They were no longer, as previously, emotionally stimulated or reserved as noticed in the shift of charts from Session 1. The number of female who were previously more emotionally stimulated as in Session 1 shifted to include more Type B charts and the hybrid type. The change in session format and the familiarity with the experiment could have affected this small shift in chart types for this session. The decrease by 1 participant each in the Type C Chart is an example that the change in session format was a positive change. An increase in Type C charts would have indicated that the change in format was not successful which would have affected the final outcome of the experiment.

6.2.3 Session 3 Chart Conclusions

Session 3 was different than the previous two sessions because of the introduction of the foam pre-prototypes. In almost all instances, the participant's level of response increased dramatically when able to interact with the pre-prototype. The affects are seen in Figure 6.10 where there is an increase in the number of female with Type B Charts and the number of hybrid charts for men.

Female Participants	Type A (3)	Type B (7)	Type C (0)	Hybrid (0)
Male Participants	Type A (4)	Type B (1)	Type C (2)	Hybrid (3)

Figure 6.10 - Session 3 GSR Chart Numerical Analysis by Gender

The format and material presented was different in Session 3 so it is not surprising that the chart results are different from the previous two sessions. The increase in female type B charts is interesting but should be expected given that females are considered more emotional beings than males. These female participants experienced a wide range of emotional responses throughout the session. Most of these female were active throughout the session demonstrating that the design of Session 3 provided stimulus for half of the participants to respond to. The increase in hybrid charts from the male participants shows an increase in their ability to respond to the stimulus. They experienced more than one kind of response. In all the charts, the period of interacting with the product provided a significant jump in response. Tips to improve this interaction may be to flash words that could be associated with the product during the time that they are interacting with the product to partially control what thoughts are being processed.

6.2.3 Session 4 Chart Conclusions

Session 4 had a slightly different format than the previous sessions because this was a conclusion session. The previous sessions had helped evaluate the designs for a MP4 player. Session 4 was set up to evaluate how well the designer captured the responses from the other sessions. The biggest difference was that the introduction of a comparison product that had not been a part of any of the designs the participants evaluated over the course of the experiment. Figure 6.11 shows the numerical analysis of how the participants responded.

Female Participants	Type A (4)	Type B (3)	Type C (1)	Hybrid (2)
Male Participants	Type A (5)	Type B (1)	Type C (2)	Hybrid (2)

Figure 6.11 - Session 4 GSR Chart Numerical Analysis by Gender

The format of direct comparison in Session 4 was done to evaluate how well the New Product represented the feedback gathered throughout the sessions. While it is now understood that this NP met just over one half the participants it is interesting to see the charts and how the participants responded. There was a serious shift in the female's responses in comparison to Session 3. The shift in the men's responses was less intense from that of Session 3. In an overall analysis of the charts in Session 4, there was an indication that the participants seem to have a familiarity with the process and an understanding of responding to the material.

6.3 GSR Chart Experiment Conclusions

As a first study using GSR as a design evaluation tool, the ability to produce such results is a success. These results are a contributing factor that more research and methods of using the biofeedback tool are needed to further confirm it as viable in design evaluation. Through further testing and technological improvements to the device and software, the ability to understand the consumer and produce more user-centered products is a increasing possibility. It is hoped that these early understanding of chart types and the understanding of how participants can respond to stimulus provided by ideas can enhance future studies of this nature.

7. GUIDELINE FOR DESIGN EVALUATION AND BIOFEEDBACK TECHNOLOGY RESEARCH

7.1 Establish if Biofeedback is Appropriate for Study

Biofeedback can be applied to future research, but variables need to be addressed to determine appropriateness for the specific research being conducted. Specifically GSR is recommended as the biofeedback technology to begin with due to its ease of use, availability, cost and understandability. There are other biofeedback technologies available that would require further research to see if it is has a more suitable application for areas of research other than design evaluation.

The use of biofeedback technology is recommended when involving participants in the design evaluation of user-centered products. As presented in this study, the technology gives insight into the participants' emotional reactions. Biofeedback use is not recommended if the research is not involving participants during the design evaluation phases. During design evaluation, certain products may have more success using biofeedback technology than others. In this study, the biofeedback technology aimed to capture a participant's emotional response as they were first presented with the product. Using biofeedback to capture specific responses towards product details may not be the best use of the technology. As discovered in this study, responses towards color could not

be understood because color can have a variety of emotions attached to it despite it being assigned to the product. Rather, a broader goal for what the biofeedback technology will be used in capturing is recommended. Examples would include concept evaluation to understand a direction the design should proceed with.

To aid the understanding of the biofeedback data, an additional form of gathering participant feedback is useful. In this study, a visual survey followed each of the design evaluation sessions. This data served as a benchmark for comparison and confirmation of the results produced by the GSR device. Once these variables have been determined, the research should proceed through the following recommendations.

7.2 Determine Time Frame for Introduction of Biofeedback into Study

In the development of a product, several times decisions need to be made that impact the form and function. Decision making in the design evaluation periods is crucial to creating a product that will be valuable to the consumer. The phases in which biofeedback technology and participants can aid the research will need to be determined before beginning use of biofeedback technology. This study presents use of biofeedback technology in multiple evaluation phases. Determining the number of phases the product will go through before completion (relative to time and constraints) depends upon the complexity of the product and the outcome desired. For the example detailed in this study, the concept model or pre-prototype was the outcome desired and determined due to constraints. These constraints consisted of the inability to produce a working prototype. The number of phases determines the number of evaluation sessions participants will be involved in. If participants are a constraint, the number of phases may

need to be adjusted accordingly. The same action would be required with time constraints as well.

Galvanic Skin Response can aid any or all phases of design evaluation from brainstorming to final form evaluation. The advantage to beginning with the use of biofeedback is the establishment of a standard. The emotional responses can provide a foundation on which future decision can be made. While incorporating biofeedback at any time during design evaluation decision periods is acceptable, it can be understood that the results will not have a foundation in emotional response. It is recommended that a clear outcome be established if biofeedback is not going to be incorporated in the beginning phases. Biofeedback outcomes may enhance or vary the outcome due to the foundation in emotional response.

7.3 Specific Uses of Biofeedback Technology in Study

7.3.1 Visual Presentation

The design of the visual presentation for the particular design evaluation phase is important because the GSR data recorded requires an understanding of what the participant was responding to at any given moment. For this reason, a presentation that is timed is highly recommended. This can be accomplished using Microsoft PowerPoint, presenting the material through a video recording or in any other method that can provide a record of what the participant was responding to at the given time. Being able to break down the time in which the participant is being stimulated by the design is important when comprehending the GSR charts.

Another factor to consider in the visual presentation is any questions that the experiment hopes to have the participants answer. This study posed questions for the participant to silently answer throughout each of the sessions. It was the hope of the study that the thought process of saying “yes” or “no” would indicate a response in the GSR charts. In some instances this was accomplished. For others, it was not clearly defined in their charts. The presentation should not have participants physically indicate a response because movement can cause “noise” and interference with the GSR device. This makes it unclear whether or not it was the participant’s intention to respond as strongly as the response indicates or if the noise picked up by the device creates a false impression of the participant’s response. For this reason, the participant is asked questions that required the participant to think about the question in a personal way. Such as “Would you like to own this MP4 player?” Posing a question needs to be done in a way that is not general, such as “Do you like this MP4 player?” This form of questioning does not provide any reason for the participant to say yes or no. Responses can be accomplished when posed correctly and at the right time in the experiment.

7.3.2 Participant Screening Process

When recruiting target participants to involve in the evaluation of the design, it is important to create a screening process in order to have participants that can provide the best data. A preliminary test is suggested as a screening process for two purposes. First, for the research to be most successful, having participants that are able to provide measurable data is essential. The preliminary test should check for response levels to various stimuli. The other purpose would be to identify how long a person needs between

stimuli to return to a neutral state. This time period is an important factor because the previous stimulus may contribute to the results of the next stimulus unless time is allowed for the participant to return to a neutral state where the previous stimulus will no longer be a factor to the next stimulus. Based on this information, either specific experiments need to be set up per person, or an average of times needs to be made for a single experiment. Additionally, when beginning the GSR design evaluations, it is suggested that the participant be connected with the GSR devices for a time period without recording a participant's answers in order to lessen the anxiety spike observed in this study. Of course, the product being evaluated should be considered when implementing these suggestions because additional time may not be something the product or experiment can afford. Almost every participant experienced an anxiety spike when the presentations began. However, it is important to understand that each participant will react differently to the stimulus. Different products may capture only a certain type of user. Not every user will be emotionally stimulated by the product which is why the screening process can assist in gather Type A users for the specific study. Type B and C users may not be useful to the study and should be not be used in evaluating the product.

7.3.3 Recommendations for Experiment Conductors and Environment

The person conducting the GSR based design evaluation experiment is also an important factor that could potentially contribute to the results. This person should be someone that the participants feel comfortable with. He or she will be talking to and touching the participant as they ensure the device is attached correctly. In addition to the conductor of the experiment, the environment the experiment is being conducted in

should be comfortable and free of possible distractions. Distractions such as other people, noise and pictures or objects other than ones related to the experiment should be eliminated from the environment. Also to be considered should be the comfort level of the space such as temperature, light and the chairs you wish the participant to sit in during the experiment. The participant should also have some freedom of movement while connected to the GSR device. These recommendations should help create an atmosphere conducive for conducting a successful experiment.

7.3.4 Recommendations for Design Evaluation Phase Materials

Depending upon the specific phase designated for evaluation, it is recommended that the materials used in the presentation follow some specific guides so that their inclusion produces the best data. The first guide to follow would be to provide the same level of integrity and quality in the presentation of the material. This should mean that sketches appear to have the same level of appearance so that no sketch visually appears to stand out. This will help prevent participants from reacting to a sketch because its appearance quality is inconsistent from the others presented. Other examples would include renderings and models. Any finish applied to the product for evaluation should provide fidelity throughout the presentation.

Inclusion of GSR in brainstorming or concept refinement can assist the product development team in sorting through a large number of ideas. In this study it was discovered that showing 20 concept sketches, one right after the other, was not conducive to achieving clear and understandable results for every concept sketch. Rather, the presentation did not make provisions for the participant becoming bored and not

responding to later concept sketches. It is suggested that no more than 25 images of the topic be shown during any one study. Provisions should be made to present these ideas or images in groups of 5 mixed with opportunities to re-evaluate the state the participant is in. The sets should be separated by a period in which the participant can resume a neutral state and then respond to the following set as if never engaged in any previous sets. Several possible separators such as neutral pictures, music, or even dialog may provide enough of a reset for the participant.

When evaluating product forms, it is recommended that care be taken to present the forms in a way that can capture optimal emotional responses from the participants. Keep in mind when involving form interaction in an experiment that the act of touching the form will act and register as a stronger stimulus than viewing an image. It will be difficult to control this type of stimulus when presented to the participant to touch. If this phase is a continuation from earlier phases that have been tested using GSR, then it is the suggestion that the forms be kept to images only. If no previous GSR testing has taken place, the inclusion of GSR may produce helpful results.

7.4 Interpretation of Biofeedback Technology Results

There is no right or wrong way to interpret the results gathered from a biofeedback technology experiment. This study presented one of many ways to evaluate the data and draw conclusions. One factor that should be considered in deciding how to evaluate the results is deciding how the results will be used. After each session in this study, the results helped to narrow down the design ideas until the final session when the results were used to confirm the final design. Depending on the design of the evaluation

phase or phases that the experiment calls for, the use of the results could have varying uses.

By looking at all the GSR charts, some visual patterns should appear. Stimulating periods should register on all the charts although the level in which the participant emotionally responded will vary. Other patterns may occur as noted in this study. A Type chart participants were those that had some form of emotional response to every period that a stimulus was presented. B Type chart participants had levels of response that varied greatly and strongly to specific stimulus. C Type chart participants had very little emotional response to the stimulus. It is suggested in the screening process that these final chart type participants not be included in the study. The best recommendation when evaluating GSR chart data is personal judgment until more studies can be done to provide a more direct method of evaluation.

Following a biofeedback experiment with a survey or other method of gathering participant's feedback will assist in the interpretation of the GSR data. In using a survey, the numerical data can provide an easy way to compare data. If using a focus group or any other method in which the participants verbally express their feedback then this would need to be formatted in a way to coordinate with the GSR data. Structured and moderated questions should correspond to the design evaluation materials and experiment. Again, judgment will be necessary in using the data for the outcome predetermined by the experiment design and needs of the study.

7.5 Conclusions

This guide should be used to assist future research in the areas of design evaluation and biofeedback technology use. This study produced initial data that seemed to indicate that GSR is an applicable biofeedback method that can be used to assist those in the design community. Other research on the incorporation of these two areas could not be found indicating that there is merit in researching this topic area. This guide should help researchers begin to discover various ways of evaluating design and interpreting the results. Ways to expand this research may be in the participant recruiting process and screening phase. This alone could potentially have dramatic results as well as choosing to be gender specific rather than equal numbers of men and female. Some of the suggestions regarding the conductor and atmosphere should be explanatory but could affect the results if not taken into consideration. The actual set up of the visual presentation and inclusion of evaluation materials could create new areas to research. The best conclusion to draw on before beginning research in this area is to remember that this is an exciting area of study and any further investigation into this topic area will uncover new data, new results and new topics to discover.

8. CONCLUSION OF STUDY

8.1 Summary of Study

This research began with the identification of biofeedback technology and decision to apply the technology to product design evaluation. The two areas had not been combined before; therefore, a method had to be created to accommodate the technology and to produce results for design evaluation. Research was conducted to justify the viability of the study. The research suggested that biofeedback technology could provide a more complete method of understanding a participant's emotional response. These emotional responses could then be applied to design evaluation when the product acts as the stimulus to produce such emotional response.

The method created for this study met the most basic needs of data gathering given constraints. A product was chosen to accommodate the constraints of time, money, and trends. An MP4 player created an option to involve participants from Auburn University because they fit the ideal target audience. It was also a product that has limited availability and acceptance in the current market place; although these trends are changing. Drawings were made in preparation of the fist experiment session.

Participants, equal numbers of both male and female age 19 and older, were recruited to participate in the study. The first session was set up for each of the 20 participants. The first session was a learning experience that influenced the latter sessions. First was the observation of boredom among the participants because so many

concepts were presented in the first session. Later sessions aimed at creating a more interesting presentation to keep the participants stimulated. Sessions 2 and 3 were more successful in capturing the participants' attention and the results showed that they were more stimulated throughout. Each of the sessions, with the exception of the initial session, used the outcome to create the material presented. The first session resulted in 7 concept sketches that were used to create 5 computer generated models for Session 2. The results from Session 2 used the top 3 computer models to develop 3 further developed computer renderings and foam models for Session 3. In Session 4, the top model from Session 3 was developed into a pre-prototype to be compared to a comparison model. The final session acted as a confirmation session to gather feedback on the participants' preference to the final model or the comparison model.

8.2 Study Accomplishments

The most important accomplishment of this study is the development of the design evaluation process using the GSR. This is important because it creates opportunities for future work using any or all of the discovered methods and techniques. In Figures 8.1 and continued in 8.2, the anticipated outcomes were compared to see if the goals had been met. While many of the outcomes from the session experiments were not expected, many of the outcomes anticipated in the beginning of this study were accomplished. Column 1 re-describes the outcomes anticipated in the beginning of the study and in column 2 are the evaluation of if the outcomes were achieved or not. In the individual session experiments, a separate set of anticipated outcomes were outlined. These were addressed in each of the discussion sections of their chapters.

Constraints were a major factor in the inability to accomplish some goals that may not be stated in the text. The presentation of the products could have been aided by incorporating some kind of interface or at least visuals of the interface. This would have given a more real quality to the products than that which they achieved. Other areas that were not fully realized were the full level of understanding of the GSR software and procedure. While the level of understanding was sufficient for producing and evaluating results, the level of proficiency is less than desired. In addition to the results, further exploration into the meanings of the results could have been conducted. Time constraints prevented exhaustive studies of the charts and their deeper meanings from appearing in this text. This is the most interesting area that was not fully accomplished because it would include trying to analyze the emotional responses the participants were experiencing during the sessions. A way to possible understand this better would be to reformat a survey using descriptive words that the participants could choose from that describes their response. This still is not the same as wanting to know what the participant was thinking and experiencing at the time. But, this is a known constraint given the specific biofeedback technology utilized.

Anticipated Outcome Evaluation	
Original Anticipated Outcomes	**Were the Anticipated Outcome Goals met? Yes or No, explain.**
1. Through research on design evaluation, a new method for evaluation will be formulated	Yes, a new method for design evaluation was developed.
2. This new method for design evaluation will include biofeedback procedures for gathering feedback and an existing survey method	GSR was determined to be the best option for using biofeedback technology. A picture survey was used as a follow up to every session.
3. Biofeedback devices will be tested to insure their accurate measurement of reaction to design concepts	GSR did provide a measurement form for recording emotional reactions to stimuli. The chart developed could not provide specifically accurate reaction measurements. Instead, the charts provided a visual recording of the participants' responses during the sessions. The charts were visually analyzed for the participants' preference.

Figure 8.1 – Anticipated Outcomes 1-3

Anticipated Outcome Evaluation cont.	
Original Anticipated Outcomes	**Were the Anticipated Outcome Goals met? Yes or No, explain.**
4. It is projected that the biofeedback devices and method for testing using design concepts will produce data that corresponds with a traditional survey method. The result will be a whole reaction produced from the central system and the peripheral nervous systems.	Yes, observation of the GSR charts and the coordinating picture survey did provide coordinating results that suggest the result is a whole reaction produced by both the CNS and PNS.
5. The selected experimental group only represents members within the target audience; however, no statistical or personal background information is collected.	Correct, the number of men, female, ages and personal backgrounds were of no statistical value to the study except in providing a selection of target audience members.
6. The results will produce only one view of how collecting information from the CNS and PNS correspond in the area of design evaluation.	Yes, these results produced were one method of many possible methods that could be used to capture both CNS and PNS responses for the use in design evaluation.

Figure 8.2 - Anticipated Outcomes 4-6

8.3 Future Areas of Study

This study creates opportunities for future areas of study to be conducted using any or all of the guidelines presented in this study. Some of the areas of study that could possibly produce interesting results:

- Gender specific product development and evaluation
- Color exploration using biofeedback technology
- Product detail evaluation rather than overall concepts
- Interface evaluation
- Integration of more detailed surveys that capture more than numerical data
- Different categories of products – very small to very large
- Allied areas of design such as interior design, graphic design, apparel design and architecture

All of these areas could utilize biofeedback technologies in some capacity. The results from these possible studies have potential for changes in evaluation standards and research focus areas. The commercial value could greatly enhance product success in the market. Commercial use of this technology for the use of evaluating product concepts would be an ultimate goal. Further pursuit in the development of a process for evaluating design using biofeedback technology should be continued and expanded. Consumers will be greatly effected by the introduction of such processes in the design of the products they use. A product that has been evaluated using a biofeedback method could become the next standard in products consumers look to purchase. Indicators such as stickers or visible logos like “Energy Star” or “Intel Inside” would let the consumer know that this

product is a biofeedback evaluated product. This standard would surely indicate probable success for consumer and the product development team.

Over the course of this research, the author has discovered the uniqueness of this area of study and the potential for furthering user-centered products by its introduction into the development of commercially produced products. While it is not practical to introduce this process to the market yet, it is the hope that others academics will apply its application to other areas of possible study. Only through expanded research will this application reach consumers and change their expectations of designed products. The author plans to continue this research in the direction of textile and apparel products. The understanding that this research has afforded is that the possibilities of bringing change to aspects of design and the production of products is a current issue that can be addressed now.

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APPENDIX

The figures located in the appendix are a concise visual explanation for the design of the New Product developed through the design evaluation process developed in this study. The figures show comparative products, an outline of design goals and design specifications. For future product design, it is suggested that other literature works and the website www.idsa.org be consulted for assistance. This study should be used as a guideline for the evaluation of products in the design development phases. It should be noted that this section is only a concise representation of the design of a product; it should not be used as a guideline for designing products.

Figure A1 - Comparison product images to assist in identifying possible market trends in design and function.

	Function	Parameters	Performance Criteria
Human Function	Practical Physiological	Size	Hand Held; approx. 4”x2”
		Navigation	Touch Screen “buttons”
		Output	Earphones & Speaker
		Screen	Wide Screen LCD
		File Types	Mp3, WMA, WAV, Mp4, Sat. TV, jpeg
	Social/Economic	Retail	Less than $400
	Cultural Aesthetic	Color	Silver, White, Blue, Metallic
		Styling	Modern, Clean Lines
		Form	Flip Screen with adjustable angle
Technical Function	Direct	Power	Internal Battery
		Speaker	Internal Battery
		Software	PC & Mac compatible
	Indirect	Storage Capacity	20GB
		Power Source	U.S. 120 volts
		Connection	USB cable
Production Function	Planning	Target Users	18-30 yr. olds; College Students & Young Professionals
	Manufacturing	Circuit Board	Outsourcing - Electrical & Computer Engineering
		LCD Screen	Outsourcing - Specific Part Manufacturer
		Touch Screens	Outsourcing - Specific Part Manufacturer
		Body (Top & Bottom)	Outsourcing - Injection Molded Plastic Parts

Figure A2 - Performance Criteria Chart

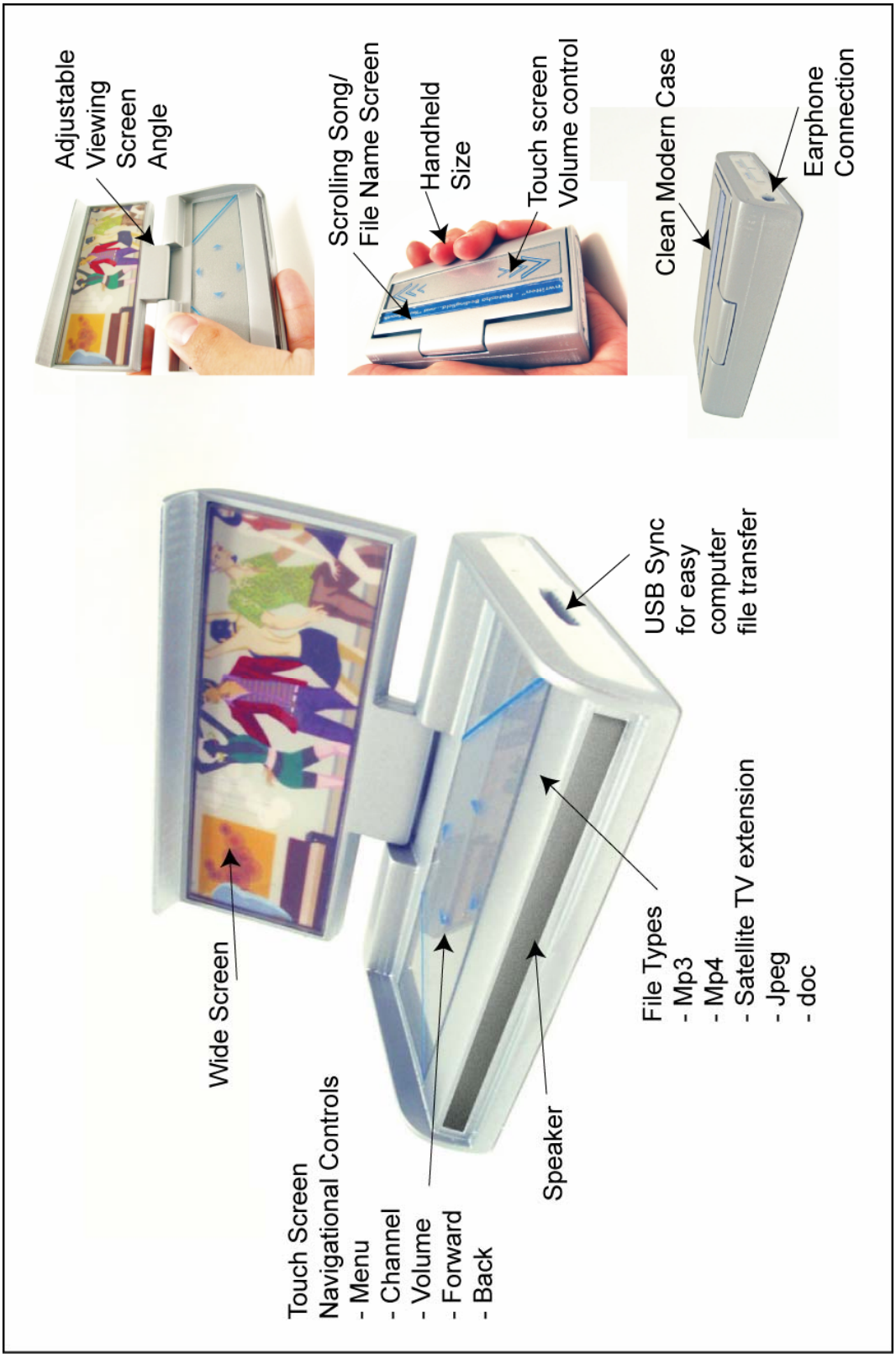


Figure A3 - MP4 Player Product Specifications

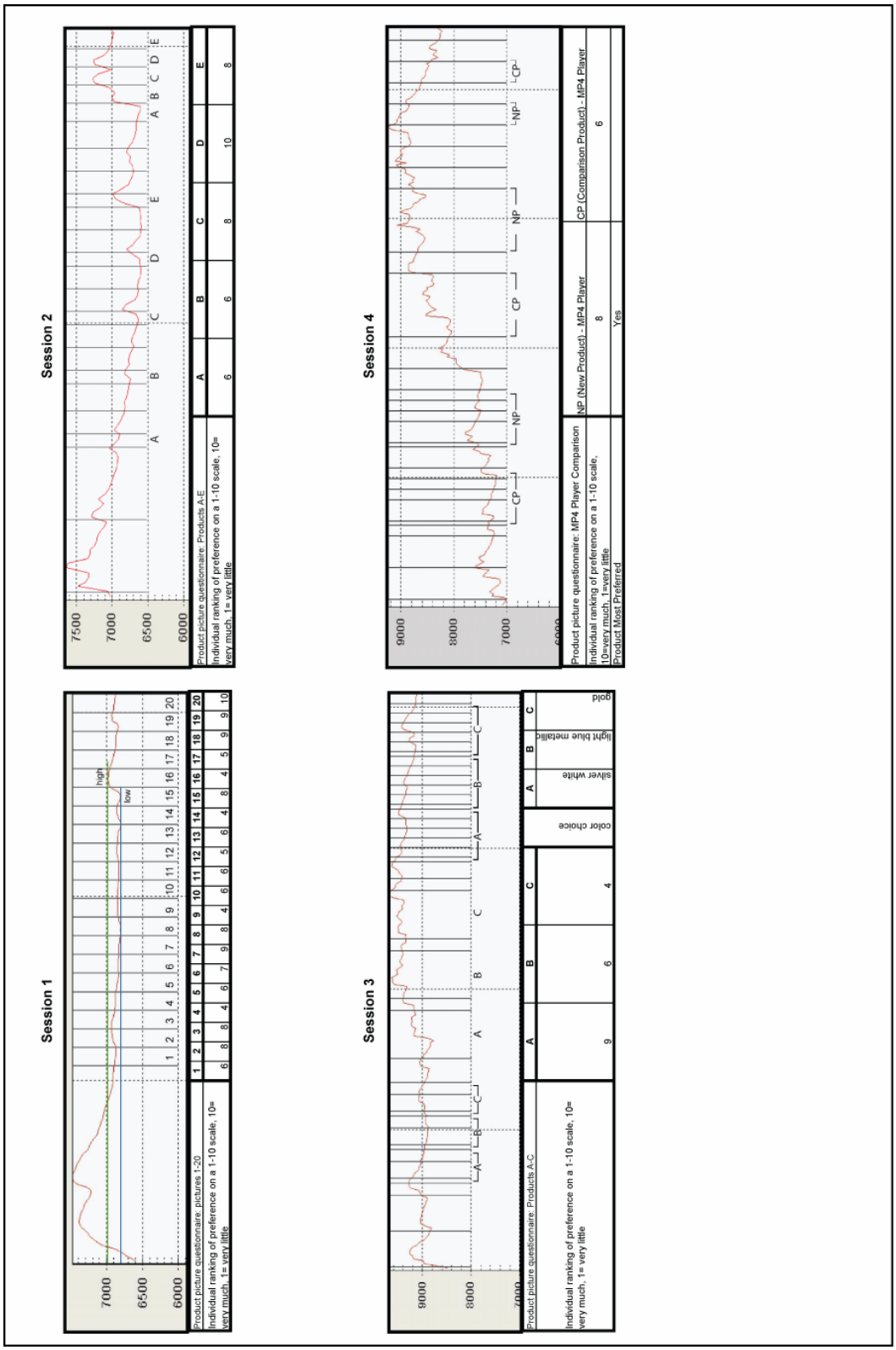


Figure A4 - Sessions 1-4 GSR Charts: Participant AA-F

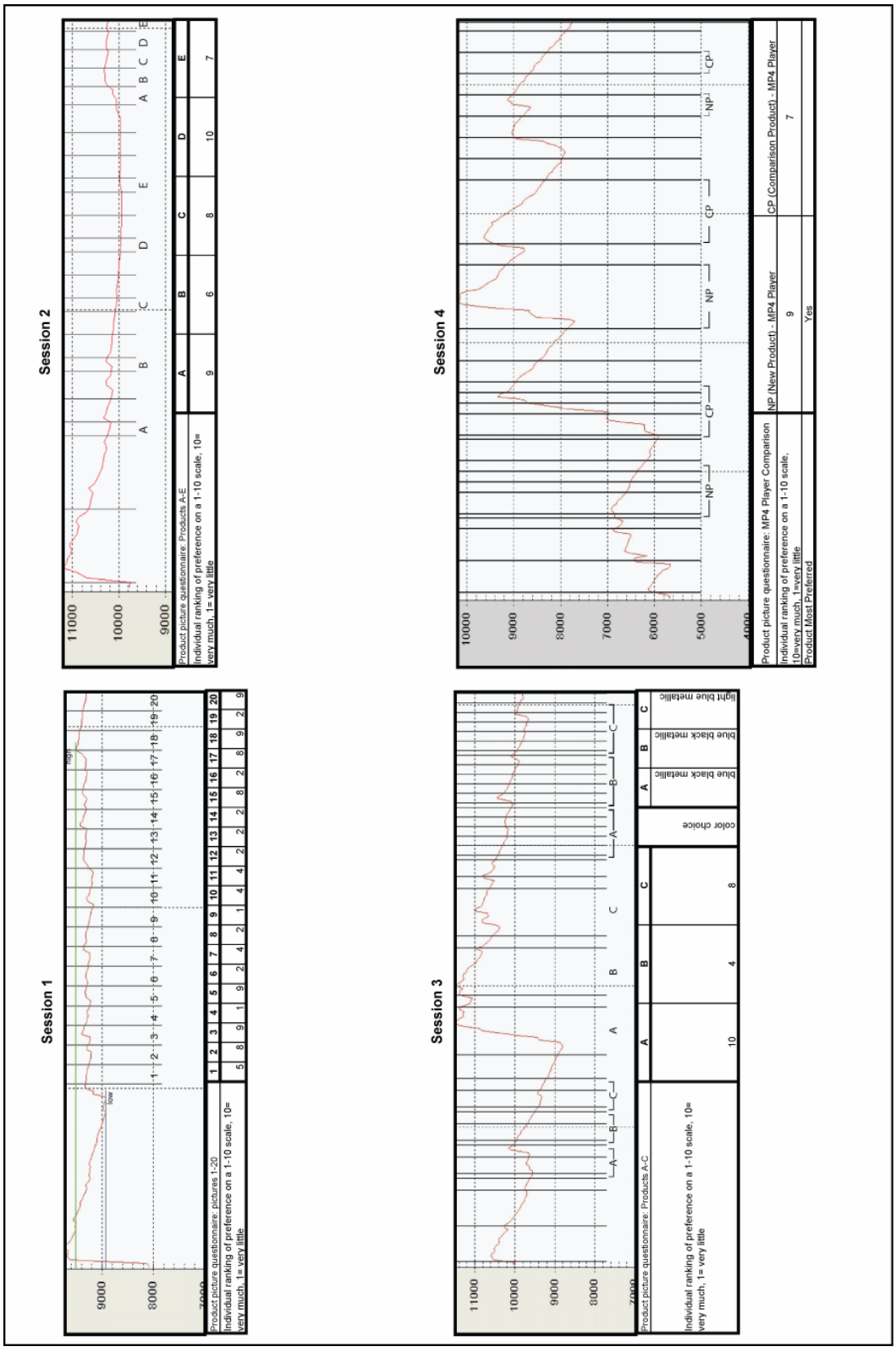


Figure A5 - Sessions 1-4 GSR Charts: Participant AF-F

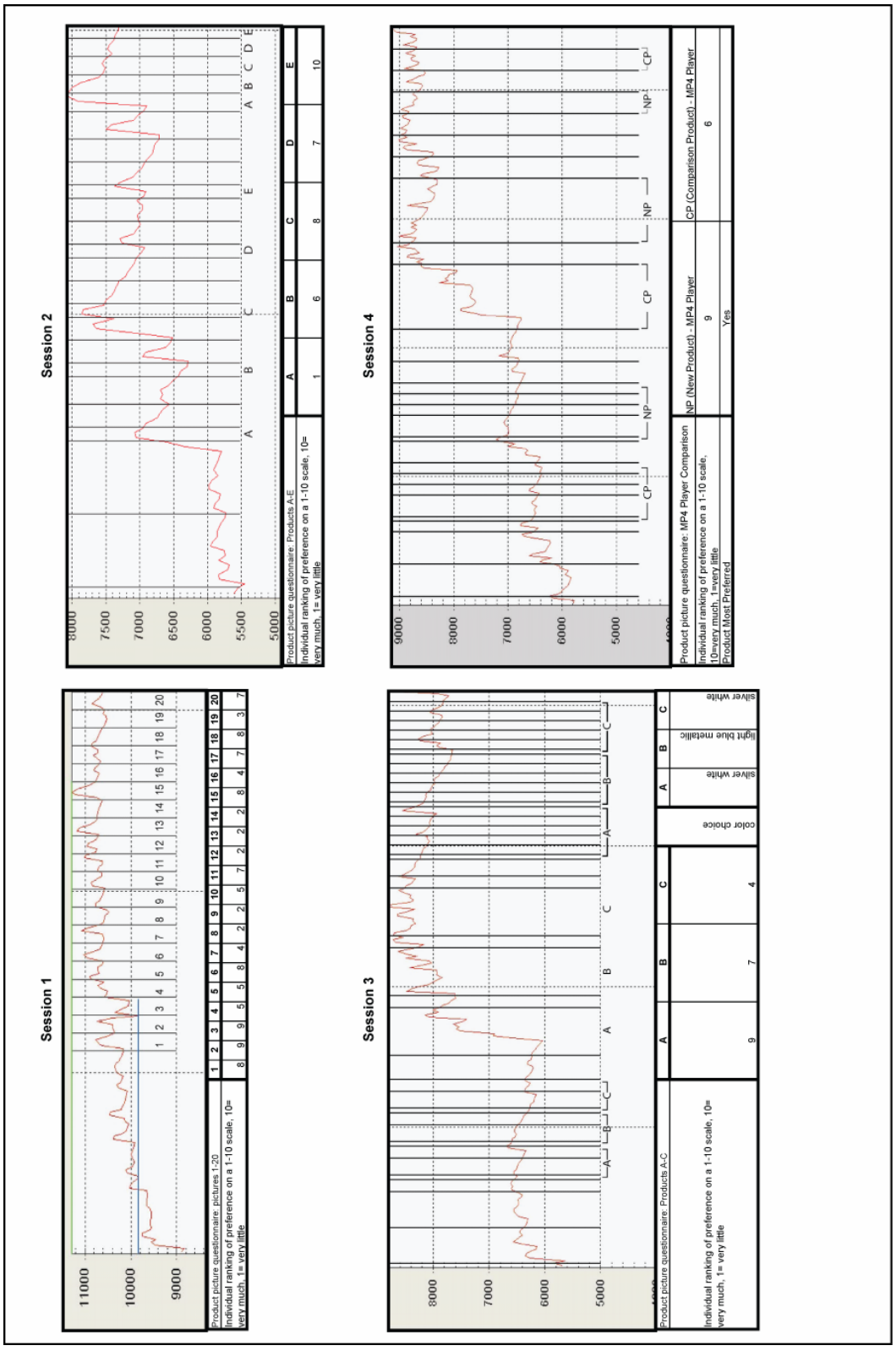


Figure A6 - Sessions 1-4 GSR Charts: Participant AM-F

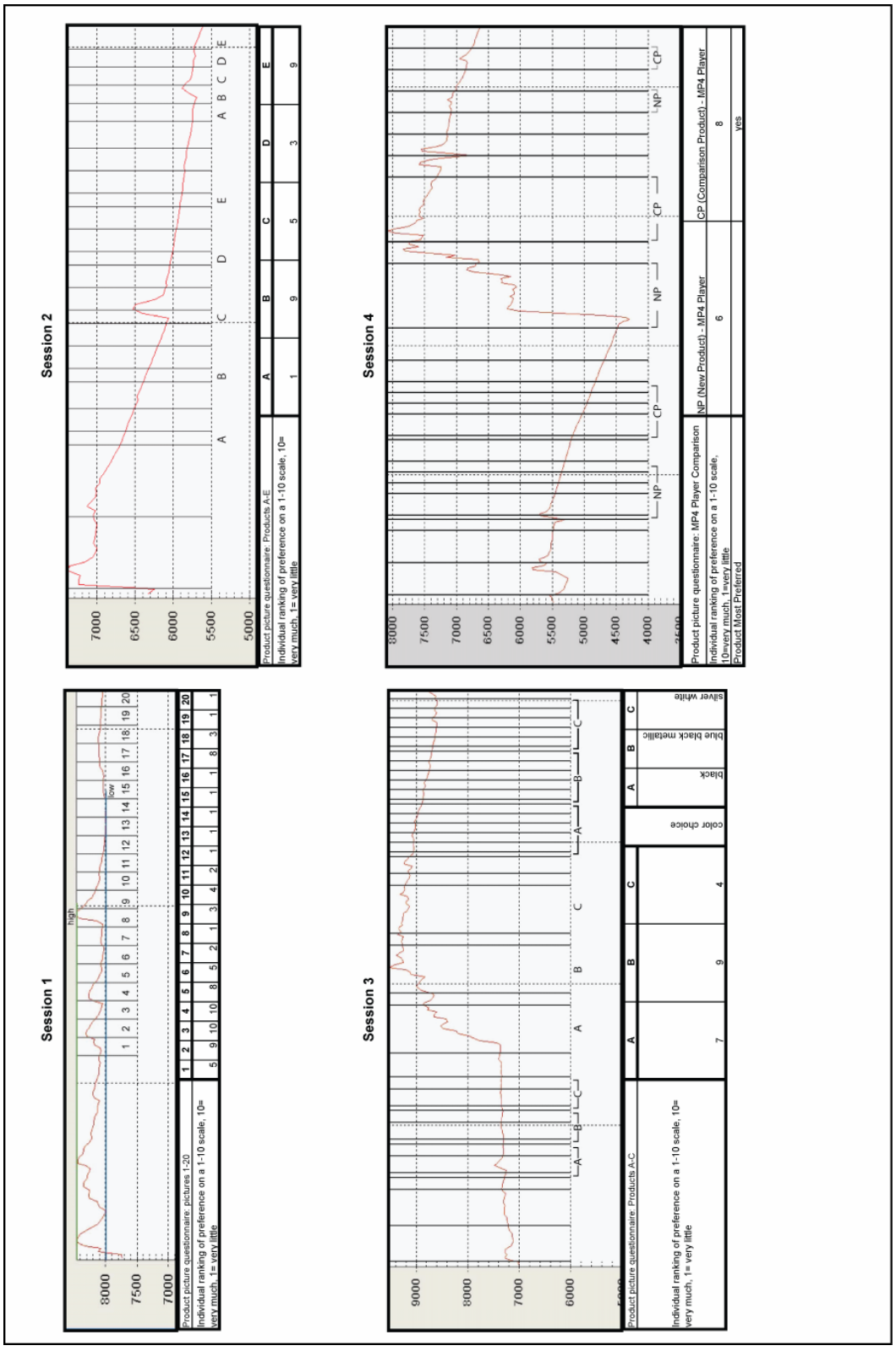
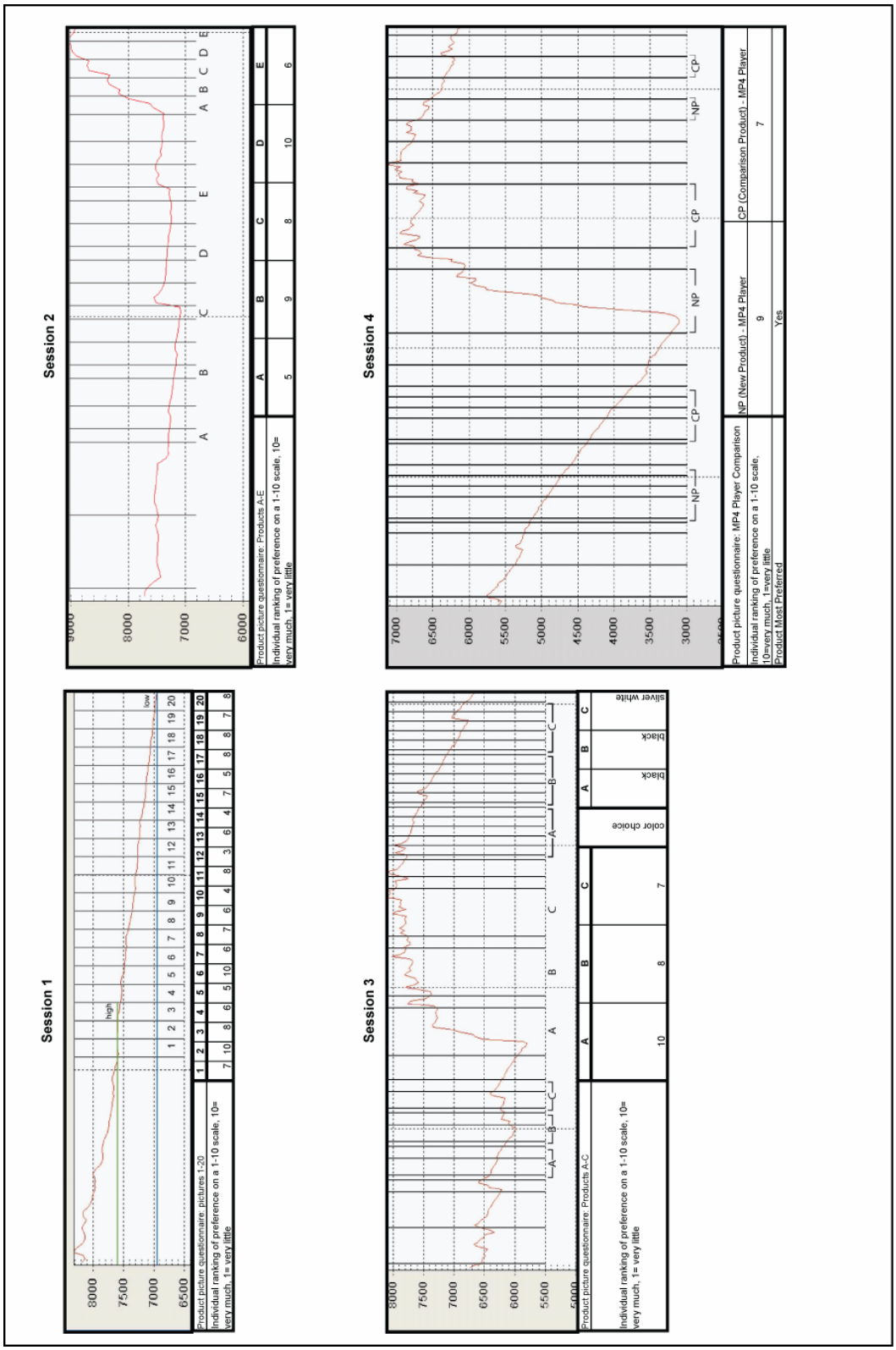


Figure A7 - Sessions 1-4 GSR Charts: Participant BB-M



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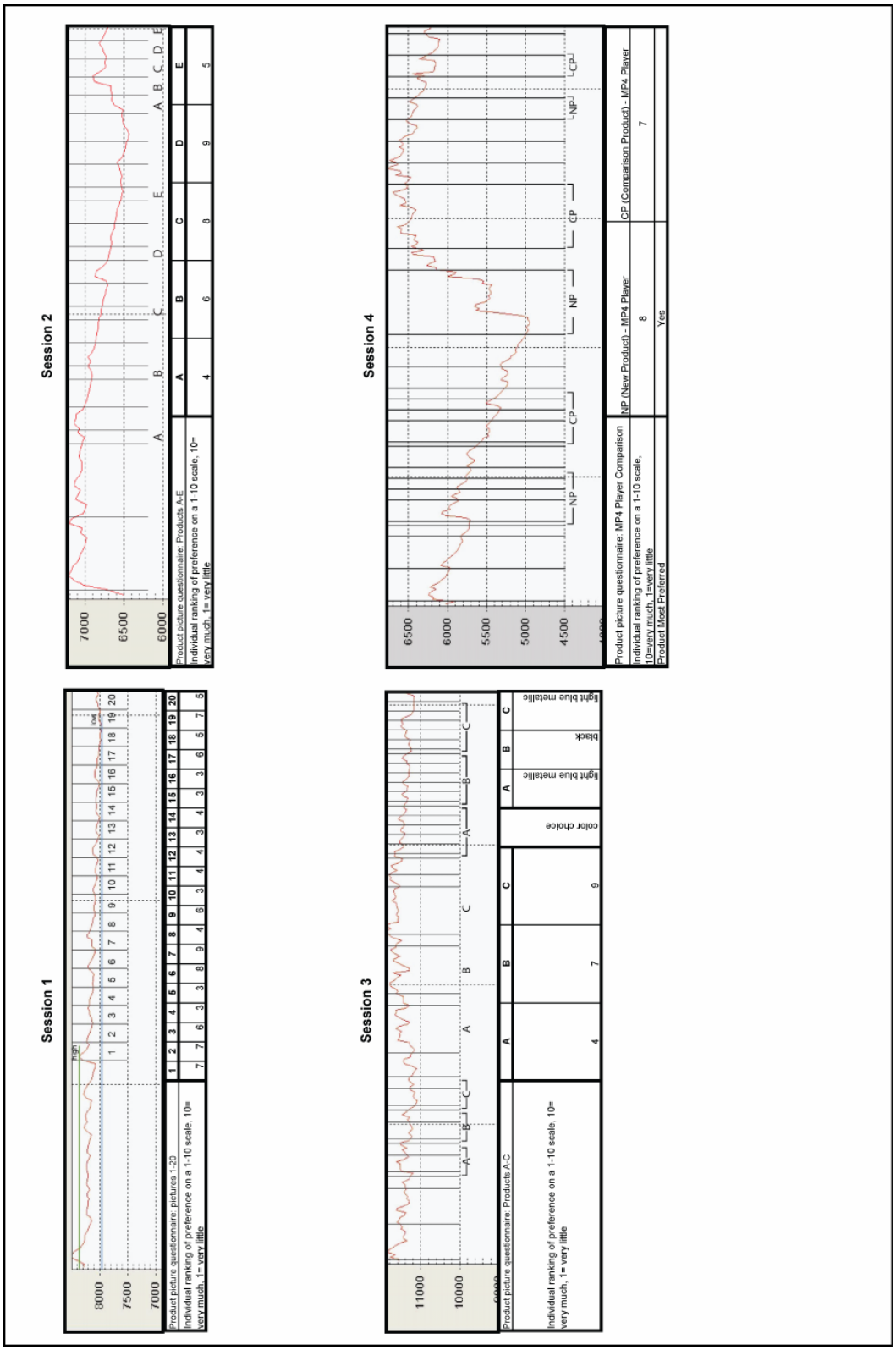


Figure A9 - Sessions 1-4 GSR Charts: Participant CS-M

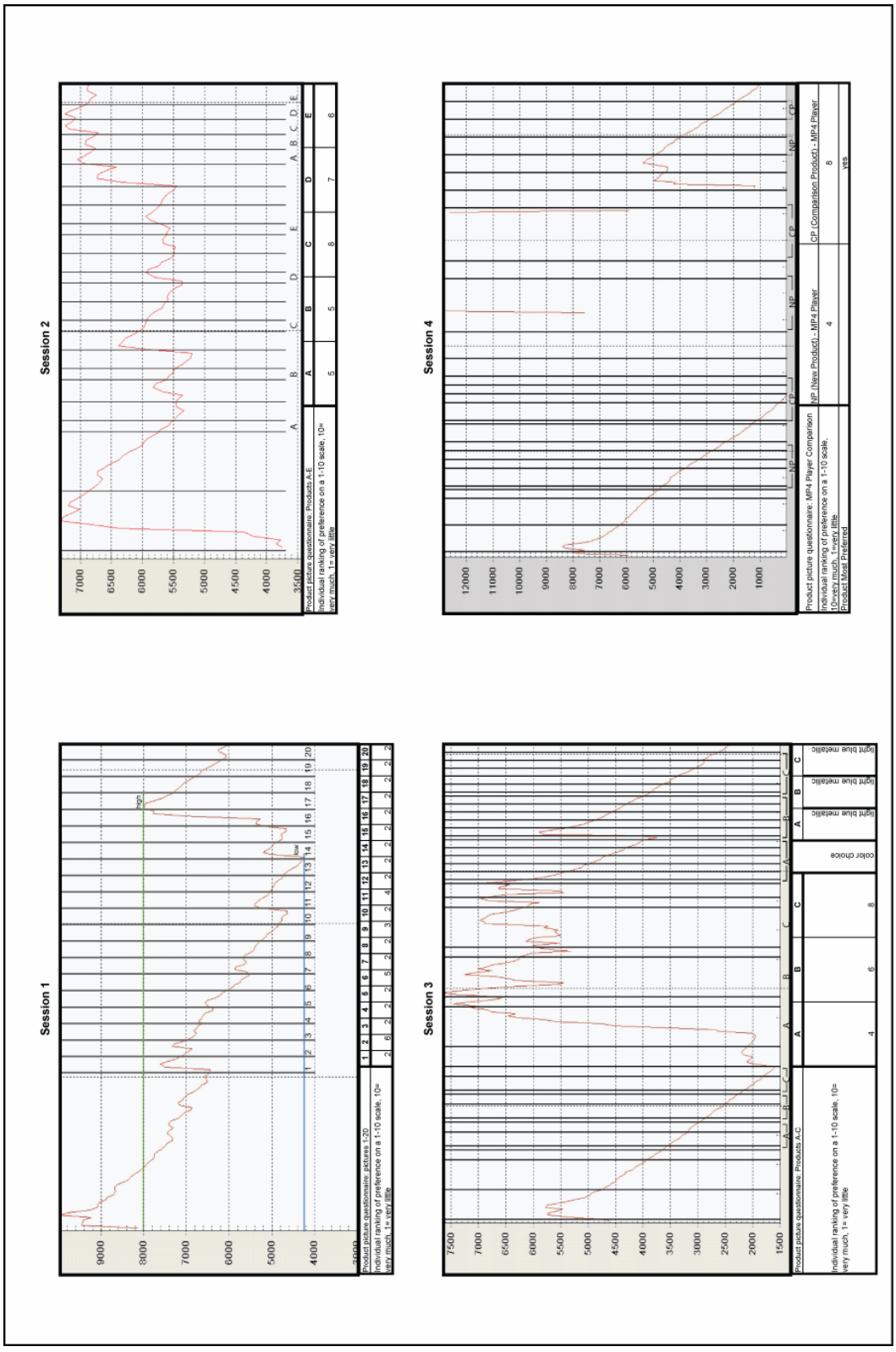


Figure A10 - Sessions 1-4 GSR Charts: Participant DO-F

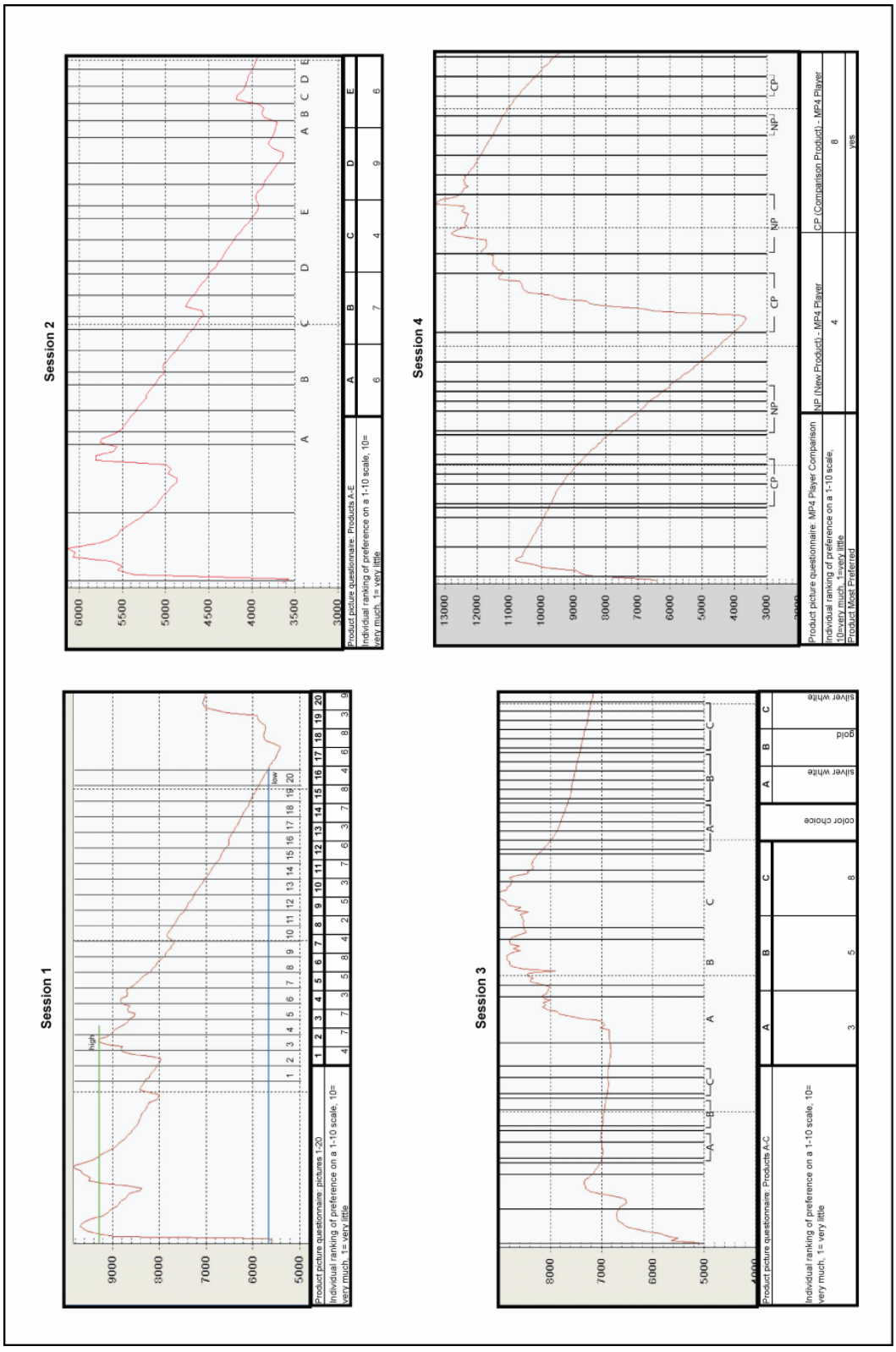


Figure A11 - Sessions 1-4 GSR Charts: Participant HB-F

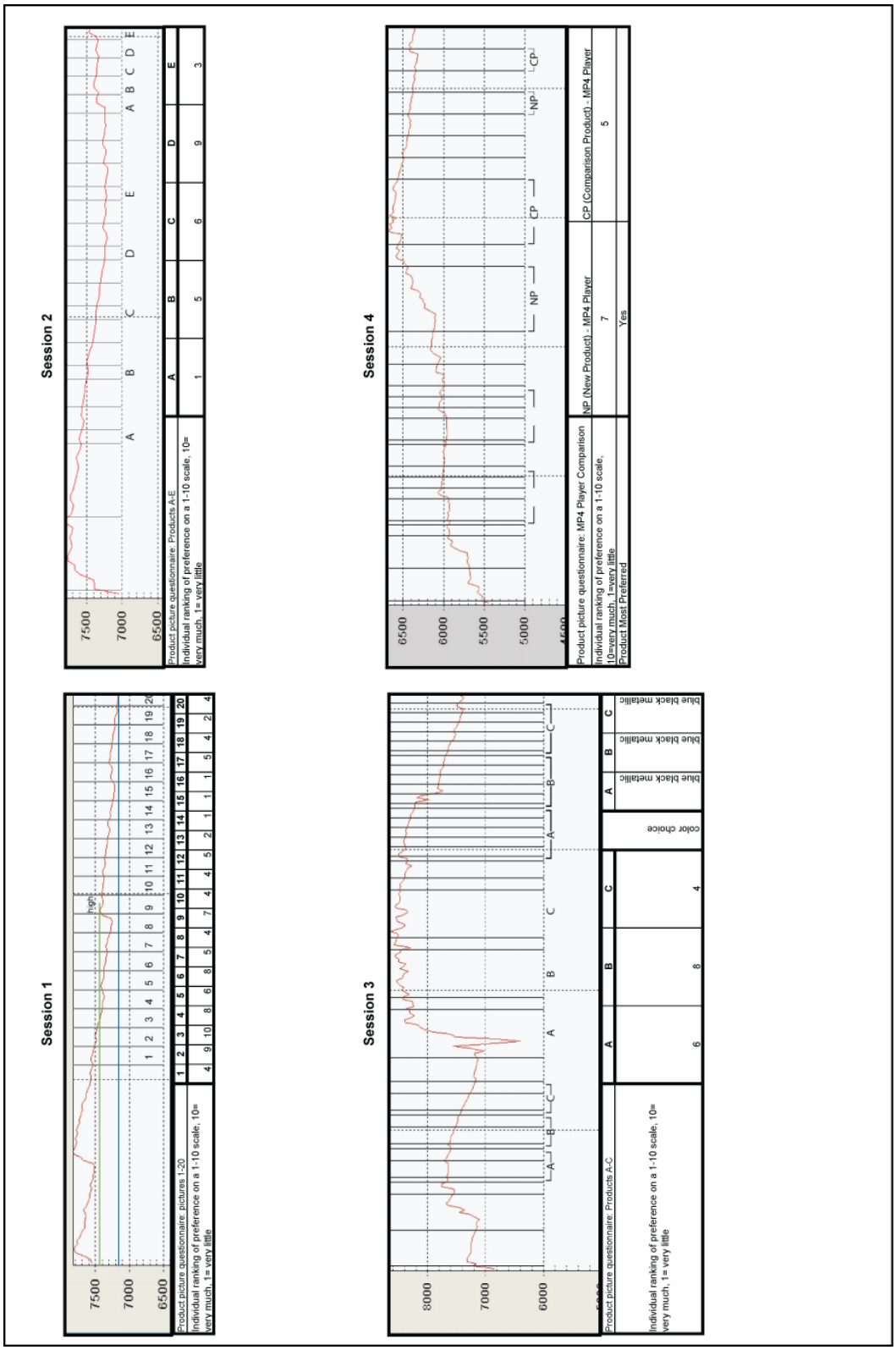
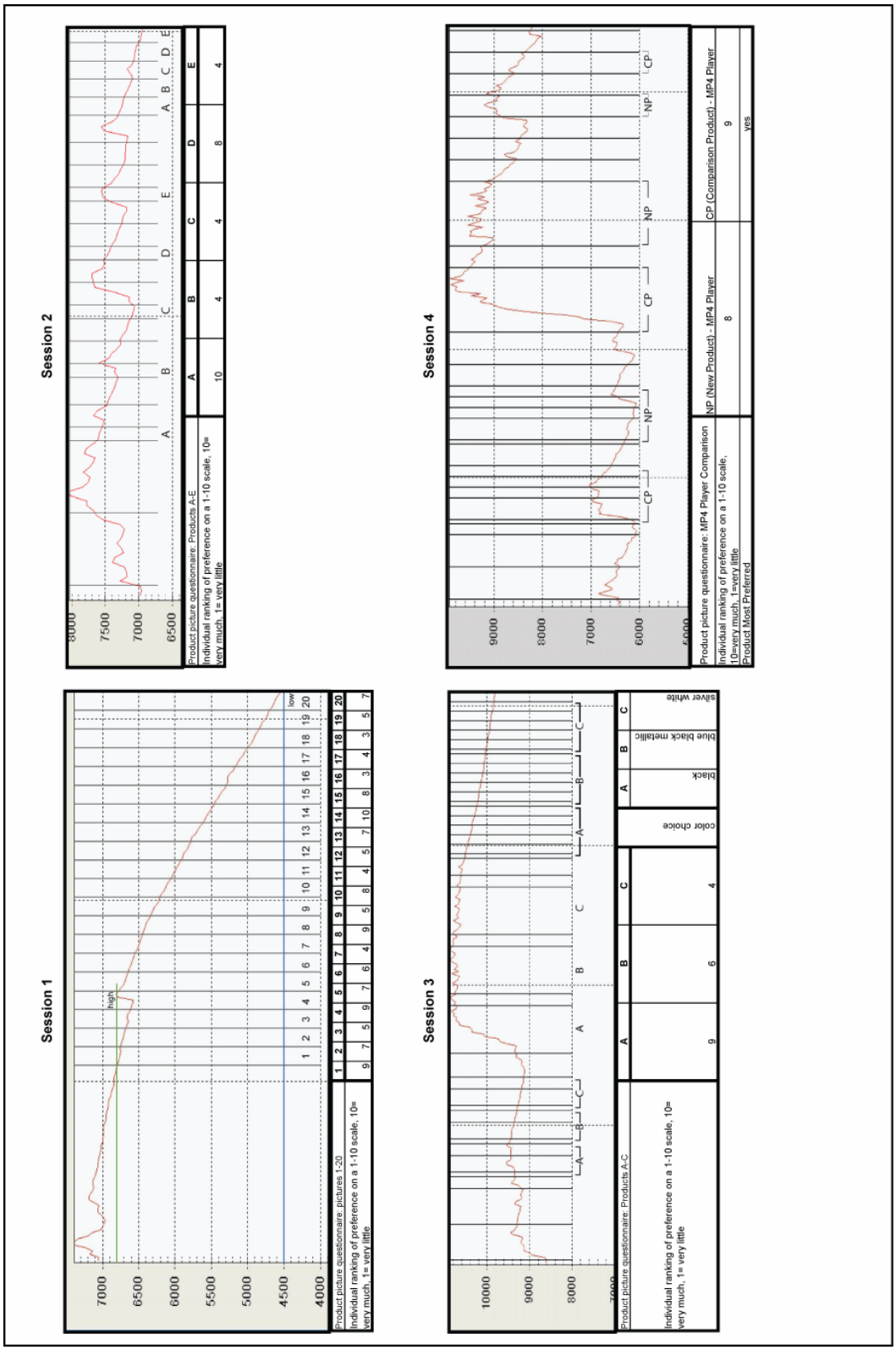


Figure A12 - Sessions 1-4 GSR Charts: Participant JC-M



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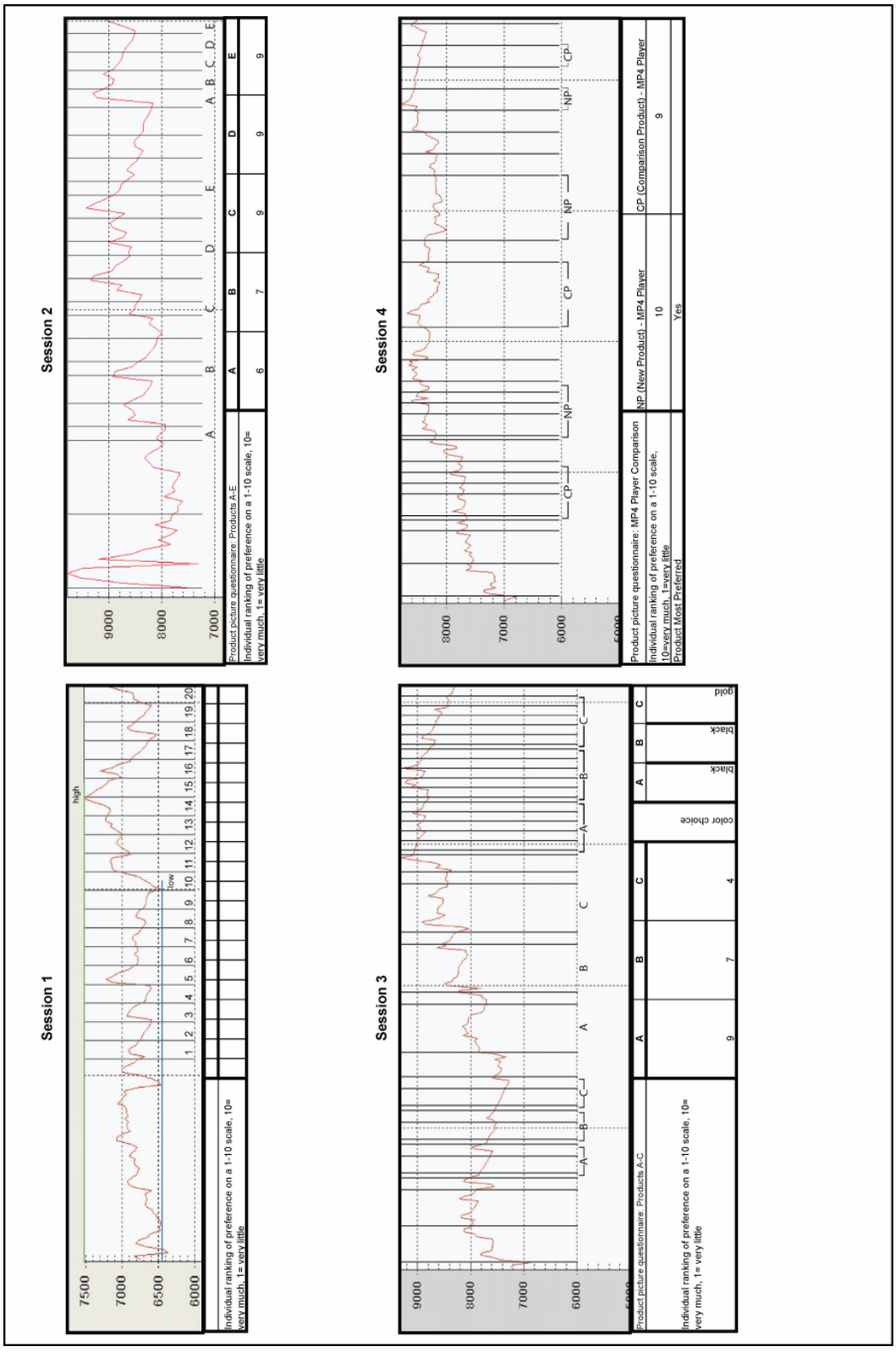


Figure A14 - Sessions 1-4 GSR Charts: Participant JP-F

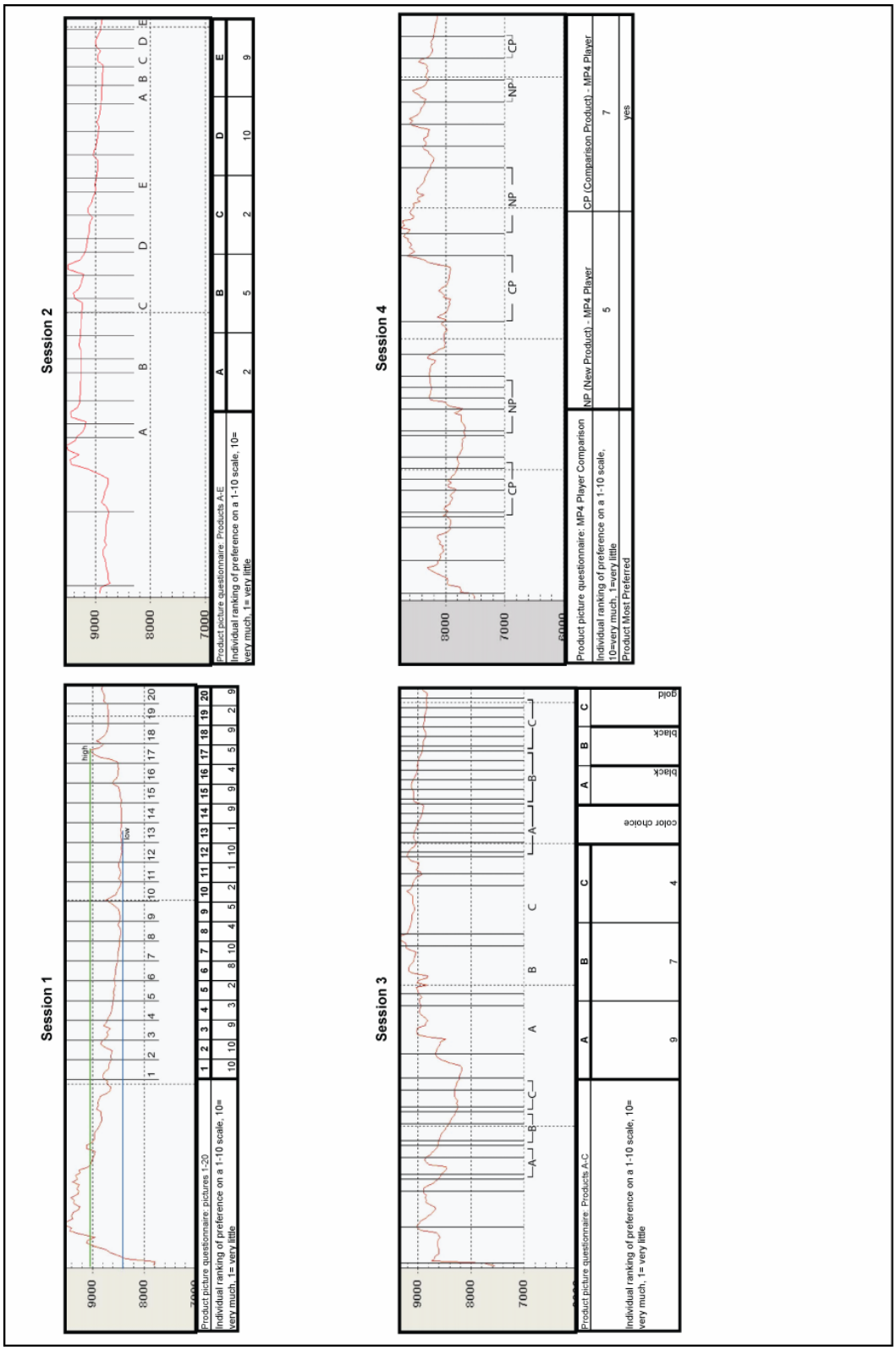


Figure A15 - Sessions 1-4 GSR Charts: Participant JR-M

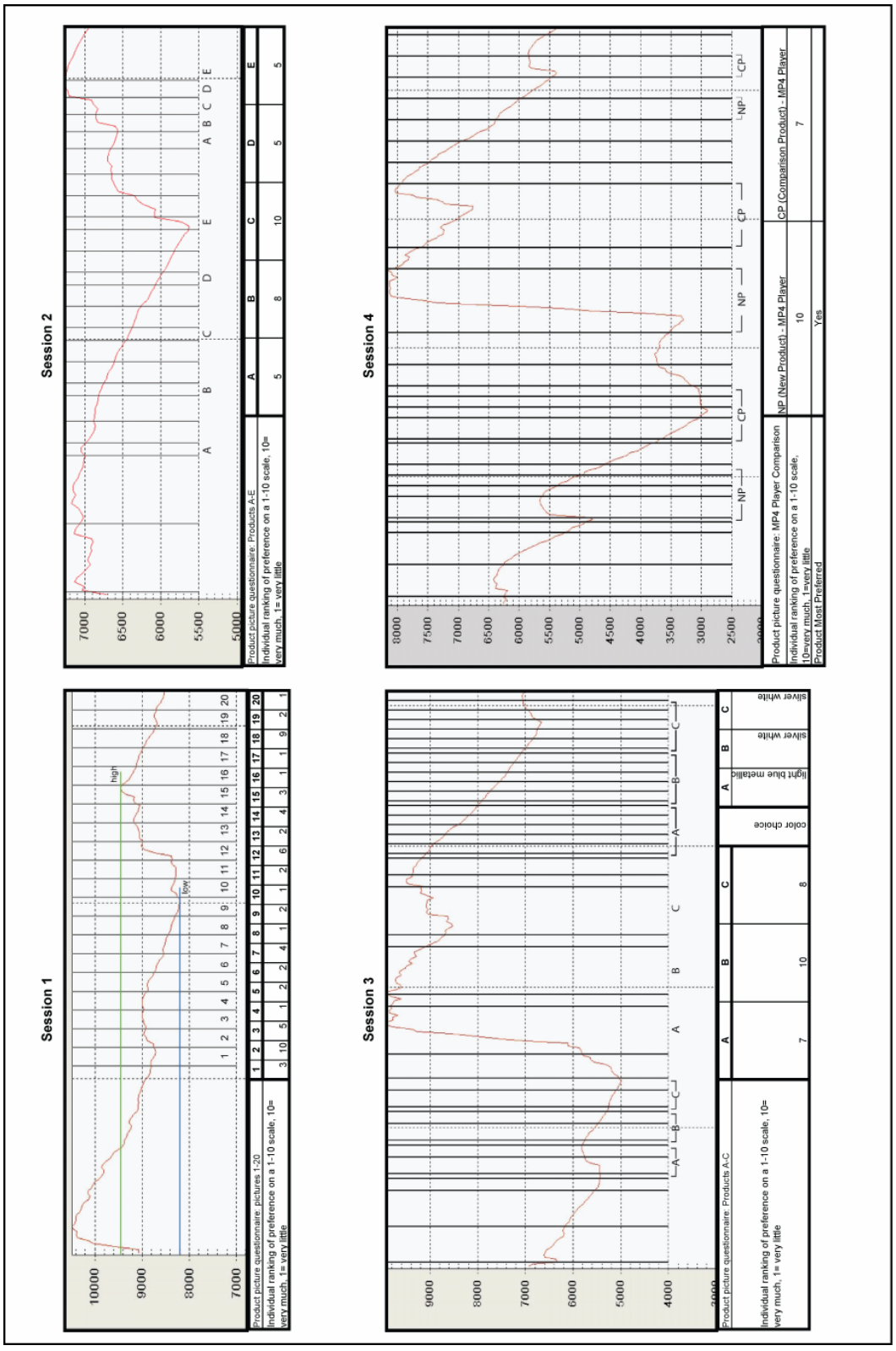


Figure A16 - Sessions 1-4 GSR Charts: Participant KP-F

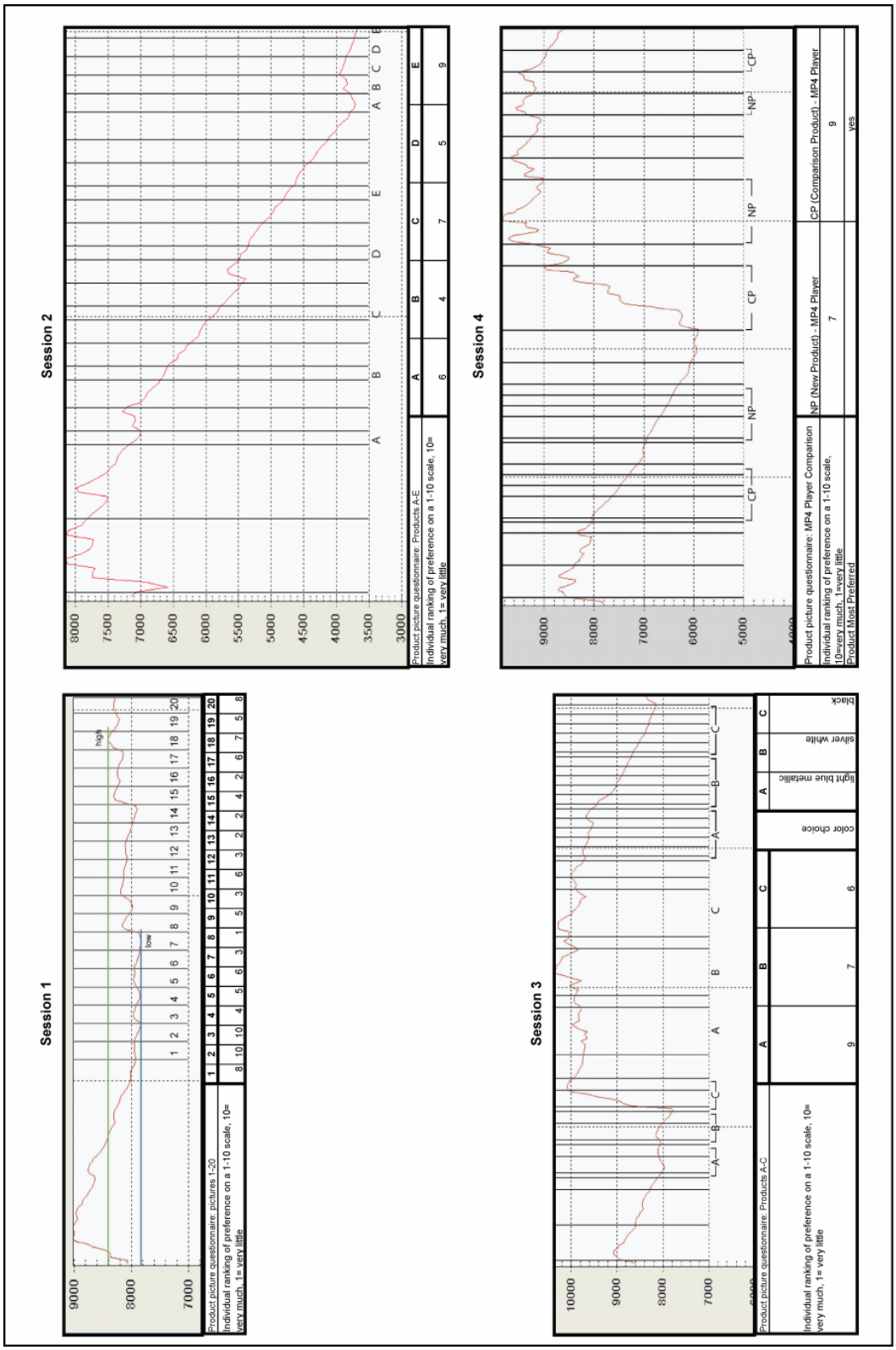
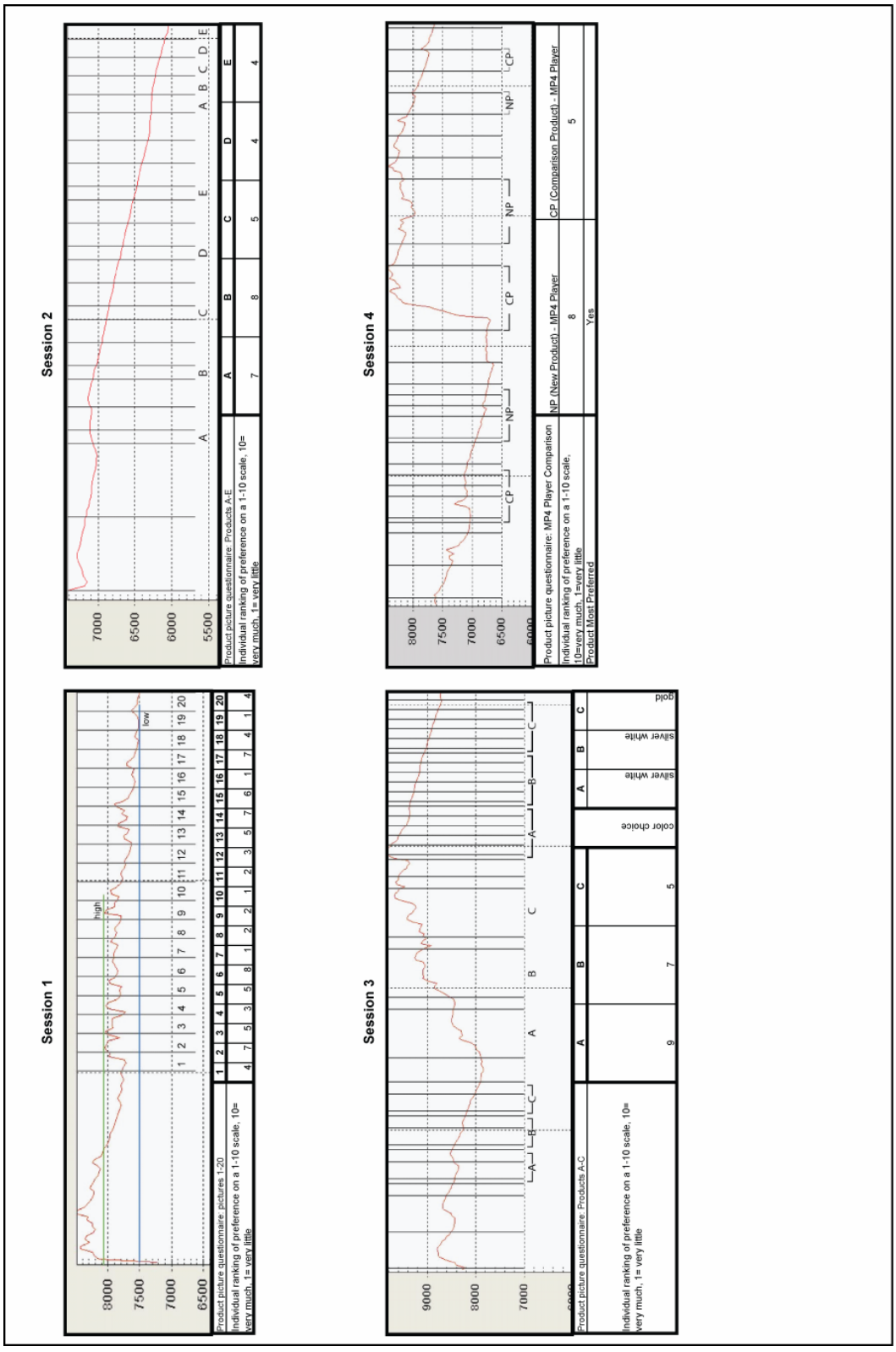


Figure A17 - Sessions 1-4 GSR Charts: Participant LL-F



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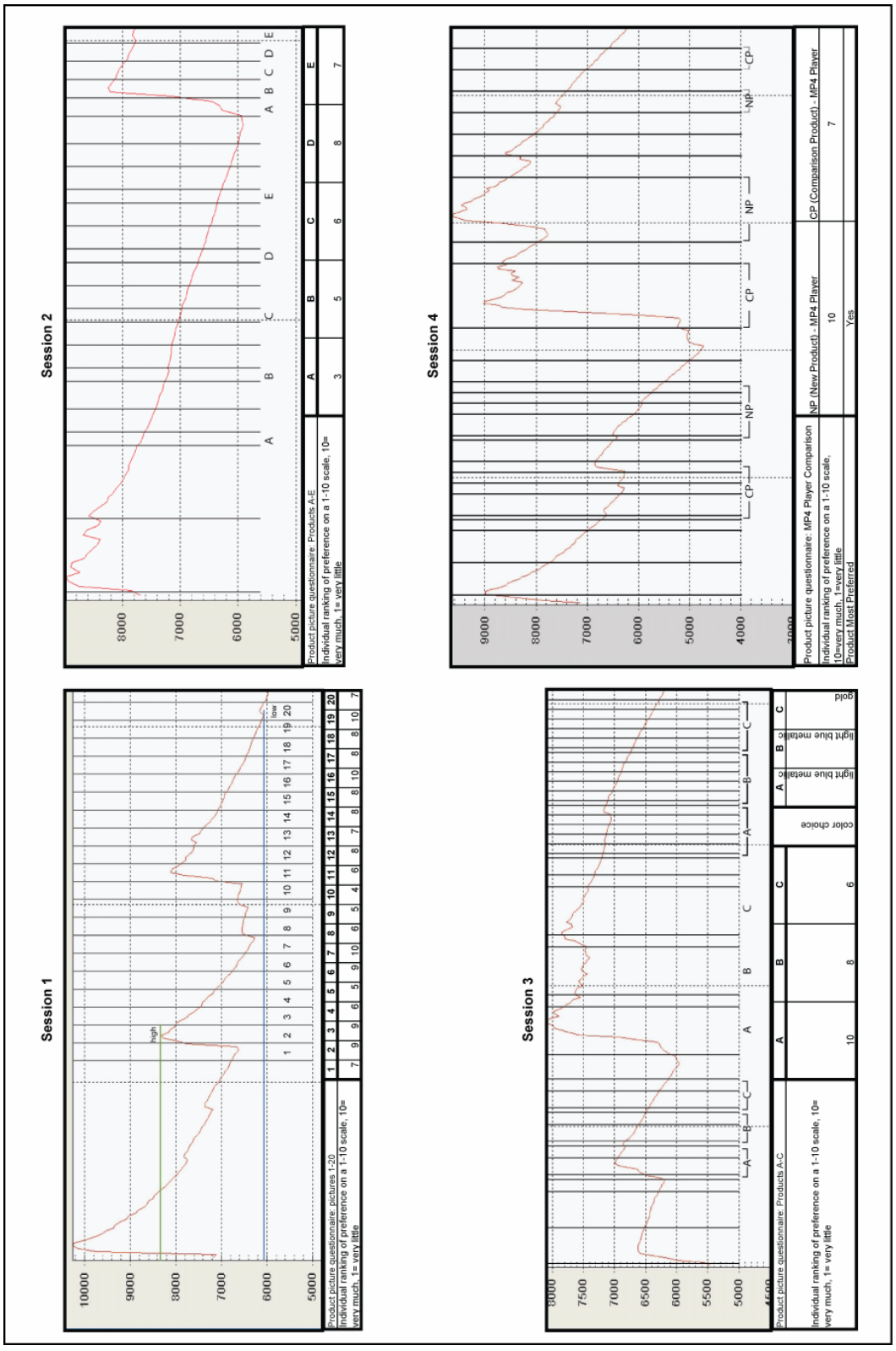
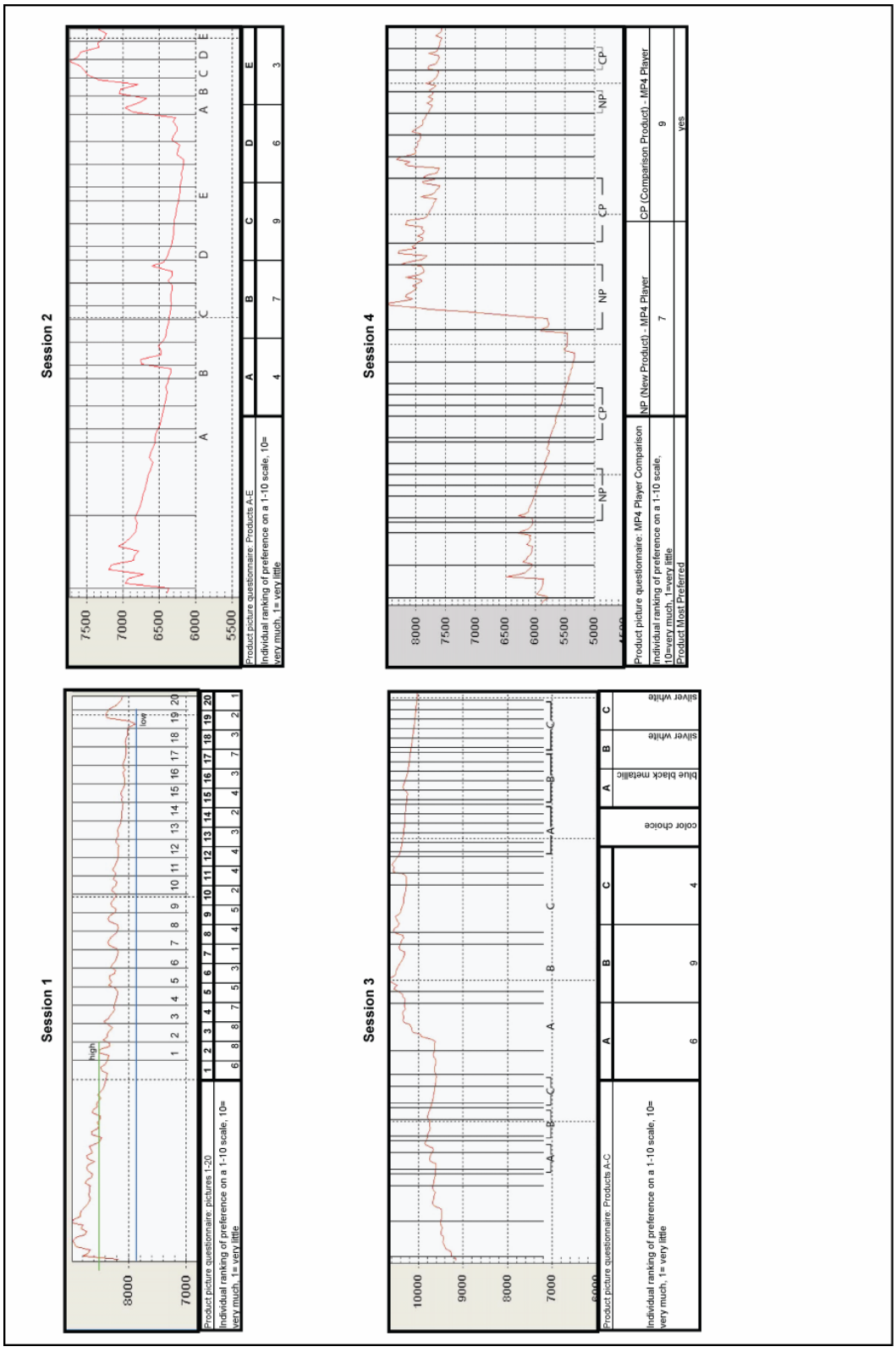


Figure A19 - Sessions 1-4 GSR Charts: Participant MJ-F



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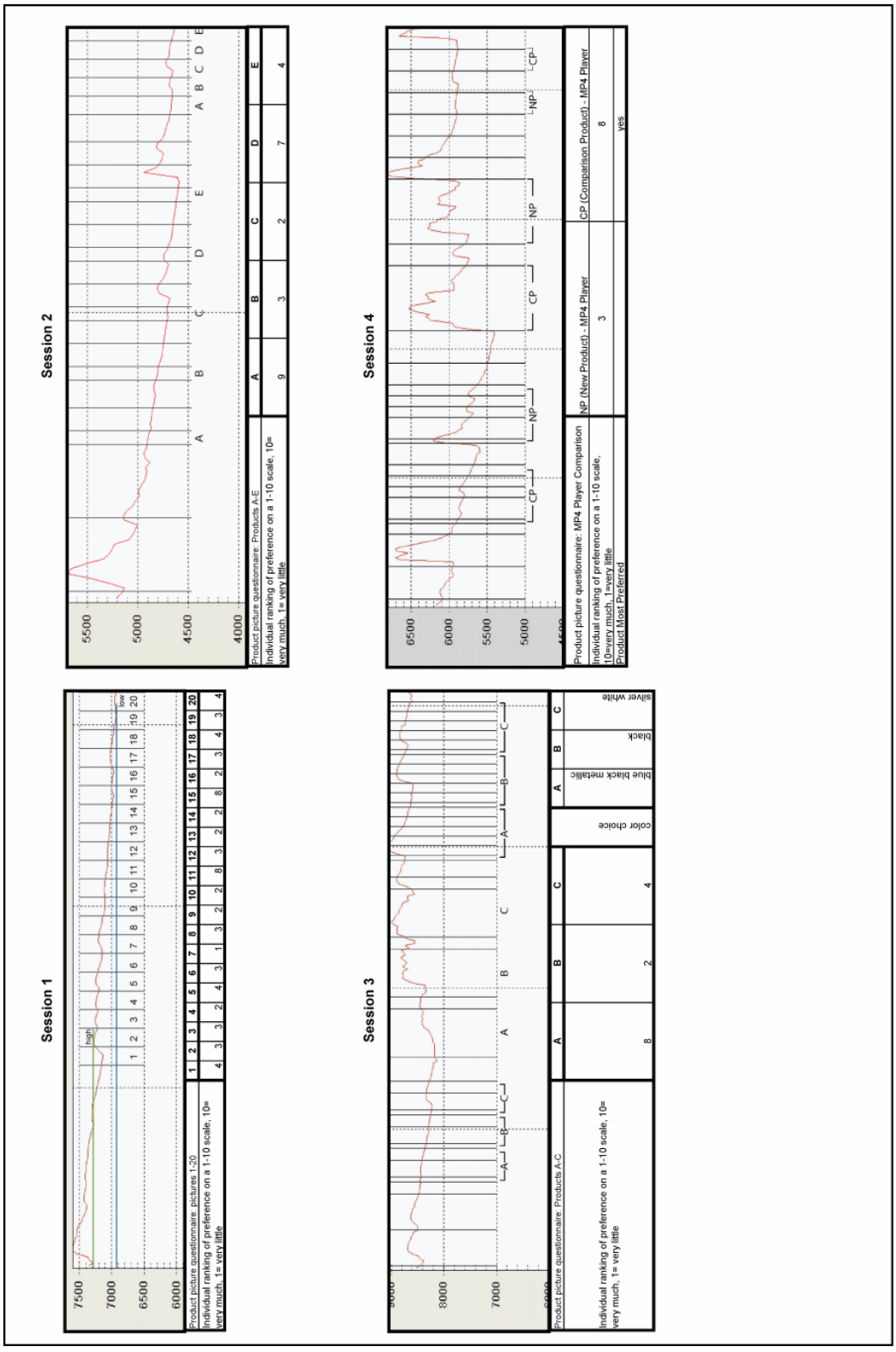

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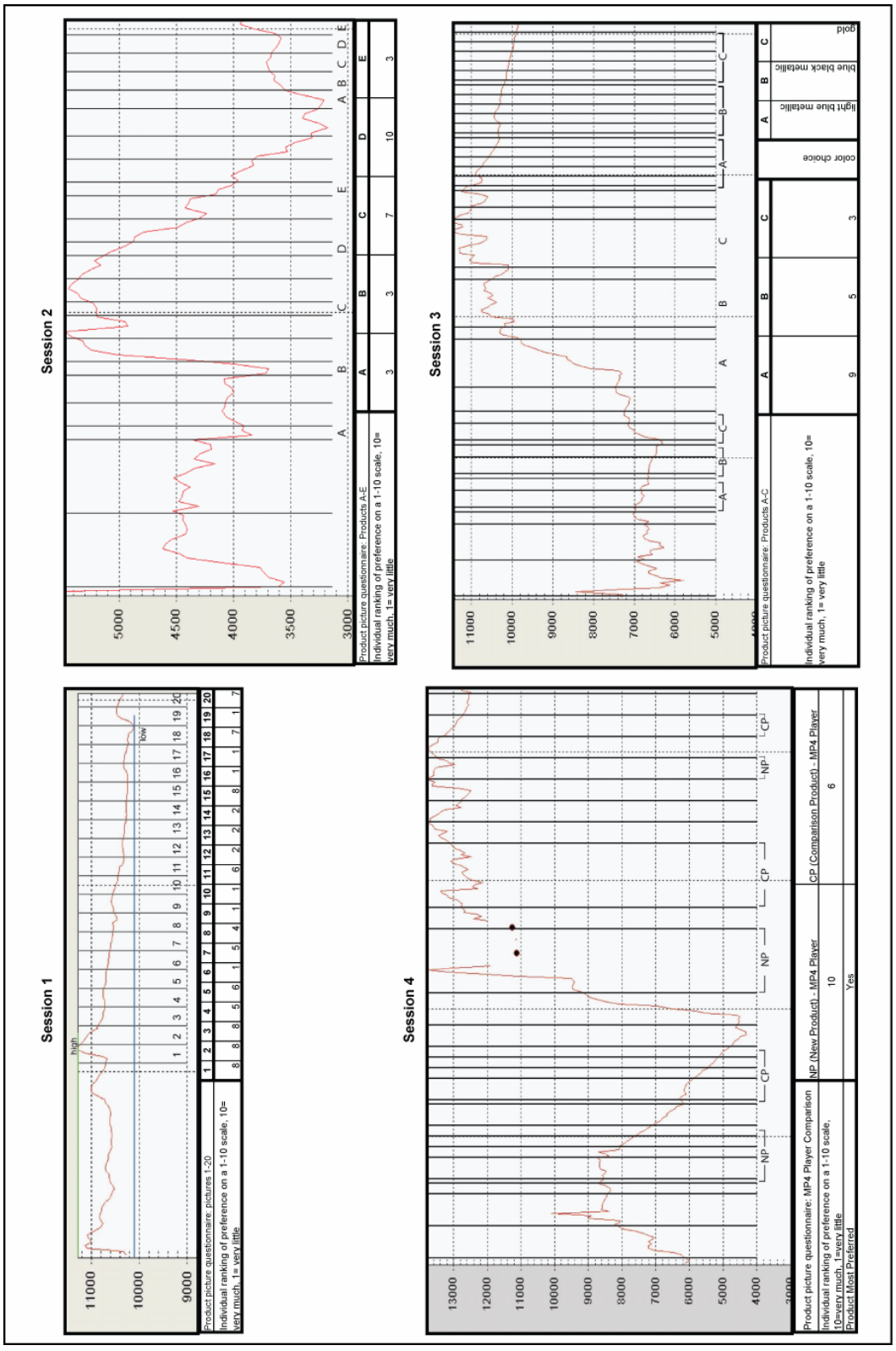

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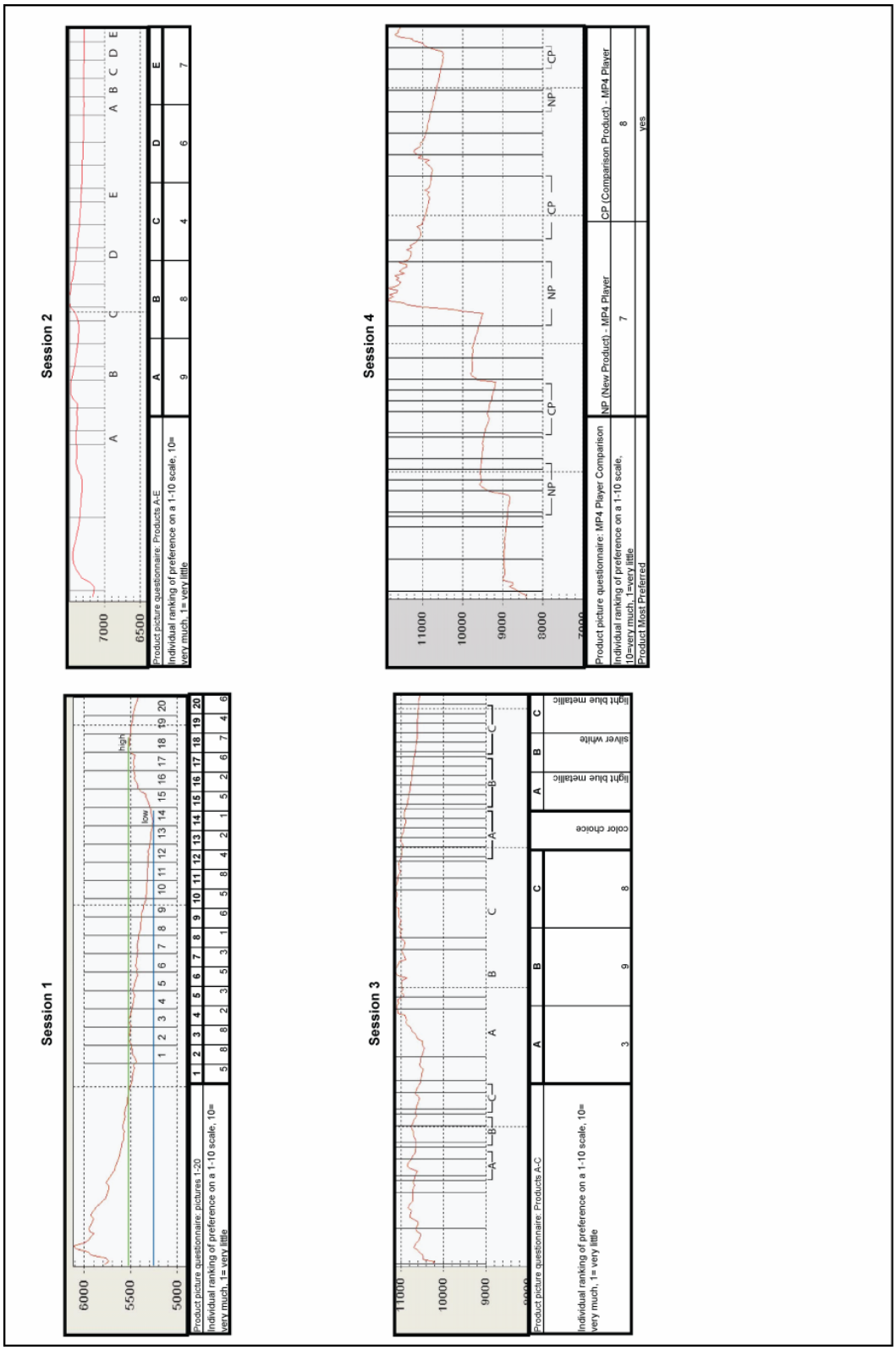

Figure A23 - Sessions 1-4 GSR Charts: Participant WS-M