

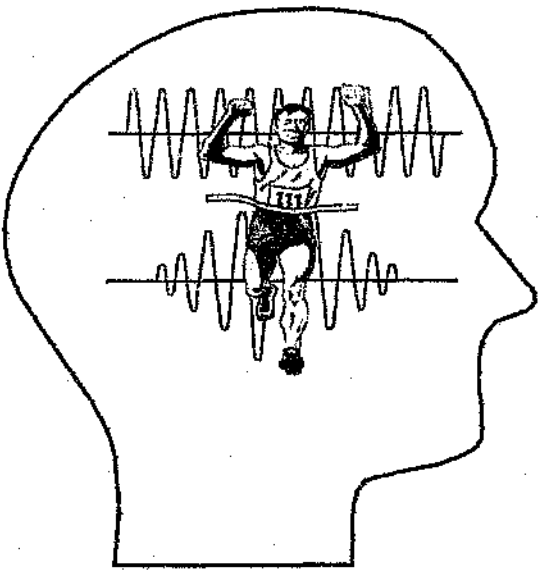
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Imagery Rehearsal Ability, Relaxation and BrainWave Activity: Implications for Imagery Intervention Programmes in Sport Psychology

A RESEARCH DISSERTATION BY

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Imagery Rehearsal Ability, Relaxation and Brainwave Activity: Implications for Imagery Intervention Programmes in Sport Psychology

MANDY BEHRMANN

A dissertation submitted to the Faculty of Arts, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree, Master of Arts (Psychology)(By coursework and Research Report).

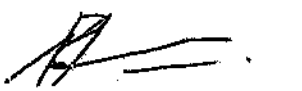
The financial assistance of the Centre for Science Development (HSRC, South Africa) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the Centre for Science Development.

JOHANNESBURG 1998



DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree, Master of Arts (Psychology)(By coursework and Research Report), to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any Degree or examination in any other university.



MANDY BEHRMANN
January, 1998

ACKNOWLEDGEMENTS

I wish to extend my grateful thanks to:

The Centre for Science Development (HSRC, South Africa) for the financial assistance towards this research.

My supervisor, Professor J.A. Fisher, for his invaluable guidance, support, and inspiration.

Ms Fiona Baker, of the Wits Sleep Laboratory, for her invaluable help in conducting this research and analysing the data.

The staff of the Wits Sleep Laboratory for allowing me access to the EEG equipment.

The students who volunteered to participate in this research study.

Last, but not least, to my parents for their encouragement and support throughout the year.

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Imagery Rehearsal Ability, Relaxation and Brainwave Activity : Implications for Imagery Intervention Programmes in Sport Psychology

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Despite the well documented advantageous functions of imagery rehearsal as it pertains to sporting performance, the relationship between relaxation, imagery rehearsal ability and brainwave activity has received relatively little attention from sport researchers. With this in mind, the primary purpose of the present study was to investigate the possibility of the existence of such a triadic relationship and consider the implications that this relationship may have on the development of imagery intervention programmes in Sport Psychology.

Two male and seven female undergraduate Physical Education students, aged between 18 and 28 years volunteered to participate in the study. The Vividness of Movement Imagery Questionnaire (VMIQ) was administered to all subjects in order to assess each subject's imagery ability. The subjects were then randomly assigned to either the control or to the experimental group. Two weeks after completing the VMIQ, the subjects completed the VMIQ for a second time. During the second administration of the VMIQ all subjects were attached to an EEG (electroencephalograph) machine. The strategically placed EEG electrodes were attached for the purpose of assessing whether or not significant changes in alpha brainwave patterns were evident during imagery rehearsal. The experimental group differed from the control group in that the experimental group took part in a relaxation exercise prior to completing the VMIQ for a second time, whilst the control group did not receive the relaxation intervention. The results of the study indicated that there was enhanced alpha brainwave activity in the right occipital lobe during the imagery conditions. Whilst it could be speculated from the research findings that imagery ability and brainwave activity differed from individual to individual and from one imagery condition to another, these differences were not statistically significant. Although not statistically significant, the differences observed between the pre and post-test scores for the experimental group were however purported to be meaningful since three of the four subjects from the experimental group showed an improvement on imagery ability following the relaxation intervention. This finding justifies the need for future research into the relationship between relaxation and imagery rehearsal. It was also concluded that whilst some subjects emitted the greatest alpha activity during the same imagery dimensions for which they reported the highest imagery abilitiy scores, other subjects emitted the greatest alpha activity during the same imagery dimensions for which they reported the lowest scores in imagery abilitiy. As such, it could not be concluded from the present research findings that a correlation between imagery ability and alpha brainwave activity actually exists.

INTRODUCTION

Athletes and coaches all over the world spend hours and hours in physical practice sessions in an attempt to develop physical skills to perfection. According to research, it is often not the physical differences between athletes that determines who succeeds at top level sports since elite athletes usually possess similar physical abilities, but rather it is the psychological differences that makes the winner (Janssen & Sheikh, 1994). This point is supported by Mark Spitz who, on winning seven gold medals in the Montreal Olympic Games stated that "at this level of physical skill, the difference between winning and losing is 99% psychological" (cited in Janssen & Sheikh, 1994, p.1). Coaches and researchers have begun to understand the potential of psychological skills training for improving sports performance (Weinberg & Gould, 1995). Mental imagery rehearsal is one such psychological skill and is the psychological skill that shall be the focus of this paper. The use of imagery rehearsal to aid physical performance is not a new phenomenon. In fact, athletes have been using imagery on occasion since sports were first conceived (Martens, 1987; Nideffer, 1985). Imagery techniques had been used extensively in training world-class athletes in the former Eastern Block countries. It is only recently that such techniques have been employed in westernised countries as a means to enhance athletic performance (Sheikh & Korn, 1994). Although there were athletes of the western world who, in the past, utilised imagery rehearsal, the difference between the use of imagery then and the systematic use of such a technique in today's competitive sporting environment is that previously if athletes engaged in imagery rehearsal it was relatively unstructured and they "just did it". Recently however, with the advent of sport psychology as a recognised academic discipline in westernised countries, along with the great amount of research that was (and still is) being undertaken in this field on an international scale, imagery training techniques are being incorporated more and more into sports training programmes (Perry & Morris, 1995).

Excellent reviews of the research literature relating to the use of imagery in sport have been published, with three findings appearing to be robust: (1) imagery rehearsal (or mental practice, as it has often been referred to) is better than no practice at all; (2) imagery rehearsal combined with physical practice is more effective than either alone; and (3) the effects of imagery rehearsal are greater for cognitive than for motor tasks (Corbin, 1972; Feltz & Landers, 1983; Richardson, 1967a; 1967b).

In light of both the above mentioned research findings and the fact that humans are psychosomatic beings, it would seem logical that both the body and the mind need to be trained to function effectively, optimally and most importantly synergistically, in order for an individual to achieve peak athletic performance; an idea attested to by all sport psychologists. Although there are qualified coaches, sport scientists, sport nutritionists, biokineticians and the like to develop and nurture the athletes' physical attributes why then, in South Africa, is the psychological side of sports training, of which mental imagery rehearsal would be a part, still being neglected to such an extent? A possible reason is that South African athletes and coaches alike are unfamiliar with the practice of sport psychology and the corresponding benefits that can be reaped from engaging in such a discipline (F. Scully, National Coaching Co-ordinator, National Sports Council of South Africa, personal communication, 10 July, 1997). The lack of understanding about what the field of sport psychology has to offer athletes and coaches alike has been supported by a number of authorities involved in South African sport. For example, Jean Meyer, tennis coaching course co-ordinator, Central Gauteng Tennis Coaches Association, agreed that since psychological interventions as applied to tennis is not a well known area of endeavour in this country and is only briefly covered in the tennis coaching courses, it is reasonable to assume that South African tennis coaches know relatively little about the application and effectiveness of mental skills training programmes that are used to enhance the level of tennis performance (personal communication, May 9, 1995). In support of this claim, Bob Hewitt, an ex-professional tennis player and prominent South African tennis coach, admitted that he knew very little about the application of imagery rehearsal as a coaching technique for improving physical performance. Furthermore, Hewitt stated that most coaches in South Africa have not really been exposed to such coaching techniques. If coaches do implement imagery intervention techniques or any other mental skills training programmes, Hewitt believes it is either through their own initiative or under the guidance of the few psychologists that work with athletes (personal communication, November 24, 1995). According to K. E. Jennings, Counselling Psychologist and author of Mind in Sport: Directing Energy Flow into Success, the general unfamiliarity with the academic realm of sport psychology is possibly very much due to the fact the number of sport psychologists practising in the sporting arena in South Africa are limited. Thus most coaches and athletes in this country are not being exposed to this form of performance enhancement

training and as such do not engage in systematic psychological skills training programmes (personal communication, October 2, 1995).

A further possible reason for why athletes might not engage in psychological skills training is because athletes and coaches are often under the impression that psychological skills are innate and untrainable. The truth of the matter is however that psychological skills are trainable (e.g. Martens, 1987; Murphy & Jowdy, 1992; Perry & Morris, 1995; Vealey & Walter, 1993; Weinberg & Gould, 1995). However, despite the well documented advantageous functions of imagery rehearsal as it pertains to sporting performance, the majority of South African coaches still need to be educated as to both the benefits that their athletes can gain from engaging in imagery intervention programmes as well as the most effective way to implement such a programme[1]. Before educating coaches as well as athletes as to how an imagery rehearsal training programme should be implemented, it would be desirable for sport psychologists to have a programme that yields the best possible results. Whilst various imagery intervention programmes currently exist, they can all undoubtedly be improved on (Fenker & Lambiotte, 1987; Rodgers, Hall & Buckolz, 1991). Although researchers do not dispute the fact that imagery rehearsal has many beneficial uses, (as shall become evident from the literature review to follow) they are at loggerheads as to what the most effective imagery rehearsal procedure to follow would be since there is still much that is not understood about this ubiquitous process (Hardy, Jones & Gould, 1996).

According to Hardy et al. (1996), when studying the concept of imagery, there is still a need to examine the role that relaxation plays since relaxation may influence the effectiveness of imagery rehearsal. From the available literature, it is evident that whilst there are those that support the use of relaxation prior to or in combination with imagery rehearsal, in order to facilitate imagery control, (e.g., Harris & Williams, 1993; Perry & Morris, 1995; Porter & Foster, 1993; Shone, 1984; Suedfeld & Bruno, 1990; Suinn, 1976), there are those that contend that the benefits of using imagery are not significant (e.g., Gray, Haring & Banks, 1984; Hamburger & Lohr, 1980; Weinberg, Seaborne, & Jackson, 1981). According to Murphy and Jowdy (1992), no conclusive evidence appears to exist at present that states that relaxation prior to imagery rehearsal is necessary since many studies of imagery have produced

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[1] It is recommended that the implementation of any psychological skills training programme be under the supervised guidance of a qualified Sport Psychologist since although the techniques used in psychological skills training can be valuable in improving athletic perfromance, the same techniques can have deleterious effects when used inappropriately (Sheihk & Korn, 1994).

significant results without the inclusion of relaxation procedures (e.g., Clark, 1960; Corbin, 1967a; Woolfolk, Parish & Murphy, 1985). According to Perry and Morris (1995) however, it is possible that in some studies, subjects who were not instructed to relax did so naturally as a precursor to imaging, which in turn could have influenced the research results. For this reason, Perry and Morris caution practitioners against discarding relaxation as a critical variable in enhancing imagery rehearsal and recommend that relaxation should be included in applied settings when dealing with imagery rehearsal, at least until the role of relaxation is resolved.

With the above in mind the present study took relaxation into account in an attempt to assess whether or not relaxation does in fact influence the imagery experience, as recorded by the self-report Vividness of Movement Imagery Questionnaire (VMIQ) (Isaac, Marks, & Russell, 1986). Furthermore, according to Heibloem (1990) relaxation influences brainwave activity, which in turn can influence mental functioning. When the body is in a relaxed state, alpha brainwave patterns, which occur at a frequency of approximately 8 to 13 cycles per second (8-13 Hz) [2], are said to predominate (Ley, 1983). When alpha brainwaves predominate, it has been claimed that this is when people are most creative and inspired. People are said to experience a high level of energy, enhanced memory concentration and learning; intuitive knowing and better decision making (Heibloem, 1990). Should this be true then it can be hypothesised that imagery rehearsal, which is used in learning new skills and/ or correcting and mentally practising the perfect execution of already learned skills, could be most effective if the waking brain was in an alpha state. According to Kimiya (1968), and Nowlis and Kimiya (1970), the vast majority of people can learn to alter their brainwave activity such that the duration of alpha activity dominance can be increased to some extent. Thus, what the present study shall further assess is whether or not those subjects who appear to have a high imagery ability as expressed by the results of the Vividness of Movement Imagery Questionnaire (VMIQ) (Isaac, Marks, & Russell, 1986), also exhibit predominant alpha waves on an Electroencephalograph (EEG) machine when undergoing an imagery rehearsal activity. The findings of the research shall be critically analysed in order to assess whether or not there is a significant relationship between relaxation, alpha brainwave activity and imagery ability.

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[2] Hertz (Hz) is the unit used to express frequency. 1 Hz = 1 cycle per second (Tortora, 1987)

If it can be shown that relaxation influences brainwave activity, inducing a predominantly alpha state, which in turn positively influences imagery ability, then there will be greater support for the use of relaxation in imagery intervention programmes.

The imagery rehearsal ability of the athlete also needs to be considered since the greater the imagery rehearsal ability of the athlete, the more effective the imagery rehearsal is said to be. If individuals are instructed to use imagery rehearsal, and those individuals have a low imagery ability then it is likely that the imagery rehearsal will have little or no effect. On the other hand, individuals with high imagery ability, by contrast, should be able to use imagery rehearsal effectively (Hall, Buckolz & Fishburne, 1992).

Before the potential triadic relationship between relaxation, brainwave activity and imagery rehearsal can be considered and discussed with reference to the development of imagery intervention programmes in sport psychology, various issues need to be addressed: The concept of imagery needs to be understood, as do the definitions of the terms *imagery* and *imagery rehearsal* as they pertain to sport, as well as the distinction between these and other supposedly synonymous terms. Thereafter the mediating variables pertaining to imagery rehearsal shall be discussed, including a discussion on the role of relaxation in imagery rehearsal programmes. Theories pertaining to imagery rehearsal and how imagery possibly functions to enhance performance shall be reviewed. The uses of imagery rehearsal in the context of sport shall be considered and measurement issues pertaining to imagery rehearsal shall be addressed, acknowledging the concerns for research and practice. Thereafter the links between relaxation, brainwave activity and imagery rehearsal ability shall be examined. Following this will be an explanation of how the present research study was conducted, after which, the research findings shall be presented. To conclude, the triadic relationship between relaxation, brainwave activity and imagery rehearsal shall be discussed, followed by recommendations for future research.

LITERATURE REVIEW

THE CONCEPT OF IMAGERY

Imagery, a basic form of cognition, has long been a subject of research interest in philosophy and psychology (Kosslyn, 1994), and more recently in the field of motor learning and sport psychology (Perry and Morris, 1995). The notion that information can be represented as images was a common one held throughout the history of philosophy, perhaps finding its heyday during the 18th century with the British Associationists (Kosslyn, 1994). With their philosophy being strongly empirical in orientation, the British Associationists sought to explain mind as a product of ideas and in so doing always incorporated the image as an element of mind (Yuille and Marschark, 1983). Imagery continued to play a major role in theories of mental events right up until philosophy and psychology parted ways; indeed it held sway during the infancy of scientific psychology when much energy was devoted toward studying it by the likes of Wilhelm Wundt (1832 - 1920), a structuralist, who believed that the image constituted a basic theoretical element in the psychological system, and William James (1842 - 1910) the chief architect of functionalism, who, in opposition to the dominant structuralists believed that mental processes ought to be studied as processes and not as static bits of consciousness (Chaplin, 1985; Weiten, 1989).

Imagery however, began to lose credibility as an issue of central concern during the early 1900's when J. B. Watson founded *behaviourism*; a theoretical orientation based on the premise that scientific psychology should study only observable behaviour. What Watson (1913) was proposing was that psychologists should totally abandon the study of consciousness (of which, images were a fundamental component), and focus exclusively on behaviours that could be directly observed (Kosslyn, 1994; Richardson, 1969; Weiten, 1989). In starting this "new science" within the field of psychology, the early experimental psychologists were intent that it be a genuine science. This apparently led these psychologists to be obsessed with methodological purity (Kosslyn, 1994). As philosophers of science have noted, the scientific method rests on being able to distinguish among alternative hypotheses to the satisfaction of others, which requires that the subject matter be publicly observable (see Popper, 1959). Mental imagery could thus not be regarded as a proper topic for scientific study because, for one, mental images - like all mental events - are notoriously difficult to put

on public display (Anderson, 1978; Kosslyn, 1994). Furthermore, when referring to the concept of mental images, scientists could not even point to the 'tracks' or the 'spoor' left behind. For this reason, the question asked time and time again is, " If there is such a concept as a mental image how does one measure it?" This methodological problem was exacerbated by deeper conceptual problems; psychologists did not even know how they could characterise the nature of mental imagery. Of concern to psychologists was the fact that mental images were not actual pictures in the head, but if not actual pictures, what?

It was these types of problems that made the concept of imagery a ripe target for behaviourists, such as Watson, who in denying the very existence of mental imagery postulated that psychology, as the behaviourist views it, "is a purely objective, experimental branch of natural science which needs introspection as little as do the sciences of chemistry and physics" (Watson, 1913, p.176.).

Although the idea of mental imagery was swept out with the receding tide of the early mentalistic psychology of Wundt, James and their followers, so it was swept back in, in the early 1950's, with the rise of cognitive psychology (Kosslyn, 1994). Advocates of cognitive psychology pointed out that internal mental events need to be understood if one is to fully understand behaviour since the manipulation of internal mental events directly influences how one behaves (Neisser, 1967; Weiten, 1989). In the 1960's Paivio, a cognitive psychologist began to conduct a large amount of research in the area of mental events. Beginning his research in the realm of verbal learning Paivio discovered that one's ability to learn a set of words was predicted by how easily one could visualise their referents (Paivio, 1971). Paivio's work opened the way for more daring investigations and by the 1970's imagery, an activity involved in the process of cognitive development, had become a major topic of research interest (Feltz & Landers, 1983; Singer & Pope, 1978). Even though the quest to understanding imagery continued to render some difficulty simply because mental images could not be directly observed, research began to demonstrate that complex properties of imagery could in fact be studied scientifically. For example, Shepard and Feng (1972) provided evidence for the fact that people could "mentally fold" objects and transform these objects in images. Similar experiments by Cooper and Shepard (1973) verified that people could mentally rotate objects in images and that this rotation operation is incremental i.e. people require progressively more time for every additional amount they must mentally rotate an object. The systematic results that were obtained from such experiments in mental imagery

convinced researchers that there was indeed something to claim about humans having "mental images". In an attempt to clarify the concept of mental images, researchers have referred to the term *image* as the internal representation that is used in information processing. *Imagery* on the other hand was the term used to refer to the experience itself, signalling that underlying brain events were taking place (Kosslyn, 1994). Following on from this line of thought, and particularly with the advent of artificial intelligence, debates have revolved around the nature of mental imagery representations. Once having observed that there are many ways to specify information in a computer, such as lists, trees or images, researchers began to consider how information is represented in the mind when one experiences visual mental imagery. A theory of such "mental activity" became a theory of what the brain does - not at the level of individual neurons, but rather at the level of what ensembles of neurons accomplish. Thus, it could be concluded that a given type of mental representation would correspond to a particular method used by the brain to store information (Kosslyn, 1994). Kosslyn used the computer as an analogy to explain his point:

> "One can talk about a "list" even though there is no physical list in the machine; rather the machine specifies the information in a way that functions as a list. The properties of representations are necessarily defined in the context of a processing system, which includes both representations and processes that can interpret and manipulate them; functional properties of a representation are only conferred if the appropriate processes are available in a system. For example, if there are no processes that could iterate through items in succession, a list could not be ordered in that system." (Kosslyn, 1994, p.4).

Kosslyn's claim is supported by Marr (1982), who effectively argued that different representations make different information easily accessed and used in a processing system. For example, in considering the difference between the pattern **A** and a description, "two symmetrical diagonal lines that meet at the top and are joined roughly halfway down by a horizontal line", both the pattern and the description are representations of the same thing. However, the former is easier to use in order to determine whether or not the pattern has an enclosed region, and if so, what shape it is. Marr explained that the difference between the two kinds of representations correspond to the difference between a *depictive* and a *propositional* representation. According to Kosslyn (1994), a *propositional* representation is a "mental sentence" that unambiguously specifies the meaning of an assertion. A *depictive* representation, on the other hand, is a type of picture which specifies the locations and values of configurations of points in space and conveys meaning via the resemblance to an object.

When a *depictive* representation is used, not only is the shape of the represented parts immediately available to appropriate processes, but so is the shape of empty space - hence one's ability to readily determine the shape of the enclosed space in the letter A. Furthermore, in a *depictive* representation, the size and orientation of the shape is always specified - this is not necessarily so when one uses *propositional* representation to describe a shape. This simplified distinction makes it clear that not only are the two kinds of representations very different, but imagery will have different properties depending on which type is used.

Despite the distinction being made as regards mental representations, much confusion still reigns amongst imagery researchers. The debate over whether or not visual mental images are purely propositional representations or if they rely on depictive representations, which in turn are interpreted by other processes, has not yet been resolved (Kosslyn, 1994). The hard-core propositionalists (see Pylyshyn, 1973) staunchly defend their position, opposing the very idea of depictive mental representations, arguing that visual images could not be depictive because there is no "little man" to look at them. Basing their arguments on putative logical problems with the idea of depictive representations, propositionalists such as Pylyshyn, have asserted that all internal representations are propositional and the pictorial aspects of the experience of imagery have nothing to do with the nature of the representation that takes part in information processing. To Pylyshyn, the pictorial properties evident to introspection are "epiphenomenal", like the heat of a flashlight's bulb, which plays no role in performing the function of the device, which is to shed light. Kosslyn and Pomeranz (1977), having studied Pylyshyn's arguments, claimed that Pylyshyn had not ruled out the possibility that depictive representations are used during imagery and as such, although the debate has not necessarily been resolved, the weight of the evidence seems to lean towards the depictive position (Kosslyn, 1994). Although the specifics of the imagery debate are beyond the scope of this paper it is important to be cognisant of the existence of such a debate since the acknowledgement of the different points of view are necessary in the process of gaining an understanding of the concept of imagery. Furthermore, such a debate leads one to realise that the concept of imagery is far from simple - there is definitely more to it than meets the eye! It is also necessary to note that researchers have for one, agreed that people do experience visual mental images. Secondly, researchers have agreed to the fact that propositional representations are sometimes used in cognition. Thirdly, researchers have agreed that for a depiction (a picture or mental image) to have meaning, it must be interpreted in a specific way, which involves a propositional component

(Kosslyn, 1994; Rollins, 1989; Tye, 1991). It had also been concluded that imagery is a crucial step to converting thoughts into reality (Perry & Morris, 1995). As such, coinciding with the renewed interest and ongoing research pertaining to mental imagery and the concept of the mental image during the 1960's and 1970's, was the application of mental imagery as a therapeutic technique. Based on the premise that solutions rehearsed at the imaginal level during therapy appear to generalise outside the therapy session (Klinger, 1980; Richardson, 1969), therapies such as autogenic training, systematic desensitisation, implosive therapy, covert modelling, stress inoculation, thought stopping, induced anxiety, self-control desensitisation, systematic rational restructuring, and hypnosis all involve imagery (Smith, 1991). According to Strosahl and Ascough (1981), imagery will continue to proliferate in the clinical setting along with the growth of the cognitive behaviour modification movement, which supports the use of imagery as a behaviour modification technique (Meichenbaum, 1977). Today, not only is imagery used in psychotherapy, but it is also being used by physicians, artists, business people, teachers, and of course, athletes (Smith, 1991).

The popularity of imagery rehearsal techniques among elite athletes has been well documented. For example, a highly successful Olympic swimmer interviewed by Orlick and Partington (1988) stated:

> I started visualising in 1978. My visualisations have been refined more and more as the years go on. That is really what got me the world record and the Olympic medals. I see myself winning the race before the race really happens, and I try to be on the splits. I concentrate on attaining the splits I have set out to do. About 15 minutes before the race I always visualise the race in my mind and "see" how it will go ... You are really swimming the race. You are visualising it from behind the block. In my mind I go up and down the pool, rehearsing all parts of the race, visualising how I actually feel in the water. (pp. 18-19).

Orlick and Partington (1988) further reported that 99% of their sample of 235 athletes used imagery. Jack Nicklaus, professional golfer, has attributed much of his success to imagery rehearsal:

> I never hit a shot, not even in practice, without having a very sharp, in-focus picture of it in my head. It's like a colour movie. First I "see" the ball where I want it to finish, nice and white and sitting up high on bright green grass. Then the scene quickly changes and I "see" the ball going there: it's path, trajectory and shape, even its behaviour on landing. Then there is sort of a fade-out, and the next scene shows me making the kind of swing that will turn the images into reality (Nicklaus, pp. 79, 1974).

Murphy (1994) reported that 90% of the athletes who were training at the U.S. Olympic Training Centre used imagery for training and competition, and 94% of the coaches at the Centre expressed that they used imagery with their athletes. According to Perry and Morris (1995), Olympic gold medalist Linford Christie used imagery as a way of preparing for his races. Mike Powell, world record holder in the long jump used imagery to enhance his performance. Tim Forsyth, Australian Olympic high jumper, paused, closed his eyes and made the imaginary jump every time just prior to approaching the bar. Testimonials from many elite tennis players such as, the late Arthur Ashe, Billie Jean King, Martina Navratilova, Tim Gulikson and Tom Gulikson have also been cited as providing additional support for the use of imagery rehearsal to help improve performance (Weinberg, 1988). Chris Evert Mill, (ex-professional tennis player) made the following comment, providing evidence for her belief that visualisation (one aspect of imagery rehearsal), helped her performance:

> "Before I play a match I try to carefully rehearse in my mind what is likely to happen and how I will react in certain situations. I visualise myself playing typical points based on my opponents style of play. I see myself hitting crisp deep shots from the baseline and coming to net if I get a weak return. This helps me prepare mentally for a match and I feel like I've already played the match before I even walk out on the court."
>
> (Chris Evert, cited in Weinberg, 1988, p.99).

Other tennis stars such as Jim Courier, Andre Agassi and Pat Cash have all extolled the benefits of imagery rehearsal in maximising performance. Olympic medalist and world record holders Kieren Perkins and Nicole Stevenson use imagery to "see" themselves swimming at their best. Commonwealth champion Jane Flemming imagines herself running in a tunnel of light that illuminates only her lane, thus eliminating her competition and helping her to focus solely on herself. Anecdotally the benefits of imagery are well documented. It is however noted that the testimonials given by the elite athletes cited above are purely subjective and as such, one cannot truly claim, but only speculate, that imagery rehearsal as a mental preparation technique was a major positive contributing factor to their sporting achievements. There are however research findings to substantiate the claim that imagery rehearsal can be an effective method for improving performance.

As research was being conducted in mainstream psychology, so research was being conducted in an attempt to link mental processes to physiological responses. This research resulted in well documented studies providing empirical evidence supporting the use of imagery as a

performance enhancer. Beginning as early as the 1890's, research literature has been replete with studies pertaining to imagery rehearsal (Martens, 1987; Murphy and Jowdy, 1992). In 1892, Jastrow examined and found involuntary muscular movements occurring during various mental operations. Washburn (1916), in her studies, found support for Jastrow's claim and contended that the slight muscle movements that were made when a person imagined himself/ herself to be engaged in an activity were identical to the movements of actual activity, except that they were of much smaller magnitudes. Jacobson (1932), substantiated this hypothesis by showing, through the use of electromyography, that actual muscle contraction did in fact occur when a person imagined an activity and that the minute muscle contractions occurred only in the muscles that were involved in the imaged activity. In 1933, Freeman likewise was able to show that concomitant muscle activity was produced during an imagined activity. In 1934, Sackett conducted a study that investigated the effects of mental practise versus physical practise. Sackett found that although physical practise was superior to mental practise, mental practise was influential in improving performance. In 1943, Vandall, Davis and Clugston investigated the role of mental practices in dart throwing and found that mental practice improved performance almost as much as physical practice. Following on from those early studies, more and more studies were undertaken in the area of mental imagery in the quest to determine the role of mental imagery in performance enhancement (Janssen & Sheikh, 1994). Clarke (1960), Grouios (1992), Hall, Buckolz and Fishburne (1992), Hall, Rodgers and Barr (1990), Mendoza and Wichman (1978), Moritz, Hall, Martin, and Vadocz (1996), Ryan and Simons (1981), Salmon, Hall, and Haslam (1994), and Shanbrook and Bull (1996) are but a handful of those who have provided research suggesting that imagery rehearsal, in and of itself, is a significantly effective motor performance enhancing technique. There have however been some researchers who failed to find support for the effectiveness of imagery rehearsal (e.g., Cratty & Densmore, 1963; Gilmore & Stolurow, 1951; Trussell, 1952).

Despite the fact that the results of imagery rehearsal studies have been somewhat equivocal and although a substantial amount of research in the area of imagery rehearsal is either largely anecdotal or methodologically weak, there has been relatively convincing evidence available to support the claim that imagery rehearsal is an effective variable for aiding skill acquisition and performance preparation. In 1967, Richardson conducted an extensive review of the previous research examining the effects of imagery rehearsal on performance and concluded that, overall, imagery rehearsal was effective in improving performance. In 1972, Corbin reviewed

the available literature and cautiously concluded that imagery rehearsal (or mental practise as it was referred to at that stage) was preferable to no practise at all. Another review was conducted by Weinberg (1982), from which he concluded that the majority of studies showed that mental practice (imagery rehearsal) was an effective means of improving performance. Perhaps the most extensive and most noteworthy review was conducted by Feltz and Landers (1983), in which a total of sixty studies pertaining to imagery rehearsal were reviewed for purposes of their meta-analysis. Feltz and Landers found, in agreement with Richardson, that "mentally practising a motor skill influences performance somewhat better than no practise at all" (pp. 41). As well as concluding that, on the whole, imagery rehearsal is better than no physical practise at all, it has also be found that imagery rehearsal combined with physical practice is more effective than either alone, and the effects of imagery rehearsal appear to be significantly greater for cognitive tasks than for motor tasks (Perry & Morris, 1995). The fact that there are some research studies that have produced differing results is not surprising since the operational definitions of imagery and related terms, (Hardy, Jones & Gould, 1996), have varied widely from experiment to experiment, thus influencing the researcher's methodology, interpretation and description of the results and consequently the validity of the results too.

IMAGERY REHEARSAL DEFINED

In distinguishing an image from a sensation or percept, William James wrote:

> "I make for myself an experience of blazing fire, I place it near my body, but it does not warm me in the least. I lay a stick upon it and the stick either burns or it remains green, as I please. I call up water and pour it on the fire, and absolutely no difference ensues. I account for all such facts by calling this whole train of experiences unreal, a mental train. Mental fire is what won't burn real sticks; mental water is what won't necessarily (though of course it may) put out even a mental fire ... With 'real' objects, on the contrary, consequences always accrue; and thus the real experiences get sifted from the mental ones, the things from our thoughts of them, fanciful or true, and precipitated together as the stable part of the whole experience-chaos, under the name of the physical world."
>
> (James, 1912, cited in Richardson, 1969).

Describing imagery is one thing, but defining it is another. Although *imagery* is a term that has often been used interchangeably with other terms such as, *visualisation*, *imagery rehearsal*, *mental rehearsal*, *mental imagery*, or *mental practice*, to mention but a few (e.g., Corbin, 1972; Feltz & Landers, 1983; Grouios, 1992; Martin & Hall, 1995; Richardson,

1967a&b; Suinn, 1983), these terms need to be considered yet differentiated between as they are not in fact synonymous in all contexts. Defining *imagery* and *imagery rehearsal*, and at the same time differentiating between the other similar terms has however proved to be no simple task. Similar to the words of William James (1890, p. 225), who said on discussing "consciousness",

> "Its meaning we know so long as no one asks us to define it, but to give an adequate account of it is the most difficult of philosophic tasks."
> (James, 1890, cited in Ley, 1983, p.253).

When considering the definitions of imagery provided by the various researchers, it may help to keep the distinction between "image" and "imagery" in mind, whereby the term *image* refers to the "internal representation that is used in information processing" and *imagery* refers to the experience itself, signalling that underlying brain events are taking place (Kosslyn, 1994).
Denis, (1985, p.4) defined *imagery* to be a *"psychological activity which evokes the physical characteristics of an absent object (either permanently or temporarily absent from one's perceptual field)."* In other words, imagery, according to Denis, is something that exists in the mind and it draws from memory the characteristics of something concrete that has previously been perceived. Similarly, Martens (1987, p.78), defined *imagery* to be *"an experience similar to a sensory experience (i.e. that which is perceived), e.g. seeing, feeling, hearing, but arising in the absence of the usual external stimuli."* According to Martens, in imagery, one does not actually see an object existing as tangible matter, or physically hear the object in movement, or physically feel the object in one's hand, or sense the physical movement of one's body, but one can experience all of these senses within one's mind. Martens (1987), clarifies an important point regarding the definition of imagery. He states that imagery is not the same as visualisation, as imagery involves more than just visualisation; an experience in one's mind's eye. Although visualisation is usually the dominant sense, (and for this reason, people often incorrectly use the term visualisation interchangeably with the term imagery), imagery can involve any or all of the five senses (Martens, 1987; Porter & Foster, 1988; Weinberg & Gould, 1995). Loehr (1991), used the term *visualisation* interchangeably with imagery, as did Jennings (1993) Loehr described *visualisation* as *"a process of creating images in one's mind, of past or future events or experiences by using a variety of senses, including visual, auditory, tactile and kinaesthetic, all of which serve to strengthen mental pictures"* (Loehr, 1991, p.99). Jennings described *visualisation* as *"seeing,*

hearing, smelling, and feeling yourself in your mind" (Jennings, 1993, p.163). What is evident is that both Loehr and Jennings's definition of visualisation, coincide with the fore mentioned definitions of imagery. Thus, when reading literature on imagery or visualisation, one needs to take note and be aware of whether or not the term "visualisation" refers to the use of the visual sense alone, or if all the senses are being taken into account as they are when one talks of imagery or imagery rehearsal.

In the context of sport, Corbin (1972, p.94), defined *imagery* as the *"repetition of a task without observable movement, with the specific intent of learning"*. Richardson (1967a, p.95) used the term *mental practice* to mean *"the symbolic rehearsal of a physical activity in the absence of any gross muscular movements"*. In an attempt to differentiate between the terms "imagery" and "imagery rehearsal", Harris and Harris (1984), argued that *imagery* involves the ability to passively develop an image without going beyond that point, whereas, *imagery rehearsal* implies being actively involved in an image or series of images. In support of this distinction between terms, Murphy and Jowdy (1992) claimed that *mental practice, (*of which *imagery rehearsal* is a specific type of mental practice), is a descriptive term for a particular *technique* used whereas, *imagery* refers to a *mental process*. In light of the above mentioned definitions Corbin (1972) and Richardson (1967a), with the use of the terms 'repetition' and 'symbolic rehearsal' in their respective definitions, clearly referred to a *technique* that is employed in this psychological process, whereas, the definitions supplied by both Denis and Martens do not seem to refer to any particular technique, but rather, like Kosslyn (1994), seem to imply some form of process taking place in the human mind.

What is evident is that the term and corresponding definition used to describe this psychological phenomenon is still a contentious issue. However, for the purposes of this study, the term ***imagery rehearsal*** shall be used hereforth, referring to a *psychological activity involving a sensory rehearsal of a physical activity in the absence of any gross muscular movements and with the aim of leading to improved physical and psychological performance. Imagery rehearsal* in this instance further implies that imagery is utilised to achieve the covert practice of a physical skill. Furthermore, imagery rehearsal usually involves the subject attempting to imagine him or herself successfully completing a physical skill that is the focus of attention (Suinn, 1983), which was precisely what the test items of the Vividness of

Movement Imagery Questionnaire (VMIQ), as used in this study, encouraged the subjects to do.

MEDIATING VARIABLES

Research to date indicates that imagery rehearsal can exert a beneficial effect on physical performance. However, inconsistencies across research studies have been found leading to the conclusion that there may be certain factors that mediate the effectiveness of imagery rehearsal across various individuals and/ or sports contexts that need to be taken into consideration when conducting research (Murphy & Jowdy, 1992). The following mediating variables, which have received major research attention, shall be discussed:

- The influence of individual differences in:
  - sports ability and familiarity with the skill being imaged
  - imagery ability
  - the quality of the mental image
  - vividness, and
  - controllability
- The nature of imagery used, with regard to imagery perspective
- The use of relaxation prior to or in combination with imagery rehearsal

The Influence of Individual Differences

In 1962, Start conducted a study on a group of subjects that had been rated as either high, average, or poor on games ability and found that those rated high on games ability exhibited a significant improvement in their performance on a basketball task after employing imagery rehearsal for five minutes everyday, for nine days. Those rated as average or poor on games ability displayed no significant improvement. In support of these findings, Whitely (1962) found that performers of high physical ability used imagery rehearsal more effectively than individuals who scored low in motor ability. Schramm (1967), Phipps and Morehouse (1969), Corbin (1972) and Perry and Morris (1995) are but a few researchers that have claimed that in order for imagery rehearsal to

be effective, a minimum amount of experience on a task is necessary. In 1967, Corbin (1967a) instructed subjects to perform a novel task in which they had no prior experience. Results showed no significant improvement in performance for the imagery rehearsal group. In a follow-up study (Corbin 1967b), subjects were given physical practice before receiving imagery rehearsal training and in this case the imagery rehearsal group displayed a significant improvement. Support for Corbin's study comes from Mahoney (1979), who stated that imagery rehearsal might be more effective when the athlete is familiar with the task and when imagery rehearsal is interspersed with actual motor practice. This point is supported by Richardson (1967) and Feltz and Landers (1983), whom, after having conducted extensive reviews of the literature concluded that imagery rehearsal combined with physical practice is more effective than either alone. Along with the obvious benefits of physical practice, a possible reason why imagery combined with physical practice leads to improved performance is because the more one practices, the more familiar one becomes with the task to be imaged. The more familiar one becomes with the task to be imaged, the easier it is to imagine that particular task. Following on from this, Pulos, who employed imagery intervention techniques with the Canadian National Women's Volleyball team, stated that what athletes ideally execute in their mind's eye, they will be able to translate into action during practice or competition (Cited in Garfield, 1985). Along with subjects needing to have a minimum amount of physical practice before imagery rehearsal can be effective, especially in a complex skill, it has been claimed that imagery rehearsal can improve performance in both the early and later stages of learning (Perry and Morris, 1995; Suinn, 1980; Wrisberg & Ragsdale, 1979). According to Harris and Harris (1984), although imagery rehearsal can be used at any skill level it is more effective with the highly skilled athlete since, as is evident from the research literature, the more one knows about what one is imaging, the more effective the imagery rehearsal is said to be.

The claim that one's familiarity with the task that is to be imaged is what makes imagery rehearsal effective is an important issue since, it is not necessarily just the positive aspects of a mental image that makes imagery effective, but rather it is the specific imaging of the task at hand which is crucial (Lee, 1990). To explain, Lee found task relevant imagery was more effective than a control condition and that task irrelevant imagery was not effective at all. In support of Lee, Perry and Morris (1995) highlight

the fact that if the athlete has no knowledge of the appropriate movements required to perform the task, chances are the imagery will not closely approximate the physical skills needed for enhanced performance. In this case, the imagery may actually be detrimental to performance as the individual will be mentally rehearsing movements that may not be appropriate to the completion of the task.

The repercussions of the above findings are that the effectiveness of imagery rehearsal programmes can be influenced by the extent of the subject's level of skill and familiarity (or lack thereof) with the task that is to be imagined and this needs to be taken into account prior to any research conclusions being drawn regarding the effectiveness of an imagery intervention programme.
Skill level and familiarity with the skill alone are not the only factors that can influence the effectiveness of imagery rehearsal – The subject's ability to image or conceptualise him or herself performing the task also needs to be taken into consideration (Perry & Morris, 1995).

Just as individual athletes differ in their physical abilities, so they differ in their imagery abilities too (Martens, 1987). According to Moran (1993), the typical research paradigm used in the field of imagery rehearsal involves a "before-after" treatment comparison between people who have been exposed to imagery training for a given task/ sport and those in various control conditions (e.g. physical practice only). Moran points out that little attention has been devoted to an obvious flaw in this strategy: What happens if the treatment effects are confounded by individual differences in ***imagery ability***? Hall, Buckolz and Fishburne (1992) claim that the imagery ability of the performer is probably the most important factor influencing the effectiveness of an imagery rehearsal intervention programme. The reason being is that the greater the imagery rehearsal ability of the athlete, the more effective the imagery rehearsal is said to be (Goss, Hall, Buckolz & Fishburne, 1986; Hall, 1985). If individuals are instructed to use imagery rehearsal, and those individuals have low imagery ability, then it is likely that the imagery rehearsal will have little or no effect. On the other hand, individuals with high imagery ability, by contrast, should be able to use imagery rehearsal effectively (Hall, Buckolz & Fishburne, 1992). It is thus clear that the imagery abilities of athletes is a

crucial issue not to be overlooked when determining whether an imagery rehearsal intervention is or is not effective as a means of enhancing physical performance.

In addressing the issue of imagery ability, the research surrounding **cerebral laterality** is most pertinent:

It has been assumed that due to brain structure development and the associated cognitive functioning, the right cerebral hemisphere is responsible for mediating cognitive abilities that involve imagery (Ley, 1983). This assumption is long-standing. In fact, an association between the right hemisphere and imagery was made more than one hundred years ago. In 1874, English neurologist, J. Hughlings Jackson wrote:

> "The posterior lobe of the right side (of the brain) ... is the chief seat of revival of images." (Cited in Ley, 1983, p.252).

In 1926, Head, an aptly named neurologist, was of the opinion that left hemisphere damage seldon interfered with imagery production. After studying a great number of aphasic patients with left-hemisphere brain damage, Head stated that it was remarkable how rarely visual imagery was affected and that spontaneous recall of visual images and mental pictures remained after left-hemisphere language disturbances (Cited in Ley, 1983). Ley cites strong support for the proposition that imagery is largely a right hemispheric function. Research on unilaterally brain-injured, epileptic, and split-brain patients, as well as the results from electroencephalograph (EEG) readings, galvanic skin response (GSR) readings, conjugate lateral eye movement (CLEM) readings and visual recognition studies of normal individuals have indicated that the right hemisphere predominantly subserves imagery processes. This is an important issue for both sport psychologists and coaches to note (Martens, 1987), since in order for imagery rehearsal to be used effectively, it is evident that the imagery function of the right cerebral hemisphere be as well developed as possible – this could be achieved through prescribed imagery rehearsal exercises (Shone, 1984). According to Martens (1987), children often reveal considerable imagery capabilities but are quickly taught to neglect this form of thinking when they enter the educational system, especially in westernised cultures, where the emphasis is placed on the development of the left cerebral hemisphere – the analytic and language centre. This point is supported by Blakeslee (1980, cited in Welten, 1989), who stated that the syllabi in westernised schools over emphasise logical,

analytic left-hemisphere thinking, while shortchanging intuitive, holistic right-hemisphere thinking. Concerted efforts thus need to be made to enhance the creative abilities of athletes. As such, Martens (1987), states that imagery training techniques should be developed with this in mind. Furthermore, along with realising that imagery rehearsal abilities differ from individual to individual, researchers need to take note of the focus being placed on left hemisphere functioning in westernised cultures because if this is the case then most subjects used in research, have probably not developed their imagery abilities close to their fullest potential, which, as already stated, will confound the effectiveness of an imagery rehearsal intervention.

Researchers have further expressed their belief that one's overall imagery ability is composed of three fundamental characteristics or dimensions: ***quality***, ***vividness***, and ***controllability*** (Perry & Morris, 1995). It should be kept in mind that each of these dimensions can, independently or in combination, influence whether or not an imagery intervention programme is deemed successful.

The ***quality*** of the imagery involves the utilisation of the various senses in image production. There are six major senses that should be used in imagery training; visual (sight), olfactory (smell), auditory (hearing), gustatory (taste), tactile (touch), and kinaesthetic awareness (body movement awareness). As more senses are used, the quality of the image improves and, hence, the effectiveness of imagery on performance also improves (e.g., Loehr, 1991; Martens, 1987; Perry & Morris, 1995; Porter & Foster, 1990; Vealey & Walter, 1993). According to Martens (1987), the visual, kinaesthetic, tactile, and olfactory senses have shown to be more beneficial in the learning and development of motor skills. As such the majority of research pertaining to the influence of imagery ability on performance enhancement seems to focus primarily on the influence of these senses as opposed to the olfactory and gustatory senses. The focus on the visual, kinaesthetic, tactile and olfactory senses shall become clear later on in the paper when the assessment instruments used to determine athletes' imagery abilities are reviewed.

Perry and Morris (1995), found that athletes seem to have a dominant or preferred sense. For example, Perry and Morris reported on one athlete who expressed difficulty in creating a visual picture, whilst reported having a strong kinaesthetic image. This

example highlights an important issue: researchers need to keep in mind that people differ in the extent to which they are able to utilise their senses in image formation. The degree to which each individual athlete can utilise his or her senses (i.e. the quality of the athlete's image), will directly influence the effectiveness of an imagery intervention programme, and/ or the outcome of a research study. Although imagery rehearsal has been reported to be more effective with skilled athletes (Harris & Harris, 1984), Orlick and Partington (1988) make it clear that imagery rehearsal is a skill and like all skills it has to learned regardless of one's level of sporting ability; even elite athletes have to learn to image successfully, and initially often do not have good control over their imagery. Imagery rehearsal can take weeks or even months of practice several times a week before it is perfected (Martens, 1987; Orlick & Partington, 1988). The quote below from a highly successful Olympic springboard diver illustrates how imagery rehearsal is a skill that is acquired through persistent daily practice:

> It took me a long time to control my images and perfect my imagery, maybe a year, doing it everyday. At first I couldn't see myself, I always saw everyone else, or I would see my dives wrong all the time. I would get an image of hurting myself or tripping on the board, or I would "see" something done really bad. As I continued to work at it, I got to the point where I could see myself doing a perfect dive and the crowd yelling at the Olympics. But it took me a long time. I read everything I had to do and I know my dive by heart. Then I started to see myself on the board doing my perfect dive. But some days I couldn't see it, or it was a bad dive in my head. I worked at it so much it got to the point that I could do all my dives easily. (Orlick & Partington, 1988, p.114).

What is evident is that researchers must not assume that just because an athlete (at elite or non-elite level) is familiar with the task to be referred to during imagery rehearsal that he/ she will have a high imagery ability; a necessity for imagery rehearsal to be effective. Furthermore, researchers must realise that imagery rehearsal takes time to perfect.

It is interesting to note that while researchers have claimed that studies referring to imagery rehearsal as an effective means for enhancing performance have been somewhat equivocal, many of the studies have neglected to account for individual differences in imagery ability. Should this variable have been accounted for, many research findings could quite possibly have been different. Furthermore, imagery rehearsal intervention programmes, are all relatively long-term since time is taken, as part of the intervention programmes, to develop each athlete's own imagery abilities (see Perry & Morris, 1995;

Vealey & Walters, 1993). In contrast to intervention programmes, research pertaining to imagery rehearsal has often utilised the common research design involving a pre-test on the task in question, an imagery rehearsal session of relatively short duration, ranging from a few minutes (e.g. Epstein, 1980), several hours (e.g. Mumford & Hall, 1985), to a few days (e.g. Andre & Means, 1986; Kendall, Hrycaiko, Marten & Kendall, 1990, Lejeune, Decker & Sanchez, 1994), followed by a post-test on the performance of the task (Perry & Morris, 1995; Rodgers, Hall & Buckolz, 1991). Although some of the studies implementing imagery rehearsal training over a short period of time did show a significant improvement in performance, it is poss le that some imagery intervention programmes that have not produced significant results, did so not necessarily because the intervention programme was not effective but simply because the subjects' quality dimension of imagery ability had not yet been perfected, i.e. the subjects may have had low imagery ability, with not enough time given to perfect their abilities. Similarly, some studies may have produced significant results over the few days of intervention however the external validity of such results have been brought into question since the Hawthorne effect may have come into play; According to McKay (1981), im ved performance from imagery rehearsal could be a consequence of giving special treatment to, and expending more time and effort with, the imagery rehearsal group as opposed to the control group(s).

For the above mentioned reasons, both an athlete's familiarity with the task to be imaged as well as the athlete's quality of imagery needs to be assessed and referred to prior to any research conclusions being drawn pertaining to the effectiveness of an imagery intervention programme. Methods of assessing imagery ability shall be described and discussed later on in the paper.

When accounting for individual differences in imagery abilities, individual differences pertaining to ***vividness*** and ***controllability*** also need to be considered. Along with the effective use of one's senses when creating mental images, it is imperative that the images are both vivid and controllable because if they are not then imagery rehearsal will be ineffective as an intervention technique (Martens, 1987; Hardy et al., 1996).

The ***vividness*** of an image denotes its clarity and "sharpness", i.e. the ability to recreate as closely as possible the actual experience in one's mind (Weinberg & Gould, 1995; Vealey & Walter, 1993). Perry and Morris (1995) describe vividness as the removal of all the "noise" that can be associated with mentally rehearsing the skills, or as if one focused a fuzzy picture on the television, or quieted a room full of people to hear someone speak, or opened a new can of pressurised tennis balls and taken in the aroma that's emitted. By eliminating all extraneous stimuli, one can concentrate more clearly on the important information. The use of the various senses are all potentially important in making images as vivid and detailed as possible. For example, if a tennis player used imagery rehearsal to recreate as closely as possible to the actual experience of serving, he or she should imagine the feeling of stretching up and swinging the racquet, imagine hearing the sound of the ball as it is hit, imagine the smells in the air and the taste of sweat, in addition to imagining performing the service action (Terry, 1989). Again, one's ability to create vivid images differs from individual to individual and being a skill, can be improved with regular, systematic practice. Learning to create vivid images is important since the closer one's images are to the real thing, the better the transfer to actual performance is expected to be (Moran,1993; Weinberg & Gould, 1995). Being able to create vivid mental images gives one the advantage of having "been there" before, thus familiarising one with the situation and/ or task at hand. This sense of familiarity can help the athlete feel more at ease when the real situation or task arises, which in turn can boost one's confidence and consequently benefit performance (Moritz, Hall, Martin & Vadocz, 1996). Another advantage of being able to create vivid images is that a required competitive action can have additional time in perfect execution, which not only aids motor learning but convinces the individual that an improved and successful action is possible (Martens, 1987). Conversely, an inability to create vivid images will confound the effectiveness of any imagery rehearsal programme.

The ***controllability*** of an image refers to the extent to which one's images can be controlled so that they do what one wants them to do (Weinberg & Gould, 1995). Controlling one's image allows one to picture exactly what one wants to accomplish instead of seeing oneself making errors (Weinberg, 1988). What has been said for the imagery dimension of vividness, applies equally to that of control (Richardson, 1972), since as the work of Start and Richardson (1964) suggested, the dimension of imagery

control may interact with that of vividness, either to enhance or reduce the benefit gained from vivid imagery rehearsal. Martens (1987), points out that while vividness is important, it is essential that athletes have the ability to control their images because vivid but uncontrollable images are counter productive as they tend to debilitate performance. For example, there was a basketball player who "reported mentally attempting to bounce the ball, preparatory to shooting, only to imagine that it would not bounce, and stuck to the floor. This disturbed him to a point where he could not successfully visualise the shooting technique" (Clark, 1960, p.567). This point was elaborated on by Cautela and McCullough (1978, p.237), who claimed that "the most difficult state in which to cause behavioural change is one in which the client experiences intensely vivid imagery but cannot control or maintain adaptive thoughts and continues to revert to maladaptive images." According to Richardson (1969), the combination of high vividness and high controllability correlates the most with behavioural change, while the combination of high vividness and low controllability correlates the least with behavioural change.

Moran (1993) points out that although vividness and controllability are usually considered as separate dimensions, the theoretical basis of a conceptual distinction between them remains obscure, since no researcher seems to have raised the obvious question of how an imagery experience can be controllable if it is not vivid! Sheikh, Sheikh and Moleski (1994) may have shed some light on this issue of potential concern. For Sheikh, Sheikh and Moleski, vividness and controllability are separate but related entities since one can have vivid images that are not controllable. However, the formation of an image is a prerequisite for it to be controllable since the success of imagery procedures is determined not only by the ability to form images but also by the ability to control them. In an attempt to determine the effects of imagery rehearsal outcome (i.e. one's ability to control the outcome of one's images), within the positivistic paradigm, Powell (1973) utilised a negative imagery manipulation, in which subjects were asked to mentally rehearse performing a task but to imagine a failure outcome. For example a subject would be told to rehearse throwing a dart at a target but would be asked to imagine the dart missing the target. Powell found that when comparing positive controlled imagery rehearsal to negative controlled imagery rehearsal, negative imagery rehearsal resulted in a significant decrease in performance. In a later study, Woolfolk, Parish and Murphy (1985) used a positive imagery rehearsal

group, a negative imagery rehearsal group and a control group and found that the negative imagery rehearsal group performed significantly worse than both the positive imagery rehearsal and control groups. According to Murphy and Jowdy (1992), the majority of imagery rehearsal studies have examined the effects of positive imagery and in doing so have assumed that subjects were imaging successful outcomes when instructed to do so. This might not necessarily have been the case, as with the example of the basketball player described above. As such, researchers need to be aware of "imagery control" as a mediating variable in influencing the outcome of imagery rehearsal programmes.

Imagery Perspective

The imagery dimension of control also involves the ***perspective*** taken when imaging, i.e., whether it is from an internal or an external perspective, and thus needs to be considered. The internal perspective, commonly referred to as ***internal imagery***, is considered to be primarily kinaesthetic in nature and involves imagining the execution of the skill from one's own vantage point. On the other hand, the external perspective, commonly referred to as ***external imagery***, is considered to be primarily visual in nature and involves imaging the execution of the skill from the perspective of an external observer (Martens, 1987; Onestak, 1991; Richardson, 1967a; Salmon et al., 1994; Weinberg, 1988; Weinberg & Gould, 1995). For example, taking an internal perspective of one's tennis serve would involve one visualising one's opponent, the racquet and ball in one's hands during the ready position, the ball toss and the contact of the ball with the racquet strings, but one would not see the back of one's head, backswing or anything else out of one's normal range of vision. In contrast, taking an external perspective of would involve one imaging oneself executing the tennis serve as if one were watching a video of oneself (Weinberg, 1988). According to Martens (1987), although the research evidence is not conclusive, in his judgement the internal perspective is usually desired because it more closely approximates the way athletes actually perform activities and can take into account the variety of images relating to the various senses in a more effective way than external imagery can. Martens continues however, by pointing out that on occasion it may be valuable to adopt the external perspective. If an athlete is having a problem doing a task, it may help to analyse the error by taking an external

perspective and analyse the entire execution of the task, as would a coach when assessing his/ her pupil's performance. In support of Marten's opinion that the internal perspective is usually desired, Hall, Buckolz and Fishburne (1992), claimed that many of the papers published prior to 1992 argued that an internal perspective is superior in terms of performance improvement. Hall, Buckolz and Fishburne cite Mahoney and Avener's (1977) research with gymnasts as being the most influential in generating an interest for this perspective. A few studies have however failed to find a difference in usage between external and internal imagery perspectives (Hall, Rodgers & Barr, 1990; Harris & Robinson, 1986; Highlen & Bennett, 1979). There have also been studies that have found the external perspective to be superior (e.g., Fishburne & Hall, 1987). It has been claimed that it is possibly too early to decide whether or not the findings by researchers indicating the imagery perspective individuals employ in practicing a motor skill is irrelevant. In light of this claim, Hall, Buckolz and Fishburne (1992) believe that more research is required on this issue since many of the studies conducted in this area have weaknesses that negate any definitive conclusions. For the present time it has been suggested that it is probably best to let both the motor task and the subject govern which perspective is to be emphasised in the imagery process. The fact that individuals differ in which perspective they prefer to adopt as a means of producing the most vivid and controllable image must not be negated, since if an individual is instructed to use a perspective in which he/ she has low ability, the effectiveness of the imagery rehearsal may be limited. Findings from the administration of the Vividness of Movement Imagery Questionnaire (VMIQ) to 21 physical education students, supports the claim that individuals differ in their imagery abilities depending on which perspective is adopted; of the 21 subjects who completed the VMIQ, 8 scored higher on imagery ability when imaging from the internal perspective whilst 13 subjects scored higher on imagery ability when imaging from the external perspective.

Relaxation and Imagery rehearsal

As mentioned in the introduction, there is still a need to examine the role that relaxation plays in imagery rehearsal since researchers have varying views regarding the inclusion of such a technique. Those who employ relaxation prior to imagery rehearsal believe that relaxation enhances the effectiveness of imagery intervention programmes (e.g.,

Suinn, 1976). It has been claimed that relaxation is one of the most important prerequisites for the experience of vivid imagery (Bakan, 1980; Gendlin, 1981), for it seems to allow the process of becoming aware of internal states to begin. According to Gendlin, during relaxation, the noisy hectic world is shut out, and the inner world, the realm of imaginal experience, has the chance to become the focus of attention. "Imagery comes very well and very richly during highly relaxed states" (Gendlin, 1981, p.71). According to Bakan, "it is evident to people who work with imagery that relaxation is conducive to the experience of imagery" (1980, p.40). According to Cox (1994), cognitive intervention programmes that utilise imagery for performance enhancement and arousal control invariably preface the imagery training with relaxation training. For example, Stress Inoculation Training (SIT), which has been used successfully with athletes, is a cognitive intervention programme that incorporates relaxation training and imagery rehearsal along with other cognitive processes in order to inoculate humans against the debilitating effects of stress (Meichenbaum, 1977). Cognitive-Affective Stress Management, which was developed by Smith (1980) also incorporates relaxation training and imagery rehearsal along with other cognitive processes in order to aid in stress management. According to Murphy and Jowdy (1992), the use of relaxation in combination with imagery extends back at least to Wolpe's (1958) seminal work on systematic desensitisation. The process of systematic desensitisation, which combines progressive relaxation with increasingly realistic and physically close experiences of an anxiety provoking stimulus, was used to help patients to overcome phobias (Cox, 1994). Suinn (1976) adapted Wolpe's desensitisation procedures for humans and developed a psychological intervention procedure called Visuo-Motor Behaviour Rehearsal (VMBR). VMBR involves the combination of imagery with relaxation whereby relaxation is seen as the base for the imagery and thus precedes imagery rehearsal (Suinn, 1976, 1983, 1985). Although Suinn initially used VMBR to treat depression, he was especially interested in applying this technique to athletes as a means to improve sporting performance. Suinn (1976) was only able to provide anecdotal evidence to support the effectiveness of VMBR in his study which lead to the improvement of performance in Alpine ski racers however, a number of other studies using VMBR with athletes have shown this combination of imagery and relaxation to be effective (e.g., Lane, 1980; Noel, 1980). There are however those that

claim that VMBR may have negative effects on performance. For example, Gray, Haring and Banks contend that:

> "... relaxation may have a negative effect on performance because it inhibits possible transfer effects of training; the individual would not be relaxed during the actual performance situation so that a conditioning in relaxation through VMBR techniques may actually be detrimental to later performance." (Cited in Hinshaw, 1991, p.9).

Janssen and Sheikh (1984) stated, in response to Gray, Haring and Banks, that relaxation prior to imagery rehearsal would make the imagery more vivid and better controlled, which in turn would render it more effective. Furthermore, Janssen and Sheikh suggest that one should keep in mind that the aim is not to keep the subject totally relaxed throughout imagery rehearsal, but instead relaxation would be used to "launch" the subject into vivid and controlled imagery rehearsal. According to Perry and Morris (1995), possibly the greatest support for the effectiveness of VMBR comes from a study conducted by Kolonay in 1977. Kolonay's study, unlike the studies conducted by Lane (1980) and Noel (1980), include a direct comparison of imagery with and without relaxation. Focusing on basketball free throw shooting, Kolonay concluded that the group that used only imagery and the group that used only re[illegible] did not differ from a control group, but the shooting of the VMBR group was significantly superior to all other groups. Despite the differing opinions as regards relaxation and imagery rehearsal, Perry and Morris (1995), purport the role of relaxation to be relevant, not as a necessary condition for imagery to take place, but as a factor that may greatly enhance the imagery rehearsal experience.

The logical question of ***why*** relaxation would influence imagery rehearsal seems to follow. This question shall be addressed later on in the paper in the section headed "relaxation, imagery rehearsal ability and brainwave activity".

THEORIES PERTAINING TO IMAGERY REHEARSAL

Imagery and motor performance may seem, at first glance, to be far removed from each other since, as Denis (1985) points out, imagery is a psychological activity, belonging to a class of "private events", whereas, motor performance is more physical, external, and public in nature. For this reason, one of the most challenging and difficult tasks of psychology is, perhaps, to

relate the observation of behaviour to the study of mental processes. (Mendoza and Wichman, 1978). In an attempt to describe how imagery rehearsal actually works as a technique for enhancing skill development and performance, numerous theories have been proposed.
It is beneficial for one to have an understanding of these theories in order to better understand the concept of imagery rehearsal in it's entirety. As such, the most prominent theories describing how imagery rehearsal possibly works to enhance performance shall now be presented.

The Psychoneuromuscular Theory (Programming muscles for action)

One o .e most prevalent explanations of ?ow imagery works is the ***psychoneuromuscular theory***. Over 100 years ago Carpenter (1894) proposed that any idea which dominates the mind, finds its expression in the muscles. This ideo-motor principle postulates that continued concentration upon a certain idea gives it "dominant" power in the mind, that then determines the movement in the muscles. In other words, if ideas occur that reach certain levels of intensity, then the content of those ideas will be expressed through subsequent muscle activity. This ideo-motor principle forms the basis of neuromuscular explanations for mental imagery effects (Hale, 1994). Carpenter's ideo-motor principle was supported by Jacobson (1930, 1932) who, when using electromyography (EMG), was able to find changes in muscle activity while subjects were imagining performance in a motor task. Jacobson found that the changes in muscle activity occurred in the same muscles used during the actual physical performance. In 1980 Suinn tested this theory on Alpine skiers when administering the visuo-motor behaviour rehearsal imagery technique. By attaching electrodes from an EMG machine to the legs of a skier and having the skier imagine skiing a downhill race, Suinn discovered that the recorded muscle patterns were strikingly similar to the muscle patterns of a skier who physically skied the course. In Suinn's words, "By the time he finished the psychological rehearsal of the downhill race, his EMG recordings almost mirrored the course itself." (Suinn, 1980, p.17). In 1984, Bird conducted a similar study with athletes in various sports (riding, rowing, swimming, water skiing and basketball). She, too, found that there was a distinct similarity between the EMG of the imagined sport activity compared to the EMG of the actual sport activity. Although during imagery rehearsal the neuromuscular innovations, as registered on the EMG machine, are of a smaller magnitude than elicited during physical practice and may even be so minor that they do not actually produce movement, it is claimed

by many theorists that imagery rehearsal facilitates the learning and mastering of motor skills because the neuromuscular impulses resulting from imagery rehearsal is capable of providing kinaesthetic feedback that is similar to when one physically performs the activity. For example, when trying to perfect a tennis service swing, one would take a bucket of balls and practise the serve continually, trying to automate it. In effect, one is strengthening the neural pathways that control the muscles related to the service motion. Through imagery, the athlete's body believes that the athlete is actually practising the serve due to the fact that "imagined stimuli and perceptual or "real" stimuli have a qualitatively similar status in our conscious mental life" (Marks, pp 285. 1977) i.e. One's brain cannot tell the difference between what is real and what is vividly imagined (Martens, 1987). As such, the athlete is in effect programming his/ her muscles and preparing the body to perform (Magill, 1989; Weinberg & Gould, 1995). Vealey and Walter (1993) use the term "muscle memory" when explaining this theory to athletes as a means of emphasising that through imagery an athlete can strengthen his/ her muscle memories by having the muscles fire in the correct sequence, without actually physically executing the movement. Recently though, this theory has met with some criticism. Although research clearly supports that vivid imagery can produce low-level innovation of muscles, there are those who claim that it is not possible to link the muscular activity to skill enhancement. As such the muscular activity might only be a by product and not directly influential in skill learning and improvement (Perry & Morris, 1995; Vealey & Walter, 1993).

The Symbolic Learning Theory (Understanding movement patterns)

A second possible explanation of how imagery works is the ***symbolic learning theory***. The difference between the symbolic learning theory and the psychoneuromuscular theory described above, is that according to the symbolic learning theory, first proposed by Sackett (1934), imagery helps develop a mental blueprint, not by the minute firing of the peripheral muscles during imagery, as with the psychoneuromuscular approach, but by creating a motor programme in the central nervous system (Martens, 1987). It has been claimed that all movement patterns that one makes must first be encoded in the central nervous system as this helps athletes acquire and understand the movement better i.e. one has a blueprint or plan of action for each movement (Vealey & Walter, 1993). Vealey and Walter use the term "mental

blueprint" in describing this theory to athletes. Vealey and Walter explain that imagery strengthens the mental blueprint (or the mental code used to perform the required movements). In strengthening this mental blueprint, movements that are applicable to a particular skill can be stored and recalled easily when needed, thus enabling the skill to become automatic. Sackett (1934), explained that imagery rehearsal facilitates motor performance by allowing the subject to rehearse the symbolic (cognitive) components of the task; namely, task strategies, and the spatial and temporal sequencing of movements that is required. As such, imagery rehearsal allows participants to plan and prepare for performance in advance. According to the theory, the better a movement is symbolically coded (i.e. coded as symbols that represent patterns of overt movement), the easier it is to make. It has been claimed that skills that are more cognitive in nature are more easily coded than pure motor skills (Janssen & sheikh, 1994). Cox (1994) referred to the play of the shortstop in baseball as an example of this theory on action: Prior to each pitch to the hitter, the shortstop, who stands between second and third base, cognitively reviews in his/ her mind the various possible events and the appropriate response for each event. If there is one out in the eighth inning, the bases are loaded and the scores tied, the shortstops play will depend upon the type of ball that is hit to him. By mentally rehearsing the various stimuli and possible responses before each pitch, the shortstop can improve his chances of making the correct play.

Many studies have provided support for the symbolic learning theory (Feltz & Landers, 1983). Support has come from a number of studies that have shown that imagery rehearsal is in fact more effective for tasks that have a high cognitive (as opposed to motor) component (e.g., Morriset, 1956; Minas, 1978; Wrisberg & Ragsdale, 1979; Ryan & Simons, 1981). Further support for this theory has emanated from the compatibility between the theoretical accounts of motor learning that argue that the early stages of learning are primarily cognitive (e.g., Fitts, 1962), and the notion that imagery rehearsal is beneficial in enhancing performance during the early stages of learning. Despite the support that has been shown towards this theory as a possible explanation for how imagery works to influence performance, some problems with this theory appear to exist: Differentiating between "cognitive" and "motor" components within or between tasks appears artificial and lacks validity (Budney, Murphy & Woolfolk, 1994). According to Janssen and Sheikh (1994), it is nearly impossible to classify movements as either strictly cognitive or strictly motor. Furthermore, it be easy to see how early skill acquisition is enhanced by the encoding of movement patterns through imagery rehearsal, but

this theory does not explain how performance is enhanced in experienced athletes who already have the movement pattern well established (Hecker & Kaczor, 1988).

The Bio-informational Theory

A third and more recent theory on the facilitating effects of imagery on performance is Lang's (1977, 1979) ***bio-informational theory***. This theory has also been referred to as the "response set" theory (Vealey & Walter, 1993), or the information-processing theory (Murphy & Jowdy, 1992). The bio-informational theory examines imagery in terms of the brains information processing mechanisms (Suinn, 1983) The model begins with the assumption that an image is a functionally organised, finite set of propositions stored by the brain. Furthermore, the model states that a description of an image contains two main types of statements: *stimulus propositions* and *response propositions*. Stimulus propositions are statements describing the content of the scenario to be imaged, and are subdivided into two types of information (Lang, 1984). The first type of information includes the descriptive referents pertaining to the elements of the external environment. For example, in shooting a free throw in basketball the stimulus information might include the feel of the ball in the player's hands, the crowd noise, the sight of the surrounding players, etc. The second type of information involves semantic elaboration that is relevant to the event. For example, "the game is important", "there are two seconds remaining, and the game is tied." (Cuthbert, Vrana & Bradley, 1991). Response propositions on the other hand, are statements that describe the imager's response to the particular scenario (Hardy et al., 1996). These response propositions are designed to "... produce a relevant physiology during imagery" (Cuthbert et al., 1991, p.7). The responses might include those proposed by somatomotor systems (e.g. limb flexion and eye movements) as well as autonomic activity (e.g. changes in heart rate and muscle tension). Thus, responses in the above free throw example might include sweaty hands, a pounding heart, the sensations of "butterflies" in one's stomach, etc. as well as the body movements involved in making the shot (Cuthbert et al., 1991). For Lang, response propositions are a fundamental part of the image structure. Lang and others have demonstrated, in a variety of psychophysiological studies, that imagery is accompanied by an efferent outflow that is appropriate to the content of the image (Brown, 1968; Hale, 1982; Jacobson, 1932; Lang, 1979). It has also been concluded that the greater the magnitude of these physiological

responses during imagery rehearsal, the greater will be the accompanying changes in behaviour (Lang, Melamed & Hart, 1970). Following on from this, it was found that imagery instructions that contain response propositions elicit far more physiological responses than do imagery instructions that contain only stimulus propositions (Lang, Kozak, Miller, Levin & McLean, 1980). Murphy & Jowdy (1992), point out that if the above is true, the sport psychologist who wishes to help an athlete change behaviour by using imagery rehearsal, would do well to include many response propositions in the imagery descriptions, enabling the athlete to access the appropriate motor programme. To describe this theory in action, Murphy and Jowdy (p.238), presented the following example comprising of two sets of imagery instruction scripts in which athlete had to imagine him/ herself running. The first is a script weighted with stimulus propositions:

> *You are engaged in a training run down a street close to your home on a beautiful autumn day. You are wearing a bright red track suit; and as you run you watch the wind blowing the leaves from the street onto a neighbours lawn. A girl on a bicycle passes you, and you see that she is delivering newspapers. You swerve to avoid a pothole in the road, and you smile at another runner passing you in the opposite direction.*

The second script is weighted with response propositions:

> *You are engaged in a training run down a street close to your home on a crisp autumn day. You feel the cold bite of the air in your nose and throat as you breather in large gulps of air. You are running easily and smoothly; but you feel pleasantly tired and can feel your heart pounding in your chest. Your leg muscles are tired, especially the calf and thigh; and you can feel your feet slapping against the pavement. As you run you can feel a warm sweat on your body.*

According to Murphy and Jowdy, the research conducted by Lang and his associates indicates that the latter set of imagery instructions is more likely to elicit vivid images than the first set of instructions. Vealey and Walter (1993), in using the term "response set" to explain this approach in a simple manner, emphasise the importance of including behavioural, psychological and physiological responses in the utilisation of imagery. According to Perry and Morris (1995), focusing on the various response propo ..ons in relation to the content of the image should all be part of quality imagery, because these propositions are generally included in actual performance. Perry and Morris state that by modifying responses to given

situations through imagery rehearsal, the athlete gains more control and hence improves performance. At present there is little research that has tested this theory. One study which has tested this theory was conducted by Hecker and Kaczor, in 1988. Using a control scene with no response propositions attached to it, propositions for a familiar action scene, propositions for a familiar athletic anxiety scene and propositions for an unfamiliar fear scene, Hecker and Kaczor found that the heart-rate physiological data supported the effects of the response propositions on the familiar scenes, as bio-informational theory would predict. However the effect of performance was not linked to the physiological data in the study. It is thus evident that further empirical verification in the field of sport psychology is still required before this theory pertaining to how imagery rehearsal works to enhance performance is accepted or rejected. (Perry & Morris, 1995; Vealey & Walter, 1993).

The Triple Code Model of Imagery

Another model that recognises the primary importance of psychophysiology in the imagery process when considering how imagery works is Ahsen's *triple code* (image-somatic response-meaning [ISM]) *model* (1984). This model, unlike Lang's model described above, goes a step further by taking into consideration the meaning of the image. To explain, Ahsen's model specifies three parts of imagery purported to be essential. The first part is the image itself: "The image can be defined as a centrally aroused sensation. It possesses all the attributes of a sensation but it is internal at the same time. It represents the outside world and its objects with a degree of sensory realism which enables us to interact with the image as if we were interacting with the real world" (Ahsen, 1984, p.34). The second part is the somatic response: The act of imagination results in psychophysiological changes in the body (Ahsen, 1984; Sheikh & Kunzendorf, 1984). For example, "Upon seeing the image of an apple, one experiences also it's colour texture, taste and smell. The somatic response always accompanies an image unless the response has been suppressed. The original somatic response, however, can be developed again by concentrating on the image." (Ahsen, 1984, p.34). The third aspect of the imagery, that has been largely ignored by the other theories so far discussed, is the meaning of the image. According to Ahsen, every image imparts a definite significance or meaning to the individual. Furthermore, every individual brings his or her unique history into the imaginal process, so that the same set of imagery instructions will

never produce the same imagery experience for any two individuals. Murphy and Jowdy provide anecdotal evidence in support of Ahsen's belief that imagery instructions elicit a different imagery experience for each individual. If Ahsen's belief is true, sport psychologists, as well as researchers, need to pay careful attention to any significant meaning an image may have for their client. The meaning component of Ahsen's theory adds to one's understanding of the negative effects sometimes produced by imagery techniques. For example, Weinberg (1988), found that when a group of tennis players were all given tl same instruction to mentally rehearse serving their first serve in, several players reported that in visualising, the ball consistently hit just outside the service box! As discussed in the section on imagery control, such a negative image inhibits performance and thus the effectiveness of the imagery rehearsal programme. Support for Ahsen's triple code model of imagery has been documented (Budney, Murphy & Woolfolk, 1994; Murphy and Jowdy, 1992). However, whilst this theory suggests the importance of the image content, somatic responses, and the meaning of the image to each individual, more research is needed that puts this theory into practice and directly assesses the influence of this model on performance enhancement.

Attentional-Arousal Set Theory

The ***attentional-arousal set theory*** of imagery rehearsal is a relatively unsophisticated explanation for why imagery facilitates performance, yet it has intuitive appeal. According to this theory, which combines the cognitive aspects of the symbolic learning theory with the physiological aspects of the psychoneuromuscular theory, imagery serves to improve performance in two ways. From a physiological perspective, imagery may help the athlete to adjust his/her arousal level for optimal performance. From a cognitive perspective, imagery may help the athlete to selectively attend to the task at hand. It has been found that task-relevant imagery is an important variable in influencing the effectiveness of an imagery intervention programme (Lee, 1990). According to the attentional-arousal set theory, if the athlete is cognitively attending to the task-relevant image, he/ she is less likely to be distracted by irrelevant stimuli, which would otherwise have a negative influence on performance (Cox, 1994). Vealey and Walter (1993) use the term "mental set" to explain this theory and emphasise that imagery helps athletes perform better by creating the right "mental set" (optimal arousal and concentration) for competition. Whilst there is support for the claim that

using productive imagery, once the right "mental set" has been created, can facilitate performance, this theory has a major weakness. Although the attentional-arousal set theory seems to explain what it is that makes imagery work , it does not specifically explain *how* imagery optimises arousal and attention, nor has the theory been sufficiently validated by research (Vealey & Walter, 1993).

Despite the variety of theories, each postulating how imagery supposedly serves to facilitate performance, none of the theories have proved to be comprehensive enough to encapsulate the imagery-performance relationship (Shwartz, 1983). As such, a single, comprehensive explanation of how imagery affects physical skill development is not available although the presented hypotheses seem plausible (Smith, 1991). From a logical perspective, Cox (1994) states that it would be impractical to exclude any one of the theories in favour of another. He further asserts that perhaps the best theory might be eclectic in nature, including elements from all theories - only research will tell.

THE USES OF IMAGERY REHEARSAL

Regardless of the fact that imagery is a process that is not yet fully understood, imagery rehearsal still appears to aid the performer during both the development and refinement of physical skills (Smith, 1991). Although the focus of this paper is primarily on determining whether or not relaxation influences brainwave activity which in turn influences imagery rehearsal ability, knowledge of the contexts in which imagery rehearsal has found to be beneficial is important. If one does not have an understanding of the contexts in which imagery rehearsal can benefit performance, there would be no need for one to implement an imagery intervention programme. For this reason, a brief description of uses for which imagery rehearsal has found to be effective shall be presented.

- **Skill Acquisition**

  Many of the studies that have been conducted to date suggest that learning a new skill can be assisted by imaginal rehearsal of that skill. Furthermore, the greater the number of cognitive components of the skill, the more assistance to the learning of the skill imagery rehearsal is said to provide (Budney, et al., 1994; Murphy & Jowdy, 1992).

- **Skill Maintenance**

  According to Murphy and Jowdy (1992), imagery rehearsal is the primary mental skills technique used by athletes to maintain a skill. It has also been found that if imagery rehearsal is used during learning, retention is usually better than that displayed by a no-practice control group (Meacci & Price, 1985). There have been several testimonial accounts of athletes who have maintained their sport skills for long periods by imagery rehearsal alone. This use of imagery rehearsal, in the absence of physical practice is particularly common with injured athletes (e.g., Gordon, 1986; Rotella, 1984, Rotella & Heyman, 1993).

- **Problem Solving**

  Just as imagery can be used in skill maintenance through the revision of the skill by imagery rehearsal, so imagery can be used to examine a routine or a skill to detect a problem and then to correct it in readiness for the next physical practice session or competitive performance (Perry & Morris, 1995).

- **Arousal Regulation**

  Imagery techniques have long been used in clinical psychology as a relaxation-inducing device (e.g., Meichenbaum, 1977). This approach has been adopted in sport psychology as a way of calming the anxious athlete prior to competition (e.g., Harris and Harris, 1984). A large body of research has examined the relationship between arousal and performance (Martens, 1987). The inverted-U hypothesis posits that performance is optimal at some moderate arousal level and that arousal levels that are too high or too low inhibit performance. The more recent reversal theory and catastrophe theory have complicated this once simple picture. Theorists have now realised that different tasks require different levels of arousal (Oxendine, 1970). For example, when competing, a weight lifter may need to be at a much higher level of arousal than a gymnast. As such, arousal levels need to be controlled for, in order to allow for optimal performance. Research has supported the use of imagery rehearsal to increase and decrease arousal levels (e.g., Murphy, Woolfolk & Budney, 1988).

- **Planning/ Event Management**

  Another popular use of imagery rehearsal in the applied sport psychology area is to prepare athletes cognitively for upcoming competitions (Orlick, 1990). A good example of this use of imagery rehearsal comes from Rotella and colleagues (1980). In their study, successful skiers developed a visual image of the course after previewing it; in the time between inspecting the course and reaching the starting gate, the skiers had concentrated on planning effective strategies for skiing the course. The less successful skiers, on the other hand, simply tried to maintain positive thoughts prior to racing.

- **Stress Management (Emotional Rescripting)**

  This use of imagery rehearsal is similar to event management but, instead of imaginally rehearsing rational cognitive strategies, athletes rehearse their emotional response to competitive situations. With the help of a sport psychologist, the negative emotions are replaced with more appropriate cognitive strategies. Finally the athlete learns to imaginally rehearse completing or coping with a task successfully (Porter & Foster, 1990). This use of imagery rehearsal for stress management by athletes stems from the clinical use of imagery rehearsal as a technique used to reduce many types of anxiety (e.g., Ellis, 1973).

- **Self-Image Manipulation**

  The image that one holds of oneself is said to be the major source of one's self esteem. The fact that imagery can influence self-confidence has long been recognised by cognitive behavioural therapists, who have developed a number of strategies that encourage behaviour change by asking clients to imagine more successful behaviours than they presently exhibit (Murphy & Jowdy, 1992). An example of an imaginal strategy would be systematic desensitisation (Wolpe, 1958) and coping imagery (Meichenbaum, 1977). Self-reports from athletes who utilise imagery techniques have indicated that their confidence levels had improved when using imagery rehearsal (Wilkes & Summers, 1984).

- **Attentional and Pain Control**

  Imagery-based techniques have been suggested by several authors for use in healing and injury rehabilitation, and in controlling pain (e.g., Epstein, 1989; Jaffe, 1980). The use of imagery in assisting the healing process and in the fighting of disease has been well

documented (Simonton, Mathews-Simonton, & Creighton, 1978). Some authors have applied this approach to athletes, suggesting that imagery can be used for the healing of sports injuries and the coping with athletic pain (e.g., Lynch, 1987; Porter & Foster, 1990).

- **The Motivational and Cognitive Roles of Imagery Rehearsal**

  According to Paivio (1985), imagery rehearsal serves two overall functions: A cognitive function and a motivational function. These functions, in Paivio's view operate at either a specific or a general level. The *motivational* function of imagery rehearsal involves symbolically representing various behavioural situations. In a specific context, this involves imagining one's goals and the activities that are necessary to achieve these goals. This, Paivio referred to as "goal-oriented responses". At the general level, imagery rehearsal's motivational role involves the feelings associated with the imagined successes or failures of these goals. The *cognitive* function of imagery is essentially concerned with the effects of practising behavioural skills with the use of imagery rehearsal to strengthen properly executed skills or to correct skills that are incorrectly executed. Paivio suggested that imagery rehearsal could be used to rehearse either general strategies of play or specific skills. According to Salmon, et al. (1994), most of the research to date has investigated imagery as a technique for enhancing skill development and performance with the results generally being positive. For the purposes of this study, with the assessment of imagery ability of junior South African tennis players at the advanced skill level and the extent of usage of this technique as a mental practice method for the enhancement of skill development, this study too, focused on the cognitive role of imagery as opposed to its motivational role.

As is evident, imagery has many uses. The above list is far from conclusive. According to Perry and Morris (1995), the limits of uses of imagery rehearsal are probably reflected in the limits of the imagination of coaches, athletes and sport psychologists. Returning to the idea of a possible theory that explains how imagery works, perhaps there is not just one relevant theory, just like there is not just on way to benefit from imagery use. Perhaps all the theories have relevance, depending directly on the purpose for which imagery rehearsal is to be used?

MEASUREMENT ISSUES

The measurement of imagery has been a problem for as long as imagery has been studied in psychology. Since imagery is a mental process, it is not directly observable. Assessing how well somebody images by simply measuring improvement on a task is not acceptable as so many other factors have the potential to influence performance. Despite the practical and conceptual problems associated with assessing imagery ability there are those who have attempted to develop testing instruments for that purpose. The method primarily adopted in imagery ability assessment is the use of self-report measures. These questionnaires simply ask individuals to estimate how proficient they are at imagery, usually by selecting a number on a scale. A potential problem with this method does however exist: nobody can observe other people's quality of imagery to make a comparison. As such, two people experiencing the same phenomenon may rate themselves differently. Although there are those critics who have expressed concern over the reliability and validity of self-report measures, the assessment results from such tests have nevertheless shown to be indicative of areas of imagery ability weakness encountered whilst generating mental images (Perry & Morris, 1995). This comment is supported by the fact those athletes who have been assessed as having high imagery abilities have also been shown to benefit more from imagery interventions than those athletes assessed as having low imagery abilities (Hall, 1985). Furthermore, in an imagery intervention programme each athlete's sport-imagery ability should be compared only to his/ her own imagery ability as recorded on a previous test. When imagery abilities within athletes rather than between athletes are being compared, the problem of whether or not people experiencing the same phenomenon rate themselves differently, is not an issue of major concern. Of primary concern would be the athletes own perceived imagery ability in relation to the effectiveness of the imagery rehearsal programme.

Following is a review of imagery ability tests. This review is not only informative, also explains the reason for the choice of the Vividness of Movement Imagery Questionnaire (VMIQ) to be used in this particular study.

The first test relating to imagery was published more than 85 years ago, when Betts's (1909) introduced the Questionnaire on Mental Imagery (QMI). In 1967 Sheehan shortened the 150 item QMI to a 35-item version and renamed the test the Shortened Questionnaire on Mental

Imagery (SQMI). Sheehan's version, with self-report responses given on a Likert scale, attempted to measure vividness of imagery across a range of sense-modalities. In 1949 Gordon developed the Test of Imagery Control (GTIC) which was also modified at a later date by Richardson (Richardson, 1969). The modified version of the GTIC was a shorter scale consisting of only 12 items designed to measure controllability.

In 1983, Hall and Pongrac developed the Movement Imagery Questionnaire (MIQ) which had much more of an orientation towards motor skill and sport than any of the previous imagery tests. The MIQ consists of 18 items which describe 9 short movement sequences. Each sequence is executed physically twice; once followed by instructions to recreate the experience using visual imagery, and once followed by kinaesthetic imagery instructions. After each imagery episode, the person rates the quality of the imagery on a Likert scale in relation to how clearly they can (a) "see" themselves perform the action, or (b) "feel" themselves perform the action. The visual scores provide one total and the kinaesthetic scores provide another total reflecting independent capacities to see and feel movement through imagery (Perry & Morris, 1995). Although the MIQ has been used in research, it has not been adequately validated (Moran, 1993). Furthermore, since the activity is physically executed directly preceding the imagery instructions, the actions are fresh in the subject's minds when using imagery rehearsal. Consequently the self-report scores on imagery ability could be exaggerated due to the influence of short-term memory. Perhaps the imagery instructions should be given sometime after the physical execution of the skill so that the subject has to rely on "memory imagery" (Smith, 1991), which is the type of imagery used in imagery rehearsal, since imagery rehearsal is very seldom employed immediately following skill execution. A further problem with this test is that it only assesses imagery ability in relation to two of the six sense modalities which, in the author's opinion could be problematic especially since this test does not allow the influence of "controllability" to be controlled for. That is, even though the concept of controllability can influence the respondent's ratings of the test, this negative influence is not controlled for. For example, some of the questions in the MIQ request the respondent has to "rate the ease/ difficulty with which you (the respondent) were able to do the mental task". It is possible that a respondent may, in some cases, give a low rating not because they were unable to visualise clearly (which is what the MIQ wants to assess) but rather because the respondent was unable to control the image i.e. although the

respondent could visualise the situation clearly he/she couldn't get the image to do what he/she wanted it to do and thus found it difficult to do the mental task.

Another test that needs mentioning is Marten's (1987) Sport Imagery Questionnaire (SIQ), which has been widely used in applied sport psychology The SIQ presents descriptions of four experiences common in sports. These are practising alone, practising with others, watching a team mate, and playing in a contest. For each of these scenes, after spending a minute imagining it, ratings are made on 5-point Likert scales from no image at all to a clear, vivid image for three sense modalities - vision, hearing, kinaesthesis - and the degree to which emotions were stimulated. Although the SIQ has been widely used, there has been no attempt to validate it (Perry & Morris, 1995). The SIQ is however the only imagery test which is sport-specific, which is consistent with Martens' (1975) proposition that sport-specific tests are more sensitive. Clearly though, with no reliability and validity to support it, the SIQ cannot be used in research and even its use in applied work may carry ethical risks, should inappropriate prescriptions be based on results from it (Perry & Morris, 1995).

In 1973, Marks developed the Vividness of Visual Imagery Questionnaire (VVIQ); a test which has been used vastly in research. The VVIQ is a 16-item scale, which is derived from the visual sub-scale of Betts's (1909) QMI. It is scored on Likert type scales with a test-retest reliability varying from adequate ($r = 0.67$) to good ($r = 0.87$) according to McKelvie (1990). The construct validity has however been questioned by some researchers (Moran, 1993).

Some time after the VVIQ was published, a similar test, but with a kinaesthetic focus, was developed by Isaac, Marks, and Russell (1986), called the Vividness of Movement Imagery Questionnaire (VMIQ). The VMIQ, which claims to measure the visual imagery associated with movement itself, as well as the kinaesthetic sensations contains 24 items to be scored on a Likert type scale. Isaac et al. (1986) estimated a test-retest reliability of 0.86 over a 3 week period. Moran (1993) proposes that its convergent validity is supported by a significant correlation with the VVIQ ($r = 0.81$). A problem with this test however, and a problem that exists with using any of the above mentioned tests in a sport-specific context, is that the tests themselves are not sport-specific. In the present study, the test was not used as a means to assess imagery ability in relation to a particular sport, as such, the fact that the VMIQ is not sport-specific did not prove to be a problem. For this reason, due to the merits of the VMIQ, it was chosen to be used in the present study as a means to assess imagery ability.

RELAXATION, BRAINWAVE ACTIVITY AND IMAGERY REHEARSAL ABILITY

In this section of the paper, the hypothesised triadic relationship between relaxation, brainwave activity and imagery rehearsal ability shall be considered.

Earlier on in this paper, the idea of relaxation prior to imagery rehearsal was discussed as a variable that could influence the effectiveness of an imagery rehearsal intervention programme by enhancing the imagery rehearsal ability of athletes. Although no conclusive evidence has appeared to exist that states that relaxation prior to imagery rehearsal is necessary (Murphy & Jowdy, 1992), Perry and Morris (1995) have stated that relaxation, whilst not a necessary condition for imagery to take place, is a factor that may greatly enhance the imagery experience. Furthermore, researchers such as Gendlin (1981) and Bakan (1980) purport imagery to be enhanced when in a relaxed state. The critical question that seems to arise is, *why* would relaxation enhance the imagery experience? It has been hypothesised that relaxation influences brainwave activity, which in turn influences mental functioning, of which, imagery rehearsal would be a part. Thus, by influencing brainwave activity, relaxation influences imagery rehearsal ability, which consequently enhances the effectiveness of an imagery rehearsal intervention programme. Following is a more in depth description of the relationship between relaxation and brainwave activity and between brainwave activity and imagery rehearsal.

Relaxation and Brainwave Activity

To use imagery to its greatest potential, one must first learn how to render one's mind completely receptive by quieting, as much as possible, the external distractions and internal chatter (Korn, 1994). According to Korn, one can do this by using a technique known as progressive relaxation. Through progressive relaxation, physiological changes are produced within one's body. These resultant physiological changes are the exact opposite of the stress response (Paul, 1969). Progressive relaxation is said to decrease oxygen use by the body (a more relaxed state), decrease respiratory rate, decrease heart rate, decreases blood pressure, decreases muscle tension, increases blood flow to the brain and produces a dominant alpha rhythm on an EEG (electroencephalogram). For the purposes of this study, the latter

physiological change is the most relevant. In 1924, a researcher named Hans Berger, was the first to detect the alpha brain rhythm. Since the alpha rhythm was the first of the brain rhythms to be observed, Berger named it alpha, a term which indicates the first or beginning of something. To place the alpha rhythm in context, one must first understand brainwaves. The brain produces minute electrical activity that can be measured by the frequency and amplitude (voltage) at which they occur. Frequency is described as cycles per second (cps). Hertz (Hz) is the unit used to express frequency whereby 1Hz = 1 cps. There are generally four accepted divisions of brainwaves: delta, theta, alpha and beta. Delta waves (also referred to as rhythms) are of the lowest frequency (1-3 Hz) and characterise the deepest levels of sleep. Theta waves elicit a higher frequency (4-7 Hz) than delta waves and are characteristic of the lighter stages of sleep. Alpha waves occur at a frequency of 8 to 13 Hz. The implications of these waves shall be discussed shortly. Some researchers designate all brain rhythms faster than alpha as beta, whereas others restrict the classification of beta waves to a frequency of 14 to 30 Hz (Shagass, 1972). Marks and Isaac (1995) separated the beta rhythm into two categories, Beta 1 (14-20 Hz) and beta 2 (21-28 Hz). The brain produces all of these frequencies (rhythms) in differing amounts at the same time throughout a 24 hour period and each rhythm makes up a total percentage of brain wave. For example, when a person is in a state of deep sleep, a greater percentage of delta rhythms are observed, whereas, when a person is awake but relaxed, alpha waves are said to predominate. For the purposes of this paper, the alpha rhythm was of central focus, particularly the amount of alpha activity observed during imagery use. It is claimed that high levels of observed alpha waves are conclusively linked to enhanced creativity, improved problem solving and a sense of relaxation (Heibloem, 1990). The important issue here is that it has been claimed that relaxation induces a predominantly alpha state.

Brainwave Activity and Imagery Rehearsal Ability

Studies in the area of brainwave activity and imagery rehearsal seem to have focused around the type of brainwave activity that predominates during visual and motor imagery. According to Marks and Isaac (1995), the first study reporting the link between EEG changes and imagery was conducted by Adrian and Matthews in 1934. The various studies that have been conducted since have however produced controversial results. For example Gibbs (1978),

claimed that when a person is concentrating, alpha waves disappear. On the other hand it has been claimed that when alpha brainwaves predominate, people are at their most creative, are at their highest level of inspiration, experience a high level of energy, enhanced memory, enhanced concentration and learning as well as expressing better decision making abilities (Heibloem, 1990). Perhaps the difference between Gibbs' observation and that of Heibloem can possibly be accounted for by the fact that for Heibloem, the individual is already in a relaxed alpha state (i.e. alpha brainwaves predominate), prior to any form of imagery. (The effects of relaxation prior to imagery shall be assessed in this study). Some 50 years ago, Golla, Hutton and Walter (1943) and Short (1953) suggested that visual imagery was indicated by the suppression of the occipital EEG alpha rhythm. In 1957, Costello and McGregor concluded that the amount of suppression of the alpha rhythm was a result of both the vividness of the image as well as the extent to which the higher order thought processes were involved. In more contemporary research, Marks and Isaac (1995), confirmed, that alpha attenuation is an objective indicator of visual imagery. Interestingly, however, Marks and Isaac also found that movement imagery was associated with alpha enhancement rather than attenuation. In light of the various findings, what seems to be relevant is both the positioning of the EEG electrodes on the cortex that have been used in order to assess changes in alpha activity during imagery rehearsal and the types of imagery (motor or visual) being rehearsed. For example, Marks and Isaac (1995) observed that alpha power was attenuated during *visual* imagery, particularly in the *left* posterior quadrant of the cortex, by those who claimed to have a high ability to produce vivid images, but the differences in alpha attenuation appear to be in the opposite direction to the results for the motor imagery task i.e. *movement* imagery was associated with alpha enhancement amongst vivid imagers, rather than attenuation, in the *right* posterior quadrant. In light of their findings, Marks and Isaac's support the official definition of the alpha rhythm as put forward by the International Federation for Electroencephalography and Clinical Neurophysiology, which states that the alpha rhythm, "usually with frequency 8-13Hz in adults, most prominent in the posterior areas, present most markedly when eyes are closed, and attenuated during attention, especially *visual*" (Cited in Evans & Mulholland, 1969). Marks and Isaac did however find differences between those reported as being vivid imagers and those categorised as non-vivid imagers. It was found that for the motor imagery task, there was, on the whole, an increase in alpha power by the vivid imagers particularly in the *right* posterior quadrant, in contrast to alpha attenuation shown by the non-vivid imagers.

Could this result possibly be due to the fact those who appear to have a high vivid imagery ability are able to produce images with greater ease, thus being more relaxed and having to pay less attention to image production than those who have a low vividness imagery ability, and tend to have to concentrate on/ pay attention to trying to produce a vivid image which, according to the above mentioned definition, reduces the occurrence of alpha? The overall finding by Marks and Isaac was that the *right* posterior quadrant was where the greatest difference occurred in cortical activation for the two groups (vivid and non-vivid imagers), the reason for which is not yet fully understood. Although the reasons for the different changes in alpha rhythm which have been observed for the two kinds of imagery (visual and motor) are also not yet fully understood and requires further research, the relevant issue is that changes in alpha activity have been reported, specifically alpha enhancement during motor imagery. With the above in mind, the present test attempted to assess whether or not those subjects who appear to have a high imagery ability as expressed by the results of the Vividness of Movement Imagery Questionnaire (VMIQ) (Isaac, Marks, & Russell, 1986), also exhibit predominant alpha waves on an Electroencephalograph (EEG) machine when undergoing an imagery rehearsal activity.

METHODOLOGY

Subjects

Nine subjects, 7 females and 2 males, ranging in age from 18 - 28 years volunteered to participate in the study. All subjects were students from the Division of Physical Education, University of the Witwatersrand and participated in various sports. Physical Education students were selected as an appropriate sample for the study since imagery rehearsal has shown to be most effective with subjects who are familiar with the physical movements to be recreated during the imagery rehearsal activity (Harris & Harris, 1984) - The VMIQ, which was implemented as a means to assess imagery ability consists of movements with which Physical Education students are au fait. For purposes of external validity, the subjects chosen for the study were not participants of only one particular sport, but rather had had general experience in a variety of sports and movement activities.

Gender differences were not considered to be a threat to internal validity for two reasons: Firstly, results from a pilot study, in which 21 physical education students (9 males, 12 females) completed the VMIQ, indicated no overall significant differences in the imagery abilities of males and females, i.e. subjects from both groups exhibited imagery abilities varying from average to high. Secondly, the results of the EEG recordings for each subject were compared only to that subject's EEG recordings during the various conditions. That is, EEG baseline recordings, EEG recordings obtained during external imagery, EEG recordings obtained during internal imagery, EEG recordings obtained during kinaesthetic imagery, and EEG recordings obtained during relaxation for each individual subject were all compared to each other rather than one subject's EEG recordings being compared to another subject's or all other subjects' EEG recordings. As such, the fact that only 2 males compared to 7 females took part in the study was not considered problematic.

Instrumentation

The Vividness of Movement Imagery Questionnaire (VMIQ) (Isaac, Marks, & Russell, 1986), including an adaptation to the test as seen in the VMIQ-Mark II, was implemented as a means of assessing each subjects imagery abilities. The VMIQ is composed of 24 items relevant to movement imagery; visual imagery of movement itself and imagery of kinaesthetic sensations. Subjects are required to image each movement item both with respect to someone else doing the movement (i.e. external imagery, referred to as "watching someone else" on the VMIQ) and with respect to imaging themselves doing the movement (i.e. internal imagery, referred to as "doing it yourself" on the questionnaire). The VMIQ, as used in this study was adapted slightly from the original VMIQ as developed by Isaac, Marks and Russell, in that respondents were not only required to provide self-report ratings in relation to how well they could image the items with respect to someone else doing the movements and themselves doing the movements, but subjects were also required to report on how well they were able to feel themselves, in imagery, doing the movements. The purpose of this inclusion to the test, as adopted from the VMIQ-Mark II, was to provide a means of assessing changes in alpha brainwave activity during kinaesthetic imagery, which is referred to as "feeling it yourself" on the VMIQ, as used in this study. The original VMIQ was designed with the intention that it could be administered to a wide variety of subjects differing in age and experience. Therefore

the items relate to common movement situations and not specific motor skills. The items cover movement situations from basic body movements to movements that demand more precision and control in upright and unbalanced situations. The items which consider basic body movements were included first in order to help the subjects image simple situations with which they would be familiar. In designing the instrument, Isaac, Marks and Russell explain that an understanding of the task during the initial stage would help the subjects in further use of the imaging technique during the other movement situations. The initial movement situations are basic movement development situations as illustrated in such items as walking and running. The items relating to basic movements with more precision develop naturally from those in the first section. Again the movements are common, although requiring the imagery of more precise movements, such as "reaching for something on tiptoe". The items then progress to movements that are still fairly familiar but more complex, including movements involving control and balance.

Rating scale: All 24 test items are rated three times according to a 5-point rating scale. Each item has to be rated according to (1) the clarity of the image when "watching somebody else", (2) the clarity of the image when "doing it yourself", and (3) the extent of the feeling/ sensation experienced when "feeling it yourself". The first two ratings for each item are rated according to the following rating scale:

The image aroused by each move might be:	**Rating**
Perfectly clear and as vivid as normal.....	4
Clear and reasonably vivid.....	3
Moderately clear and vivid.....	2
Vague and dim.....	1
No image at all, you only "know" that you are thinking of the skill.....	0

The third rating for each item is to be made according to the following rating scale:

The feeling/ sensation aroused by each move might be:	**Rating**
Very strong (you can *feel* yourself performing the move as if you were actually doing it)	4
Reasonably strong (although you can *feel* yourself performing the move, the sensations aren't as strong as if you were physically performing the move).....	3
Moderately strong	2
You have a very vague *feeling* of performing the move...	1
You cannot *feel* yourself performing the move at all	0

Although the original VMIQ is scored on a rating scale ranging from 1-5, with a score of 1 representing "no image at all", it was decided that for the purposes of this study, the rating scale shall range from 0-4, with 0 representing "no image at all", since for purposes of statistical analysis it is more practical not to reward a numerical score if one is unable to imagine a sensation or create an image in one's "mind's eye".

Based on the rating scale, the highest possible score for an individual to attain would be 96.

Instructions: The following instructions appear on the front page of the VMIQ that was used in the present study:

> "Movement Imagery" refers to the ability to imagine movement. The aim of this questionnaire is to determine the vividness of your movement imagery ability and your ability to imagine feeling the sensations as if you were actually performing the movement. The items of the test are designed to bring certain images to your mind. You are asked to rate the vividness of each item by reference to the 5-point scales.
>
> After each item, write the appropriate number in the box provided. The first box is for a visual image obtained watching someone else, the second box is for a visual image obtained doing it yourself, and the third box is for an image associated with the feel (kinaesthetic sensation) of the movement. Try to respond to each item separately, independently of how you may have responded to other items.
>
> First complete all the items obtained watching somebody else. Secondly, visualise the movement again and rate the image obtained as if you were doing it yourself. Thirdly, rate the feel (kinaesthetic sensation) of the image. Your 3 ratings for a given item might **not** necessarily be the same in all cases. While you are imaging please have your eyes **CLOSED**.

Isaac, Marks and Russell (1986) conducted a test-retest reliability, on the original VMIQ, over a 3 week interval, whilst stability was assessed over 6 months and validity was correlated against the Vividness of Visual Imagery Questionnaire (Marks, 1973) . The results suggested that the VMIQ is reliable ($r = 0.76$), stable and valid ($r = 0.81$) as a measure of an individual's ability to produce images of movement (Isaac, et al., 1986). The use of such a self-report measure as a means of assessing imagery ability has received further support from Marks and Isaac (1995). In light of the results obtained from their study, Marks and Isaac confirmed that the VMIQ self-report measure of imagery vividness, is a valid measure of differing mental experience. This finding was based on the fact that the subjects selected for their differential reporting on the VMIQ of vivid or non-vivid imagery show significant differences in EEG patterning during visual imagery (Marks and Isaac, 1995).

For purposes of assessing brainwave activity, an EEG machine was used under the supervision of the staff at the Wits Sleep Laboratory.

Procedure

All potential subjects were informed, verbally as well as by means of a written subject information sheet of the purpose of the study (Appendix A). Based on the explanation provided to them, nine students from the Division of Physical Education, University of the Witwatersrand, volunteered to participate in the study. The study was in two stages. In stage one, all subjects completed and signed a consent form, and a general health questionnaire (Appendix A). The subjects were then requested to complete the VMIQ in their own time. Stage two took place approximately two weeks after the VMIQ was administered for the first time. During this second stage the subjects met, at allocated times, at the Wits Sleep Laboratory, Wits Medical School, where EEG electrodes were attached to the subjects prior to the subjects completing the VMIQ for a second time. The researcher randomly divided the subjects into an experimental and a control group. The experimental group, consisting of 4 subjects, were subjected, whilst attached to the EEG machine, to a relaxation exercise prior to completing the VMIQ for a second time. The control group, consisting of 5 individuals, did not receive the relaxation intervention.

Preparation of the head included measurement and marking in accordance with the international 10-20 electrode placement system, which involves measurements being made at 10 and 20 percent of the distances from inion to nasion, from left to right preauricular points, and around the circumference of the head. The intersecting points denote electrode placements (Harner & Sannit, 1974) (See Fig.1).

For the purposes of assessing changes in alpha brainwave activity, a total of seven electrodes were linked to the subject. After the sights for the electrode placements were cleaned, slight abrasions were made in order to enhance the conduction of the electrical impulses through the electrodes. Two of the electrodes were secured on the head, by way of glue specifically designed to attached the electrodes comfortably to the skull, in positions O2 and C3 as depicted in Fig.1. Three electrodes were attached to the face with micropore; one electrode

in the middle of the forehead, approximately an inch above the frontonasal suture acting as an earth, one on the frontal bone above and to the left of the left eye, and the third electrode was placed on the zygomatic bone below and to the right of the right eye (as depicted in Fig.2) in order to record movement in the eye muscles.

Figure 1. Schematic diagram showing measurements for the 10-20 electrode placement system

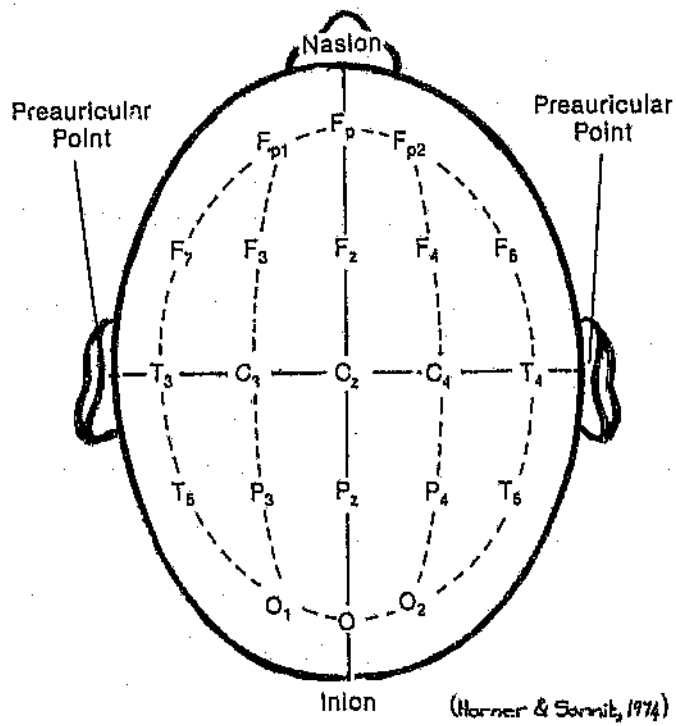
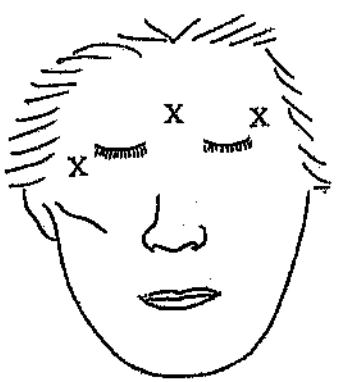


Figure 2. Schematic diagram showing markings for electrode placement on the facial region



X = Placement of electrode

Linked ears (one electrode was placed behind each ear, on the mastoid portion of the temporal bone), were used as reference electrodes.

Once all the electrodes were in place the cups on the ends of the electrodes were filled with conducting gel and then the electrodes were checked, by computer analysis, to ensure that the electrical impulses from the brain were being conducted effectively through the electrodes. The high and low pass filters were set at 30 Hz and 1.6 Hz respectively, the paper speed was set at 60 mm/s, and the sensitivity at 2 μv/mm. The sampling rate was 240 Hz/ second (i.e. 240 samples per second).

The subjects were first requested to close their eyes and a baseline EEG reading was obtained over a 30 second period. Those in the experimental group were then exposed to a relaxation exercise (with eyes closed), with the researcher as narrator. The relaxation exercise, as presented in Appendix B, took approximately five minutes to complete. Thereafter the VMIQ was administered for the second time (to both the experimental and control groups). In the second administration of the VMIQ, the subjects were instructed to sit with their eyes closed while the researcher verbally described the actions to be imaged. Subjects were requested to keep their eyes closed so that (a) they would not be distracted by external stimuli and (b) because according to the definition of the alpha rhythm as described by the International Federation for Electroencephalography and Clinical Neurophysiology (cited in Evans & Mulholland, 1969), the alpha rhythm is present most markedly when eyes are closed.

The subjects were required to rate how well they were able to image the actions as if "watching someone else". The researcher recorded each subject's ratings according to the appropriate 5-point scales, as the subject expressed his/ her rating by a show of fingers on one hand. The researcher then returned to the top of the list of 24 items and asked the subject to rate each action for a second time in accordance with how well they could image themselves doing the action. In order to assess how well each subject could sense the feeling of doing the movements, the subject rated each item for a third time with reference to the kinaesthetic imagery dimension.

The results of the VMIQ's were then statistically analysed in order to determine if there were significant differences in imagery ability between the self-report scores recorded on the first and second administration of the VMIQ.

Due to technical problems, only 2 seconds of brainwave activity could be selected, per condition, (i.e. during baseline reading, external imagery, internal imagery, kinaesthetic imagery, and during relaxation) for analysis. The two seconds of brainwave activity were randomly selected from each imagery condition. The random selection was employed so that unsuspected sources of bias could be controlled for even though the characteristics of the sampling unit cannot be guaranteed. The 2 seconds of randomly selected EEG activity per condition, as recorded on computer, through the electrode placed on O2, was subjected to *Fourier analysis,* by means of the *Fast Fourier Transform* computational procedure, in order to calculate power estimates for a middle range band including alpha (8 to 14Hz) and a higher band composed of beta 1 (14 to 20Hz). Electrical activity that was emitted via the electrode placed on O2 was used for statistical analysis, as opposed to the impulses emitted from the C2 region because firstly, due to technical complications, electrical impulses emitted from only one of the regions could be subjected to statistical analysis. Secondly, cortical activity emitted through the electrode placed on O2 was chosen for the purposes of this study in accordance with the findings of Marks and Isaac (1995), who claimed that movement imagery is associated with an increase in alpha power in the right posterior quadrant. Enhanced alpha activity in the right posterior quadrant during imagery has also been supported by the likes of McGee (1979), Morgan, McDonald and MacDonald (1971), Shone (1984), and Tucker et al. (1981).

For purposes of the Fast Fourier Transform computation, which requires that the length of the analysed series is a power of two, 512 consecutive brainwave readings were used, with each reading taken approximately every 0.47 milliseconds. The electrodes used to record movement changes in eye muscles were referred to as a means of distinguishing the EEG recordings for each condition (i.e. during baseline and relaxation recordings, during "image of other" (external imagery), "image of self" (internal imagery), and "sense of feeling" (kinaesthetic imagery)). That is, before EEG readings were obtained for each of the conditions, the subject was instructed to rapidly blink his/ her eyes four times. The marked changes in the electrical impulses elicited by the muscles signalled the end of one condition and the beginning of another.

Graphical representations depicting the randomly selected 2 second samples of EEG brainwave patterns for each subject under the different conditions are presented in Appendix

D. These graphs were then reconstructed, for purposes of comparison, using the data obtained from the Fast Fourier Transform calculations, such that the *x*-axis represents alpha and beta 1 brainwave activity measured in Hertz, and the *y*-axis represents the corresponding "power" of the electrical activity, measured in microvolts squared (μV^2). These reconstructed graphs are presented in Appendix E. Keeping in mind that subjects 1-5 were from the control group and subjects 6-9 were from the experimental group, the first graph expressed in Appendix E for each subject depicts the alpha and beta 1 brainwave activity recorded over a period of approximately two seconds for each of the conditions that the individuals were subjected to. That is, the EEG baseline recordings, the EEG recordings taken during the relaxation exercise (for those in the experimental group) and the EEG recordings taken during the second administration of the VMIQ whereby the subjects were requested to image "watching someone else" do the actions (graphed as "Image of other"), image "doing it (the actions) yourself" (graphed as "Image of self"), and image "Feeling it (the actions) yourself" (graphed as "sense of feeling") were all superimposed onto one graph. The graphs that follow are for purposes of clarification whereby (a) only the baseline alpha and beta 1 recordings are presented together with the EEG recordings emitted whilst "watching someone else", (b) only the baseline alpha and beta 1 recordings are presented together with the EEG recordings emitted whilst "doing it yourself", (c) only the baseline alpha and beta 1 recordings are presented together with the EEG recordings emitted whilst "feeling it yourself". For those of the experimental group, graphs representing the baseline alpha and beta 1 recordings are presented together with the EEG recordings emitted during the relaxation activity. Furthermore, graphs representing the EEG activity recorded during relaxation is presented together with the EEG recordings whilst "watching someone else", whilst "doing it yourself", and whilst "feeling it yourself", respectively.

Findings

From the data obtained from the first administration of the VMIQ, Cronbach alpha's were calculated to be 0,937842; 0,909480; and 0,907911 with respect to the three categories "watching somebody else", "doing it yourself" and "feeling it yourself". As such, the VMIQ, as used in this study, has shown to have strong internal consistency, thus reflecting it to be a stable and reliable instrument for measuring imagery ability. Other calculations pertaining to

the reliability of the VMIQ, are presented in Appendix C. The self-report scores of the VMIQ's were statistically analysed in order to determine if there were significant differences in reported imagery ability between the scores on the first administration and those reported on the second administration of the VMIQ. From a t-test for dependent samples, although a difference in scores were apparent between those reported on the first VMIQ and those reported on the second VMIQ, the difference was not statistically significant. It was interesting to note however that whilst only one of the five subjects from the control group showed an improvement in overall imagery ability during the second administration of the VMIQ, three of the four subjects from the experimental group improved in overall imagery ability as recorded by the second VMIQ. Total scores for each subject with reference to the separate imagery dimensions (i.e. external, internal and kinaesthetic) as well as an overall imagery ability score (i.e. the sum of the totals on the three imagery dimensions) are presented in Table 1. Note: subjects 1-5 belong to the control group, whilst subjects 6-9 are of the experimental group.

Table 1. Total VMIQ scores for imagery ability

	VMIQ 1				VMIQ 2			
Subject	Total: "Watching somebody else"	Total: "Doing it yourself"	Total: "Feeling it yourself"	Sum Total	Total: "Watching somebody else"	Total: "Doing it yourself"	Total: "Feeling it yourself"	Sum Total
1	86	90	89	265	78	90	80	248
2	70	81	84	235	57	75	77	209
3	96	96	96	288	89	69	51	209
4	62	76	87	225	61	82	81	224
5	66	69	65	200	88	90	83	261
6	79	71	80	230	73	82	84	239
7	81	94	89	264	53	59	67	179
8	87	77	79	243	87	92	94	273
9	95	66	72	233	93	84	82	259

The calculated means and standard deviations for each of the three imagery dimensions obtained from the first and second administrations of the VMIQ for all subjects are reported in Table 2.

Table 2. Calculated means and standard deviations obtained from the first (VMIQ1) and second (VMIQ2) administrations of the Vividness of Movement Imagery Questionnaire.

	VMIQ I			VMIQ 2		
	"Watching somebody else"	"Doing it yourself"	"Feeling it yourself"	"Watching somebody else"	"Doing it yourself"	"Feeling it yourself"
MEAN	80.22	80	82.33	75.44	80.33	77.66
STD.DEV	12.18	11.05	9.51	15.2	10.92	12.23

It should be noted that due to the small sample size, the data is not conducive to extensive statistical analysis in order for comparisons between subjects of the control and experimental groups to be justly made. Thus some caution should be exercised when interpreting such results.

Due to the fact that imagery rehearsal ability as well as alpha brainwave activity differs from individual to individual (as can be seen by how the imagery rehearsal ability scores on the VMIQ as well as the alpha rhythm baseline recordings differ from individual to individual) (see Table 1, and Appendix E respectively), the results of the VMIQ and the respective EEG readings were primarily subjected to a within- as opposed to between-subject statistical analysis. Within-subject analysis involves repeated measurements being made in a single subject or group of subjects. The assumption is that each subject acts as its own control and within-subject/s comparisons can thus be made.

With regards to assessing significant changes in alpha activity, paired two-sample t-tests were conducted with reference to the average alpha power recorded during baseline reading of each subject and each subject's respective average alpha power recorded during external imagery i.e. "watching somebody else" (labelled "Image of other" on the graphs, in Appendix E). Similarly paired two-sample t-tests were conducted with reference to the average alpha power recorded during baseline reading for each subject and:

- the respective average alpha power recorded during internal imagery i.e. "Doing it yourself" (labelled "Image of self" on the graph),
- the respective average alpha power recorded during kinaesthetic imagery i.e. "Feeling it yourself" (labelled "Sense of feeling" on the graph).

The data obtained from the subjects of the experimental group were subjected to further statistical analysis i.e. paired two-sample t-tests were conducted with reference to the average

alpha power recorded during baseline reading and the average alpha power recorded during relaxation, "Image of other", "Image of self", and "Sense of feeling", for each subject respectively. It was concluded from the statistical analysis that no significant changes in alpha activity were evident for any of the conditions, in both the subjects of the control and experimental groups. From the graphs presented in Appendix E, it is however evident that whilst changes in alpha activity might not be significantly different within each individual, there are in deed shifts in alpha intensity over the various conditions. It can be speculated from the graphs in Appendix E as well as from the data in Table 3 that these shifts in alpha intensity are however not the same for all subjects, when comparing one subject's recordings with that of another, nor the same for all conditions, when comparing one subject's recordings for one condition with that of another condition or when comparing one subject's recordings for one condition with that of another subject's recordings for the same condition. That is, whilst the graphical representations of brainwave activity, as presented in Appendix E, leads one to believe that alpha activity over the right occipital lobe is, on average, enhanced during all imagery conditions (with respect to the baseline readings) in subjects 1, 3, 4 and 7, this was not the case for the other subjects. Furthermore, whilst it is speculated that the greatest mean alpha activity was emitted during external imagery (graphed as "image of other"), in subjects 3, 5 and 6, the greatest mean alpha activity is emitted during kinaesthetic imagery (graphed as "sense of feeling") for subject 1, during internal imagery (graphed as "image of self") for subjects 2 and 4, and during the baseline reading for subjects 8 and 9. It is interesting to note that whilst relaxation supposedly induces a predominantly alpha state, one can speculate from both the graphs and from the data in Table 3 that only subject 7 (i.e. one of the four subjects to have received the relaxation intervention) emitted the greatest alpha activity during relaxation as opposed to the other conditions. With regards to subjects 8 and 9, who, as is evident from Table 3, emitted greater alpha activity on average during the recording of the baseline reading, compared to the recordings for the other conditions it is possible that at that time these subjects were more relaxed than during the relaxation exercise itself. A reason for this could be that during the recording of the baseline reading, subjects were requested to "sit and relax" and their attention was able to wander, which according to Evans and Mulholland (1969), is associated with optimal occipital alpha rhythm. On the other hand, the relaxation exercise was new to the subjects and the subjects were instructed to *concentrate* on relaxing their bodies. Such focused concentration, according to Evans and Mulholland can result in

alpha attenuation rather than alpha enhancement. It is only when the art of relaxation is perfected after many hours of practice that relaxation can be obtained effortlessly and thus without having to concentrate (Shone, 1984).

Table 3. Calculated Means and Standard Deviations for Absolute EEG Readings

		Baseline EEG Reading	"Image of other" EEG Reading	"Image of self" EEG Reading	"Sense of feeling" EEG Reading	EEG Reading During Relaxation
Subject 1	**Mean**	220.73	328.63	301.42	510.62	
	Standard Deviation	138.491	283.354	142.133	399.113	
Subject 2	**Mean**	511.41	396.22	589.08	441.62	
	Standard Deviation	228.228	214.45	346.289	213.917	
Subject 3	**Mean**	291.67	706.65	649.7	375.95	
	Standard Deviation	132.518	477.36	421.749	136.664	
Subject 4	**Mean**	381.7	610.96	737.09	720.35	
	Standard Deviation	224.314	419.728	520.196	495.949	
Subject 5	**Mean**	491.66	694.63	265.87	436.88	
	Standard Deviation	271.161	779.79	121.448	307.483	
Subject 6	**Mean**	578.66	949.61	612.68	330.41	633.22
	Standard Deviation	329.307	1,067.817	315.552	166.564	458.918
Subject 7	**Mean**	336.61	555.48	430.42	470.21	711.47
	Standard Deviation	146.5	342.764	236.828	255.32	530.424
Subject 8	**Mean**	538.75	459.3	333.35	512.77	305.99
	Standard Deviation	555.195	429.808	173.768	304.509	144.48
Subject 9	**Mean**	392.97	229.22	247.95	209.74	319.94
	Standard Deviation	206.271	160.67	173.287	89.111	153.432

It can also be observed in all graphs in Appendix E that alpha brainwave activity is more pronounced than beta activity during the imagery conditions, thus supporting the claim that specific changes in brainwave patterns are evident during various types of mental functioning (Evans & Mulholland, 1969).

In determining whether or not those subjects who reported the highest imagery ability scores on the second administration of the VMIQ also emitted alpha waves of the highest intensity, as recorded by means of an EEG, it was evident that whilst subjects 8, 5, 9 and 1 reported having the four highest imagery ability scores, respectively, (see Table 1) their respective graphical representations of alpha power did not seem to correlate with imagery ability. In fact, as mentioned above, from the graphs for subjects 8 and 9, one can speculate that the alpha power was, on average, higher during baseline activity, than during any of the imagery conditions. Furthermore, it became evident from the recorded data and the graphs that there were subjects

who, when compared with another subject, reported a lower overall imagery ability score, but emitted alpha brainwave patterns of greater intensity. For example, as can be seen from Tables 1 and 3, when comparing subject 7, (who, of all nine subjects, obtained the lowest overall score in imagery ability), with subject 9, (who had obtained the third highest imagery ability score on the second administration of the VMIQ), subject 7 exhibited an increase in alpha power, from baseline reading, over all imagery conditions such that the mean alpha activity emitted by subject 7 during the imagery conditions (i.e. 555.48, 430.42, and 470.21, for the external, internal and kinaesthetic imagery conditions respectively) were greater in all cases compared to the mean alpha activity emitted during the same imagery conditions for subject 9, which were 229.22, 147.95 and 209.74, respectively.

From the scores on the VMIQ and the baseline EEG alpha readings, it is evident that imagery ability and the power of the emitted alpha brainwave activity differs from individual to individual. As such, comparing a subjects score with his/ her other scores would appear to be more appropriate than comparing a subject's score(s) with the score(s) of the other subjects. When qualitatively comparing each individual's scores obtained on the second administration of the VMIQ with their respective mean alpha activity emitted during the different conditions, the following was observed: Subject 3 scored highest on external imagery (i.e. the category "watching somebody else" on the VMIQ in Table 1, for which subject 3's score was 89 compared to scores of 69 and 51 for the categories "doing it yourself" (internal imagery) and "feeling it yourself" (kinaesthetic imagery) respectively), and also emitted the greatest alpha activity, on average, during this same imagery condition (i.e. the category labelled "image of other" on the graphs in Appendix E and Table 3, for which subject 3's mean EEG recording was 706.65, compared to the mean EEG recordings of 649.7 and 375.95 for "image of self" (internal imagery) and "sense of feeling" (kinaesthetic imagery), respectively. A similar relationship between imagery ability and emitted alpha activity was observed in subject 4 for internal imagery, whereby subject 4's highest imagery ability score was for internal imagery (referred to as "doing it yourself" on the VMIQ in Table 1, which was recorded as 82, compared to scores of 61 and 81 for "watching somebody else" (external imagery) and "feeling it yourself" (kinaesthetic imagery), respectively) and greatest alpha activity, on average, was also for internal imagery (referred to as "image of self" on the graph in Appendix E and Table 3, which was recorded as 737.09, compared to mean EEG readings of 610.96 and

720.35 for "image of other" (external imagery) and "sense of feeling" (kinaesthetic imagery), respectively). Whilst subject 8 emitted the greatest alpha activity on average during the recording of the baseline alpha EEG, (i.e. 538.75, see Table 3), the greatest alpha activity recorded during an imagery condition was during kinaesthetic imagery, (referred to as "sense of feeling" on the graph in Appendix E and Table 3, for which subject 8 emitted a mean alpha rhythm of 512.77, compared to mean alpha rhythms of 459.3 and 333.35 for internal imagery and external imagery, respectively). According to the scores on the second VMIQ, (see Table 1) subject 8 also scored highest on kinaesthetic imagery (i.e. a self-report score of 94, compared to scores of 87 and 92 for internal and external imagery respectively). Conversely, both subjects 2 and 4 scored lowest on external imagery ability (i.e. scores of 57 for external imagery ability and 75 and 77 for internal and kinaesthetic imagery abilities, respectively for subject 2 and scores of 61 for external imagery ability and 82 and 81 for internal and kinaesthetic imagery abilities, respectively, for subject 4), whilst also emitted the lowest alpha activity during the external imagery condition (i.e. a mean alpha EEG recording of 396.22 for external imagery, compared to mean alpha EEG recordings of 589.08 and 441.62 for internal and kinaesthetic imagery respectively, for subject 2 and a mean alpha EEG recording 610.96 for external imagery, compared to mean alpha EEG recordings of 737.09 and 720.35 for internal and kinaesthetic imagery respectively, for subject 4). Similarly, subject 9 appeared to have the lowest imagery ability for kinaesthetic imagery (i.e. a score of 82 compared to scores of 93 and 84 for external and internal imagery, respectively), and also recorded the lowest alpha activity for this imagery dimension (i.e. mean alpha EEG recording of 209.74, compared to mean alpha EEG recordings of 229.22 and 247.95 obtained during external and internal imagery, respectively). The findings for subjects 1, 5 and 6 were somewhat different. Subject 1, whom although having the fourth highest overall imagery ability score with respect to the other eight subjects (see Table 1), and, as described in Table 3, having also emitted an increase in alpha activity for all imagery conditions compared to the baseline reading, (i.e. a mean baseline EEG reading of 220.73 compared to mean EEG readings of 328.63, 301.42 and 510.62 during internal, external and kinaesthetic imagery respectively), scored highest on internal imagery (i.e. a self-report score of 90 for internal imagery, compared to a score of 78 and 80 for external and kinaesthetic imagery respectively), but emitted the lowest alpha activity during this imagery dimension. Similarly, when assessing subject 5 and subject 6's VMIQ scores and corresponding alpha activity, it is evident that subject 5 scored highest on

internal imagery ability (i.e. a self-report score of 90 for internal imagery compared to a score of 88 and 83 for external and kinaesthetic imagery respectively) whilst emitting the lowest alpha activity whilst imaging in this dimension (i.e. a mean alpha EEG recording of 265.87 for internal imagery, compared to mean alpha EEG recordings of 694.63 and 436.88 obtained during external and kinaesthetic imagery, respectively). Subject 6 scored highest on kinaesthetic imagery (i.e. a self-report score of 84 for kinaesthetic imagery compared to self-report scores of 73 and 82 for external and internal imagery respectively), but emitted the lowest alpha activity during this dimension (i.e. a mean alpha EEG recording of 330.41 during kinaesthetic imagery, compared to mean alpha EEG recordings of 949.61 and 612.68 obtained during external and internal imagery respectively). Although a relationship between imagery ability and enhanced alpha activity for these subjects was not observed, one cannot rule out the possibility that subjects 1, 5 and 6, concentrated harder on producing vivid and controllable mental images during the dimensions for which they obtained the highest scores, which, as mentioned above, could be the reason for the resultant alpha attenuation rather than alpha enhancement.

Discussion

From the findings it is evident that whilst the difference in VMIQ scores for the control and the experimental conditions do not differ significantly from the first administration of the questionnaire to that of the second, the fact that three of the four subjects from the experimental group did show improvements in overall imagery ability is quite meaningful. The reason being is that this finding, although obtained from a small sample and is not statistically significant, does at least provide support for the possibility that relaxation can in fact aid imagery rehearsal and also highlights the fact, as claimed by Perry and Morris (1995) that even though further research is still required, relaxation should not be excluded from imagery rehearsal intervention programmes. Furthermore, even though the changes in alpha activity emitted by the subjects during the various conditions were not statistically significant, it should be noted that firstly, one's ability to relax with the aid of a relaxation exercise improves with practise, as does one's ability to recreate vivid and controllable mental images. Thus, should the study have been conducted over a longer period of time, with the subjects being exposed to frequent relaxation and imagery rehearsal practice sessions, perhaps a more significant

difference would be seen in both one's ability to utilise imagery rehearsal effectively, (since, as mentioned earlier in this paper, psychological skills such as imagery rehearsal are actually trainable), as well as an increase in one's alpha activity recorded over time, due to one's improved ability to relax (since, as already mentioned, physiological changes associated with relaxation include the emission of predominantly alpha brainwave activity). In light of one of the purposes of this study, which was to assess whether or not those subjects who appear to have high imagery ability also exhibited predominantly alpha rhythms, it was found that in some cases the greatest alpha activity was emitted during the imagery condition which was, according to the scores on the second administration of the VMIQ, reported to be of the highest quality for the individual concerned (e.g., subjects 3, 4 and 8), whereas, there were also those subjects (for example subjects 1,5 and 6) who emitted the highest alpha activity during the same imagery condition reported as being of the lowest quality, according to the scores on the second administration of the VMIQ. These conflicting results highlight two issues of concern when considering the relationship between imagery ability as recorded on the VMIQ and alpha activity as recorded by means of the EEG machine: Firstly, with regards to imagery ability as recorded by the VMIQ, there is "no way of knowing whether or not subjects are applying the same standard of marking in their ratings" (Anderson, 1981, p.157). As such, not only could the making of comparisons between one subject's self-report data and that of another be problematic, but when comparing an individual's imagery ability score on the subjective self-report VMIQ, with that of his/ her more objective EEG recordings, the findings could be confounded by that subject applying different standards of marking in his/ her self-report ratings. For example, it is questionable whether or not subject 7, who scored the lowest in overall imagery ability in the second administration of the VMIQ, did in fact experience the greatest difficulty, compared to all other subjects, in creating vivid and controllable mental images since one cannot rule out the possibility that subject 7 was stricter than the other subjects in the rating of the mental images. As such subject 7 could have reported lower scores than the other subjects, not because subject 7's ability was necessarily lower than that of the other subjects, but because subject 7's ratings were that much stricter those given by the other subjects. In fact, for the same reason, it is possible that subject 7 may not have had a low overall imagery ability at all. This example highlights one of the major problems experienced with self-report methods of testing. Another major problem that has been observed when attempting to assess imagery ability is that none of the available tests

employed for this purpose have acceptable validity, even though some tests (such as the VMIQ) have satisfactory reliability (Perry & Morris, 1995). This means that while some of the imagery ability tests might give the same results on different occasions, and all the items may be measuring the same construct, there is no evidence that the construct being measured is imagery or, more precisely in most cases, vividness of imagery or its controllability. One must thus keep this problem of test validity in mind and be cautioned when attempting to draw definite conclusions from the apparent relationship between reported imagery ability and the objective EEG recordings.

The secondly issue of concern is made with respect to the alpha activity as recorded by means of the EEG machine for this particular study. As mentioned, due to technical limitations, only two seconds of randomly selected EEG activity, per condition, (i.e. baseline, relaxation (for those in the experimental group), external imagery, internal imagery and kinaesthetic imagery) were subjected to statistical analysis. Keeping in mind that the frequency and amplitude of brainwave activity is never constant and considering the fact that the baseline reading was taken over a 30s period with each of the other EEG readings taken over a period of at least 3 minutes in duration, results might have proved more significant if all EEG recordings, not only the randomly selected two seconds, could have been statistically analysed.

Conclusion

Whilst it is clear from past research as well as the findings in this study that imagery ability differs from individual to individual, three of the four subjects from the experimental group showed an improvement on imagery ability on the second administration of the VMIQ. It is noted that this improvement was however not statistically significant. This lack of significant difference could be very much due to the small sample size used in this study. As such, one can only speculate that the improvement in imagery ability, in some subjects, was due to the relaxation intervention. Furthermore, whilst it is evident that brainwave activity differs from individual to individual, no statistically significant changes in alpha activity were observed in the absolute EEG recordings (as graphed in Appendix E) for subjects of either the control or of the experimental group. It was however speculated that all subjects emitted, on average, greater alpha power than beta and that seven of the nine subjects did emit an increase in alpha

activity, from baseline, during at least one imagery condition. It can also be speculated though that only three of the nine subjects reported their highest imagery ability scores for the same dimensions in which, according to the EEG readings, they emitted the greatest amount of alpha activity. As such, although in general it appears that the imagery process may be accompanied by an increase in right occipital alpha, it cannot be concluded, from the present research findings, that a direct relationship between a specific imagery ability and the corresponding alpha power actually exists. Furthermore, an increase in alpha activity (although not statistically significant) following relaxation was only observed in two of the four subjects from the experimental group. Despite not having received the relaxation intervention, all the subjects from the control group showed an increase in alpha activity (although not statistically significant), in at least one imagery condition compared to baseline reading. As such, due to lack of statistical evidence, one can only speculate, from the findings of this study that relaxation might not necessarily enhance one's emission of alpha activity but may be beneficial for imagery intervention programmes in sport psychology in that relaxation may enhance one's ability to produce vivid and controlled mental images, which, according to research is a necessary condition for an imagery rehearsal intervention programme to be effective. More research is however needed in order to determine the influence of relaxation on alpha brainwave activity and imagery rehearsal ability.

Future Recommendations

The aim of this research was to assess whether or not a triadic relationship exists between relaxation, brainwave activity and imagery rehearsal ability, such that by employing relaxation into an imagery intervention programme, results would prove most desirable. With this in mind, perhaps more significant findings would have been observed if the study had been conducted over a longer period of time whereby the subjects could have been exposed to frequent relaxation practice sessions in order to improve their ability to relax and frequent imagery rehearsal practice sessions, in order to improve their imagery abilities. As such, it is recommended that future studies attempting to find if such a triadic relationship exists, be conducted over a longer period of time, giving subjects time to become familiar with and learn the art of relaxation and imagery rehearsal.

With regards to measuring EEG activity when a subject is subjected to imagery rehearsal instructions, Lang's theory should be kept in mind. According to Lang's theory, (as described on page 33), imagery instructions that contain response propositions elicit more physiological responses than do imagery instructions that contain only stimulus propositions. The VMIQ does not employ response propositions to initiate mental imagery, only stimulus propositions. For this reason, it is recommended that future research should involve the assessment of changes in alpha activity, with respect to different imagery instructions, such that the imagery instructions themselves are not potential confounding variables.

Due to the small sample size used in this study one could only speculate that the improvement in imagery ability, as recorded by means of the VMIQ, was due to the relaxation intervention. For this reason, it is recommended that more subjects are used in future studies whereby more complex statistical techniques can be employed in order to produce significant findings. It should be kept in mind however, that single-case research designs also have a place in this type of research, since, confounding variables inherent in individual differences can greatly reduce the external validity of the research findings, if they are not sufficiently controlled for, which is often difficult, if not impossible to do.

As already mentioned earlier in the paper, further investigation is still required regarding how imagery actually works to enhance performance. In doing so, more consideration should be given to the specific brainwave patterns that are emitted during such a process, as well as the physical and mental conditions associated with such brainwave patterns. Keeping in mind that according to Kimiya (1968) and Nowlis and Kimiya (1970), the vast majority of people can learn to alter their brainwave activity such that the duration of alpha activity dominance be increased to some extent, research is still needed in order to confirm whether imagery rehearsal, as used in learning new skills and/ or correcting already learned skills, is most effective when a person is in an alpha state (i.e. alpha waves predominate).

It is evident that whilst studying the concept of imagery rehearsal as an aid to improving physical performance is a difficult yet exciting challenge, and whilst there is support for implementing relaxation as part of an imagery intervention programme in sport psychology, before the most desirable imagery intervention procedure can be developed, further research

needs to be undertaken. Until more significant findings are observed, imagery rehearsal, as a psychological performance enhancement technique shall continue to remain as controversial as it is fascinating.

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APPENDIX A

Subject Information Sheet

Relaxation, Imagery Rehearsal and Brainwave Activity:
Implications for Imagery Intervention Programmes in Sport Psychology.

Dear Volunteer,

I, Mandy Behrmann invite you to participate on a voluntary basis in a study to assess potential links between relaxation, imagery rehearsal and brainwave activity.

I require both male and female volunteers from the Division of Physical Education, University of the Witwatersrand.

Volunteers must not be on any medication (other than for contraceptive purposes) or drugs and must not have a history of mental illness.

Volunteers will be required to complete a questionnaire used to assess imagery ability. The questionnaire takes approximately 15 minutes to complete. This initial questionnaire will be administered at the Division of Physical Education at a time suitable to the volunteer.

Volunteers will then be asked to make themselves available within two weeks after completing the questionnaire, for further testing at the Wits Sleep Laboratory, Wits Medical School. Testing at the Sleep Laboratory will involve completing the imagery ability questionnaire for a second time, however volunteers will be linked to an EEG (electroencephalograph) machine and EEG readings will be taken during this time. The procedure at the Sleep Lab. will take approximately half an hour to complete.

It is important that volunteers have a good night's sleep prior to the testing.

As participation is voluntary, participants are free to withdraw from the project at any time without prejudice.

If you have any further questions regarding the study and / or you would like to volunteer, please contact Mandy Behrmann, Room 34, (716-5717/8), Division of Physical Education, Wits University.

Sincerely

Mandy Behrmann

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
WITS SLEEP LABORATORY

CONSENT TO ACT AS A SUBJECT IN A RESEARCH PROJECT

1. I, ...
being 18 years or older, consent to participating in a research project entitled "Relaxation, Imagery Rehearsal Ability and Brainwave Activity: Implications for Imagery Intervention Programmes in Sport Psychology",
and allow the necessary procedures to be performed on me.

2. The procedures have been explained to me and I understand and appreciate the purpose of the research, any risks involved and the extent of my involvement.

3. I understand that the procedures form part of a research project, and may not provide any direct benefit to me.

4. I understand that my participation is voluntary, and that I am free to withdraw from the project at any time without prejudice.

....
Participant's signature Date

....
Researcher's signature Date

General Health Questionnaire

Please cross (X) appropriate response:

1. Are you right or left-handed? | R | L |

2. Are you presently on any medication? | yes | no |

   If yes, please state what medication you are on .....
   .....

3. Did you have a good night's sleep? | yes | no |

4. Are you feeling nervous or anxious about anything? | yes | no |

5. Have you had any history of medical disorders such as epilepsy? | yes | no |

   If yes, please state the disorder.....
   .....

Any other comments and / or questions: .....
.....
.....
.....

THANK YOU
FOR YOUR PARTICIPATION

MANDY BEHRMANN
Master's student
Wits University

APPENDIX B

Self-Directed Relaxation Script

Take a deep breath and slowly exhale. Think "relax" (pause). Inhale deeply . . . exhale slowly . . . inhale deeply . . . exhale slowly. Now focus all your attention on your head. Feel any tension in your forehead. Just relax the tension in your forehead. Relax . . . (pause). Relax even deeper . . . and deeper . . . and deeper.

Feel any tension in your jaw or other facial muscles. Just relax the tension in these muscles. Feel the tension flow away.

Inhale deeply . . . exhale slowly. Feel the relaxation in your facial muscles. Relax . . . (pause). Inhale deeply . . . exhale slowly (pause). Relax even deeper . . . and deeper . . . and deeper.

Now feel any tension in your arms, forearms, and hands. Just relax the muscles in your arms. Relax . . . (pause).

Feel any tension in your hands, fingers, or arms, and just relax the tension in these muscles. See the tension flow out your body.

Inhale deeply . . . exhale slowly. Feel the relaxation in your arms and hands. Relax . . . (pause). Inhale deeply . . . exhale slowly (pause). Relax even deeper . . . and deeper . . . and deeper.

Now focus your attention on your neck and upper back. Feel any tension in the muscles of your neck and upper back. Just relax the tension in these muscles. Relax . . . (pause).

See the tension flow out of your body. Inhale deeply . . . exhale slowly. Feel the relaxation in these muscles. Relax . . . (pause). Inhale deeply . . . exhale slowly (pause). Relax even deeper . . . and deeper . . . and deeper.

Remember to keep your facial muscles relaxed. Keep your arms and hand muscles relaxed. And keep your neck and upper back muscles relaxed. Keep all these muscles relaxed. Inhale deeply . . . exhale slowly. Feel the relaxation in all these muscles. Feel the relaxation even deeper . . . and deeper . . . and deeper.

Now feel any tension in your lower back and stomach muscles. Focus all your attention on these muscles and ask them to relax. Relax these muscles fully. Feel the tension flow away.

Inhale deeply . . . exhale slowly. Feel the relaxation in your lower back and stomach muscles. Relax . . . (pause). Inhale deeply . . . exhale slowly (pause). Relax even deeper . . . and deeper . . . and deeper.

Now feel any tension in your upper legs, both the front and back. Focus all your attention on these muscles and ask them to relax. Relax these muscles fully. Feel the tension flow away.

Inhale deeply . . . exhale slowly. Feel the relaxation in your upper legs. Relax . . . (pause). Inhale deeply . . . exhale slowly (pause). Relax even deeper . . . and deeper . . . and deeper.

Remember to keep your facial muscles relaxed. Keep your lower back and stomach muscles relaxed. And keep your upper leg muscles relaxed. Keep all these muscles relaxed. Inhale deeply . . . exhale slowly. Feel the relaxation in all these muscles. Feel the relaxation even deeper . . . and deeper . . . and deeper.

Now feel any tension in your lower legs and your feet. Focus all your attention on these muscles and ask them to relax. Relax these muscles fully. Feel the tension flow away.

Inhale deeply . . . exhale slowly. Feel the relaxation in your lower legs and feet. Relax . . . (pause). Inhale deeply . . . exhale slowly (pause). Relax even deeper . . . and deeper . . . and deeper.

Now relax your entire body. Relax it completely. Feel all the tension flow away from your facial muscles . . . your arms and hands . . . your neck and upper back . . . your lower back and stomach . . . your upper legs . . . and your lower legs and feet.

Inhale deeply . . . exhale slowly. Feel the relaxation in all your body. Relax . . . (pause). Inhale deeply . . . exhale slowly (pause). Relax even deeper . . . and deeper . . . and deeper.

(Martens, 1987, p. 123).

VIVIDNESS OF MOVEMENT IMAGERY QUESTIONNAIRE

Combination of the Vividness of Movement Imagery Questionnaire and Vividness of Movement Imagery Questionnaire - (Mark II)

ANNE ISAAC, University of Otago
DAVID F. MARKS, Middlesex Polytechnic and
DAVID G. RUSSELL, University of Otago

****

Name: _____ **Date of birth:** _____

Male or Female: _____ **Tel.:** _____

"Movement Imagery" refers to the ability to imagine movement. The aim of this questionnaire is to determine the vividness of your movement imagery ability and your ability to imagine feeling the sensations as if you were actually perfroming the movement. The items of the test are designed to bring certain images to your mind. You are asked to rate the vividness of each item by reference to the 5-point scales.

After each item, write the appropriate number in the box provided. The first box is for a visual image obtained watching someone else, the second box is for a visual image obtained doing it yourself, and the third box is for an image associated with the feel (kinaesthetic sensation) of the movement. Try to respond to each item separately, independently of how you may have responded to other items.

First complete all the items obtained watching somebody else. Secondly, visualise the movement again and rate the image obtained as if you were doing it yourself. Thirdly, rate the feel (kinaesthetic sensation) of the image. Your 3 ratings for a given item might **not** necessarily be the same in all cases. While you are imaging please have your eyes **CLOSED**.

Rating Scale for columns 1 & 2:

The image aroused by each move might be:	**Rating**
Perfectly clear and as vivid as normal	**4**
Clear and reasonably vivid	**3**
Moderately clear and vivid	**2**
Vague and dim	**1**
No image at all, you only "know" that you are thinking of the skill	**0**

Rating Scale for column 3:

The feeling/ sensation aroused by each move might be:	**Rating**
Very strong (you can *feel* yourself performing the move as if you were actually doing it)	**4**
Reasonably strong (although you can *feel* yourself performing the move, the sensations aren't as strong as if you were physically performing the move)	**3**
Moderately strong	**2**
You have a very vague *feeling* of performing the move	**1**
You **cannot** *feel* yourself performing the move at all	**0**

Think of each of the following moves and classify the image according to the degree of clearness, vividness and feel as shown on the **Rating Scale.**

Moves	Watching Somebody Else	Doing it Yourself	Feeling It Yourself
1. Standing			
2. Walking			
3. Running			
4. Jumping			
5. Reaching for something on tiptoe			
6. Drawing a circle on paper			
7. Kicking a stone			
8. Bending to pick up a coin			
9. Falling forwards			
10. Running up stairs			
11. Jumping sideways			
12. Slipping over backwards			
13. Catching a ball with two hands			
14. Throwing a stone into water			
15. Kicking a ball into the air			
16. Hitting a ball along the ground.			
17. Running downhill			

Moves	Watching Somebody Else	Doing it Yourself	Feeling It Yourself
18. Climbing over a high wall			
19. Sliding on ice			
20. Riding a bike			
21. Jumping into water			
22. Swinging on a rope			
23. Balancing on one leg			
24. Jumping off a high wall			

THANK YOU

For official use only:

(a) Other =

(b) Self =

(c) Feel =

APPENDIX C

STAT. RELIABL. ANALYSIS	Summary for scale: Mean=80.2222 Std.Dv.=12.1838 Valid N:9 Cronbach alpha: .937842 Standardized alpha: .944843 Average inter-item corr.: .47177

variable	Mean if deleted	Var. if deleted	StDv. if deleted	Itm-Totl Correl.	Alpha if deleted
OTHER1	76.55556	122.0247	11.04648	.643745	.934817
OTHER2	76.66666	121.7778	11.03530	.641910	.934804
OTHER3	76.77778	116.8395	10.80923	.802198	.932116
OTHER4	77.11111	119.6543	10.93866	.728910	.933488
OTHER5	76.55556	122.6914	11.07661	.865357	.933524
OTHER6	77.00000	120.0000	10.95445	.553509	.936392
OTHER7	77.00000	120.8889	10.99495	.771744	.933350
OTHER8	77.33334	121.1111	11.00505	.523154	.936753
OTHER9	77.11111	117.2099	10.82635	.889645	.931153
OTHER10	77.00000	125.7778	11.21507	.409823	.937707
OTHER11	77.22222	117.9506	10.86051	.751803	.932965
OTHER12	77.55556	115.5803	10.75083	.763690	.932668
OTHER13	76.44444	124.9136	11.17647	.738641	.935102
OTHER14	76.33334	128.0000	11.31371	.541667	.937158
OTHER15	76.55556	124.0247	11.13664	.503842	.936601
OTHER16	76.77778	118.6173	10.89116	.862243	.931856
OTHER17	76.55556	125.5803	11.20626	.581915	.936099
OTHER18	77.00000	121.1111	11.00505	.591127	.935474
OTHER19	77.33334	127.5555	11.29405	.183666	.942245
OTHER20	76.44444	126.0247	11.22607	.391925	.937919
OTHER21	76.66666	124.4444	11.15547	.460493	.937175
OTHER22	77.22222	118.6173	10.89116	.605965	.935556
OTHER23	76.88889	120.7654	10.98933	.496885	.937510
OTHER24	77.00000	115.1111	10.72898	.713593	.933778

STAT. RELIABL. ANALYSIS	Summary for scale: Mean=80.0000 Std.Dv.=11.0454 Valid N:9 Cronbach alpha: .909480 Standardized alpha: .902778 Average inter-item corr.: .329652

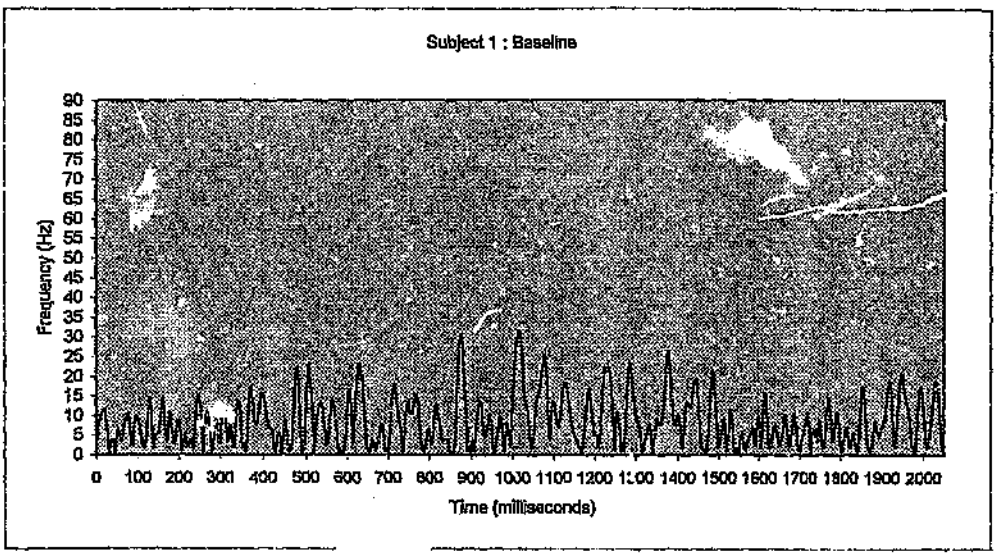
variable	Mean if deleted	Var. if deleted	StDv. if deleted	Itm-Totl Correl.	Alpha if deleted
SELF1	76.55556	100.0247	10.00123	.580321	.904805
SELF2	76.33334	102.6667	10.13246	.581553	.905910
SELF3	76.77778	97.5062	9.87452	.558098	.905143
SELF4	76.66666	100.4445	10.02220	.448078	.907448
SELF5	76.33334	104.0000	10.19804	.439138	.907699
SELF6	76.33334	110.0000	10.48809	-.179787	.915213
SELF7	76.44444	106.9136	10.33990	.124948	.911694
SELF8	76.77778	101.0617	10.05295	.552937	.905482
SELF9	77.11111	94.3210	9.71190	.604424	.904510
SELF10	76.44444	102.0247	10.10073	.614936	.905285
SELF11	77.00000	92.6667	9.62635	.961281	.895865
SELF12	77.77778	89.0617	9.43725	.846251	.897056
SELF13	76.22222	105.2839	10.26080	.350185	.908888
SELF14	76.44444	102.6914	10.13367	.546739	.906195
SELF15	76.55556	100.4691	10.02343	.546667	.905427
SELF16	76.55556	101.8025	10.08972	.446608	.907261
SELF17	76.44444	99.3580	9.96785	.428912	.908537
SELF18	77.11111	96.3210	9.81433	.661392	.902612
SELF19	77.44444	90.2469	9.49984	.842608	.897289
SELF20	76.22222	103.9506	10.19562	.319799	.909372
SELF21	76.22222	104.1728	10.20651	.482975	.907432
SELF22	77.11111	91.2099	9.55039	.691333	.902249
SELF23	76.33334	108.6667	10.42433	-.047965	.915753
SELF24	76.77778	94.8395	9.73856	.648718	.898748

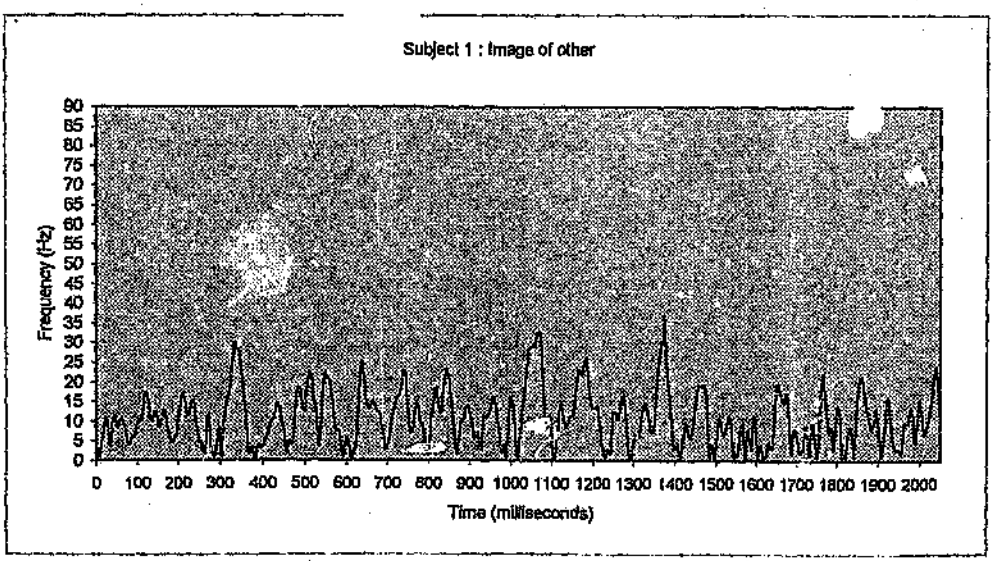
STAT. RELIABL. ANALYSIS	Summary for scale: Mean=82.2222 Std.Dv.=9.43104 Valid N:9 Cronbach alpha: .907911 Standardized alpha: .915776 Average inter-item corr.: .347590				
variable	Mean if deleted	Var. if deleted	StDv. if deleted	Itm-Totl Correl.	Alpha if deleted
FEEL1	78.88889	74.98766	8.659541	.314361	.908447
FEEL2	78.66666	74.66666	8.640987	.483046	.905093
FEEL3	78.44444	77.35803	8.795341	.209330	.908975
FEEL4	78.77778	77.28395	8.791129	.175222	.909846
FEEL5	78.55556	72.46913	8.512880	.793715	.900480
FEEL6	78.55556	76.69136	8.757360	.260176	.908462
FEEL7	79.00000	70.66667	8.406347	.757042	.899339
FEEL8	78.77778	71.95062	8.482371	.571611	.903023
FEEL9	79.11111	67.20988	8.198163	.666728	.901042
FEEL10	78.55556	75.80246	8.706461	.369985	.906855
FEEL11	79.33334	66.22222	8.137704	.732743	.898888
FEEL12	79.55556	64.69135	8.043094	.587115	.908189
FEEL13	78.55556	74.69135	8.642416	.509091	.904793
FEEL14	78.44444	76.46913	8.744663	.332795	.907388
FEEL15	78.88889	71.65432	8.464888	.616928	.902074
FEEL16	78.88889	73.87654	8.595146	.612441	.903242
FEEL17	78.33334	76.88889	8.768631	.376322	.907135
FEEL18	79.22222	76.83951	8.765815	.152106	.911749
FEEL19	79.22222	70.39507	8.390177	.734986	.899509
FEEL20	78.66666	71.11111	8.432740	.647649	.901342
FEEL21	78.66666	71.99999	8.485281	.808138	.899894
FEEL22	78.55556	69.58025	8.341477	.812539	.897800
FEEL23	78.55556	73.58025	8.577893	.650310	.902669
FEEL24	78.88889	72.54321	8.517230	.534864	.903831

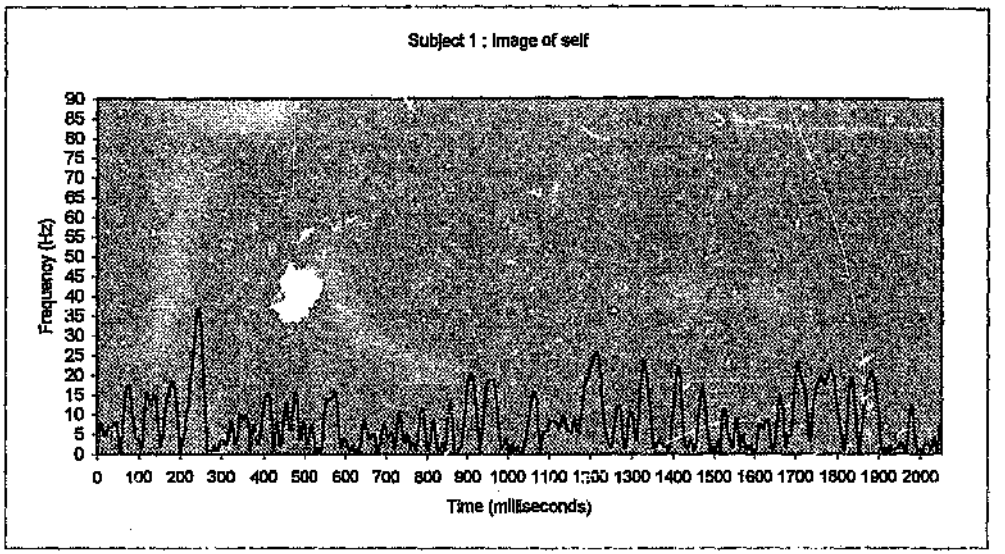
NOTE: Variables labelled "OTHER1 – OTHER24", refer to items 1-24, on the VMIQ. that are rated according to "Watching someone else". Similarly, variables labelled "SELF1-SELF24" and "FEEL1-FEEL24", refer to items 1-24, on the VMIQ, that are rated according to "Doing it yourself" and "Feeling it yourself" respectively.

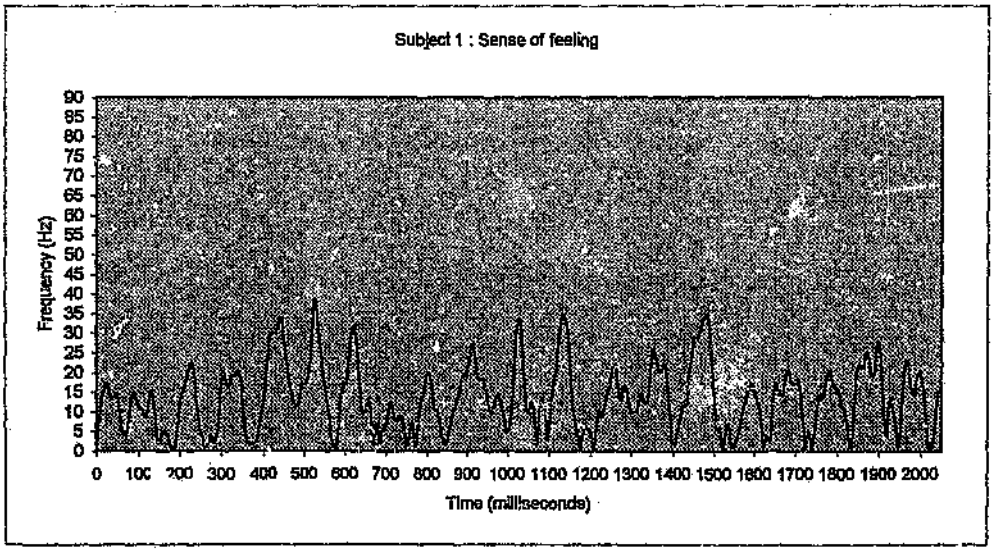
APPENDIX D

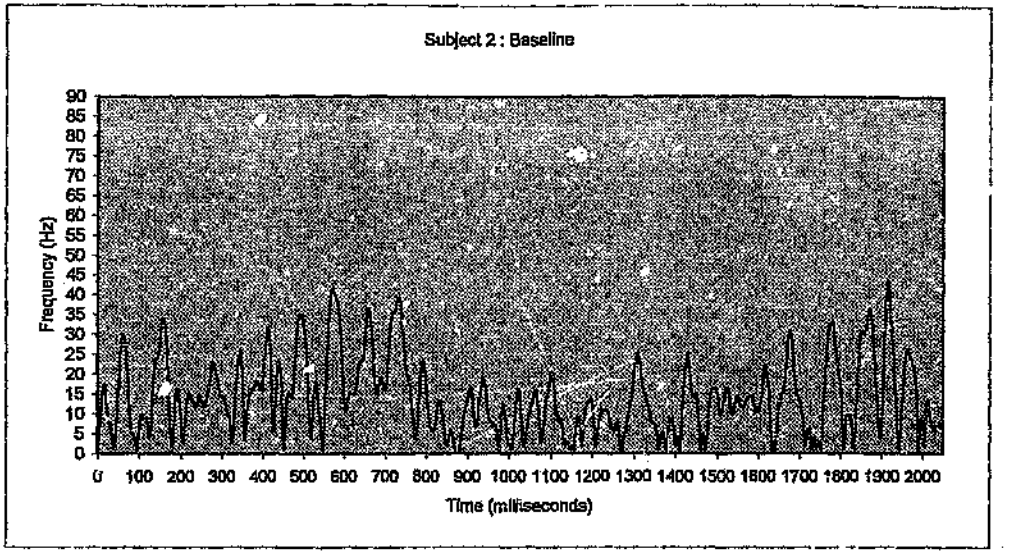
The following graphs depict the EEG activity for subjects 1 – 9, observed over a randomly selected two second period during baseline reading, whilst "watching someone else" (Image of other), whilst "doing it yourself" (Image of self) and whilst "feeling it yourself" (Sense of feeling). For subjects 6 – 9, graphs depicting EEG activity during the relaxation intervention are also presented.

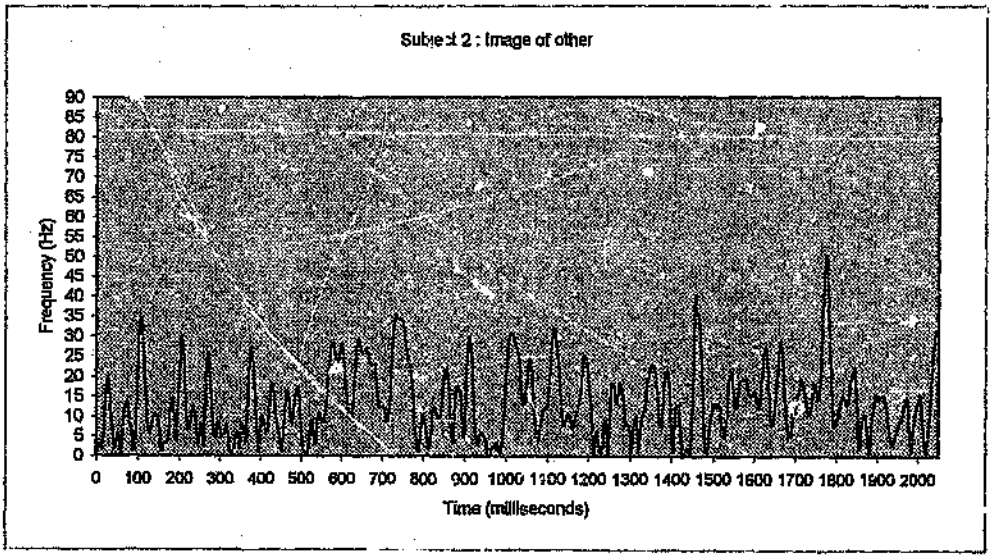


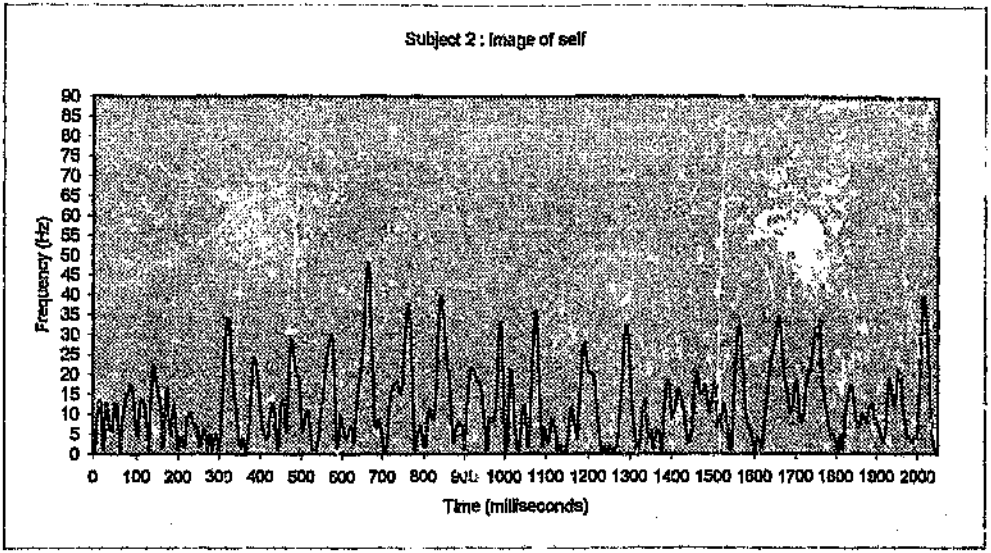


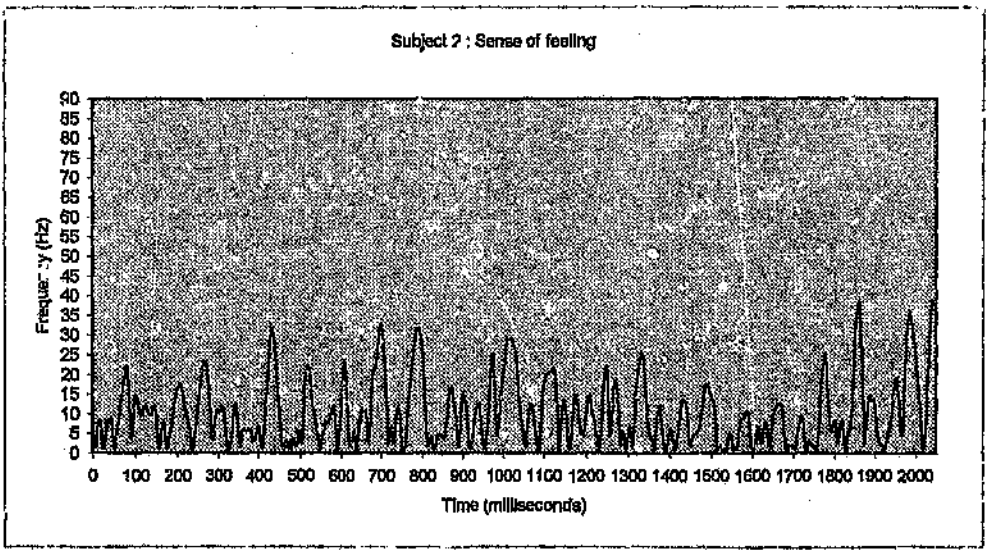

Subject 1 : Image of self
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

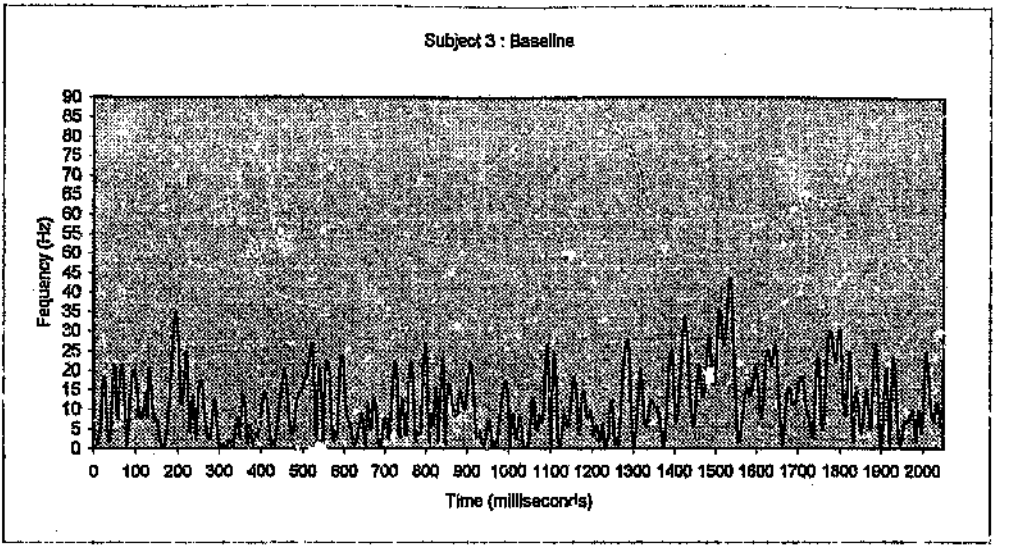

Subject 1 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

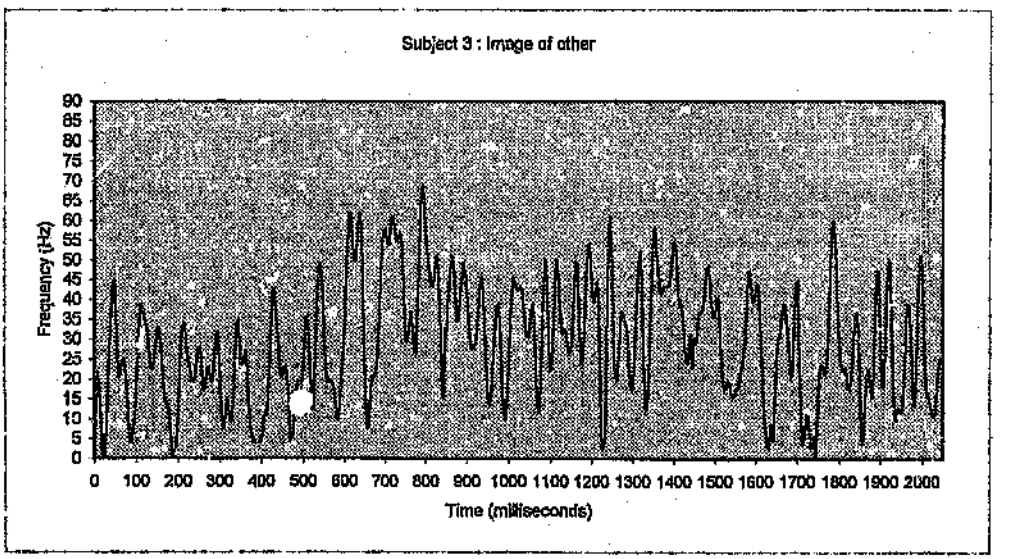

Subject 2 : Baseline
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

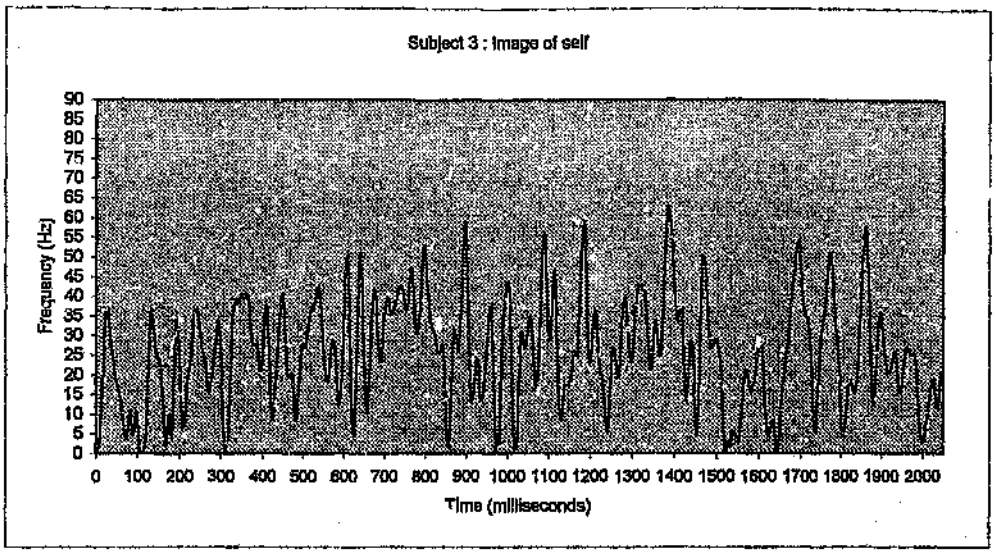

Subject 2 : Image of other
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

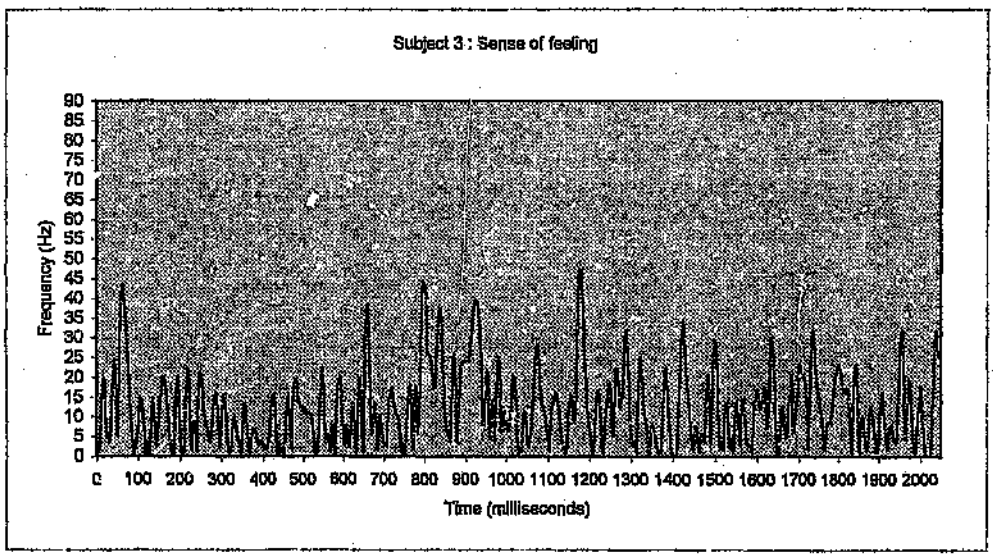

Subject 2 : Image of self
Frequency (Hz)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

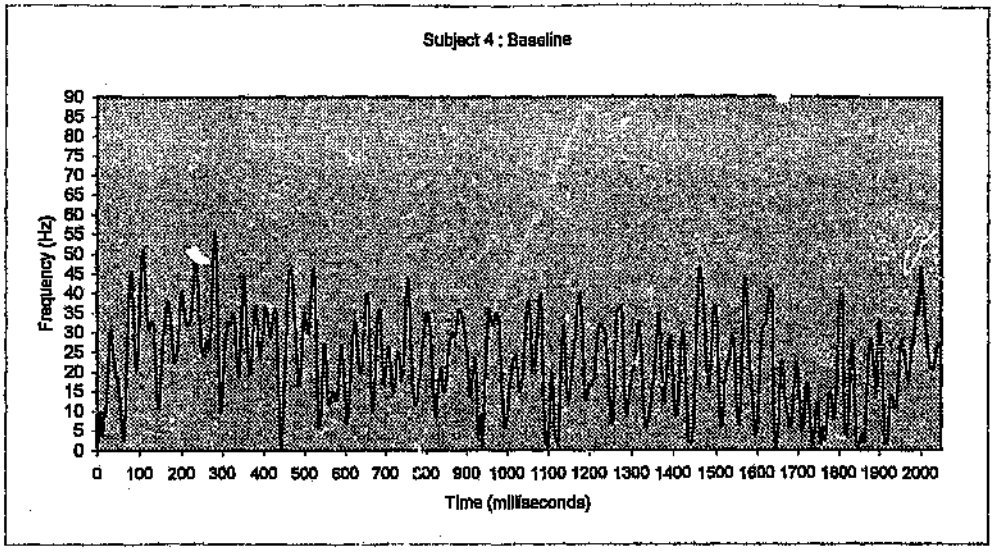

Subject 2 : Sense of feeling
Frequency (Hz)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

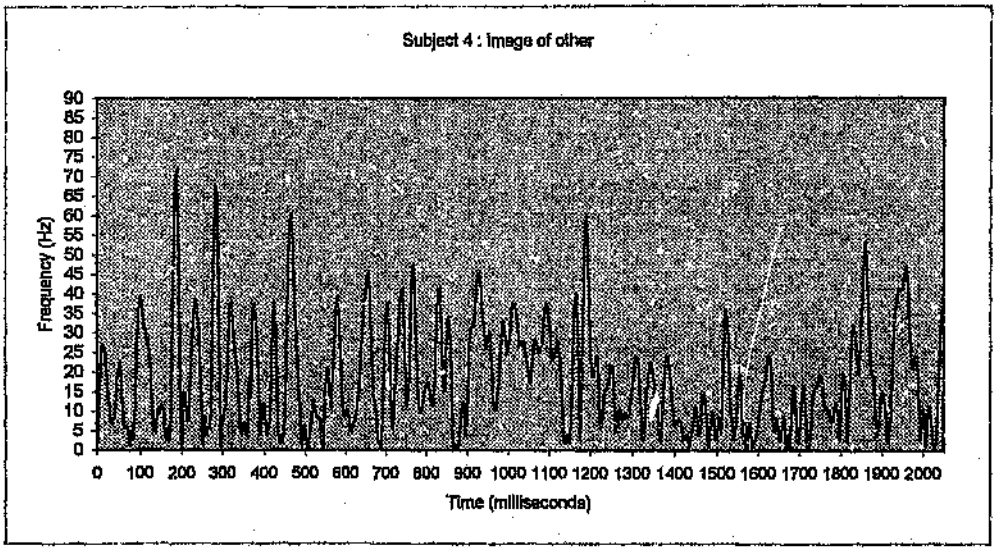

Subject 3 : Baseline
Fequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

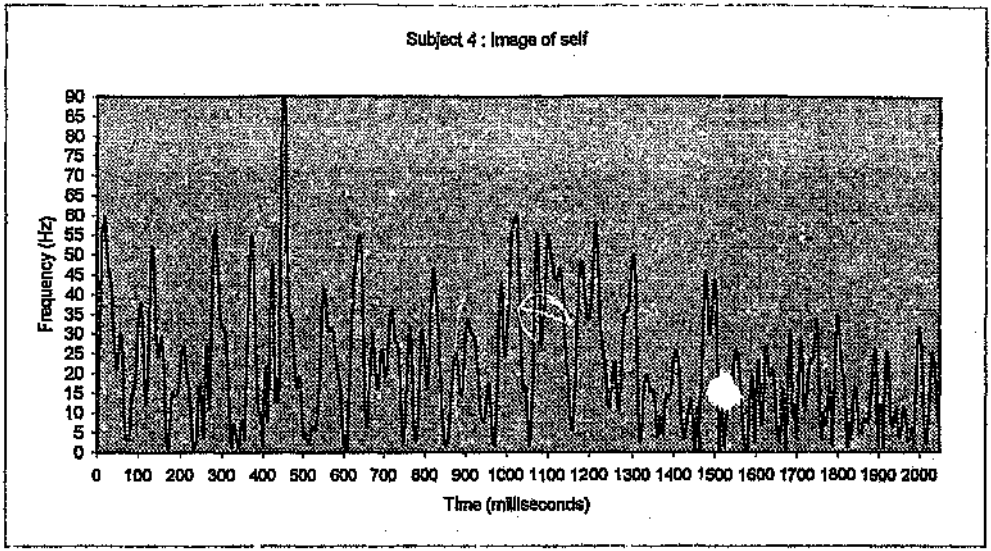

Subject 3 : Image of other
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

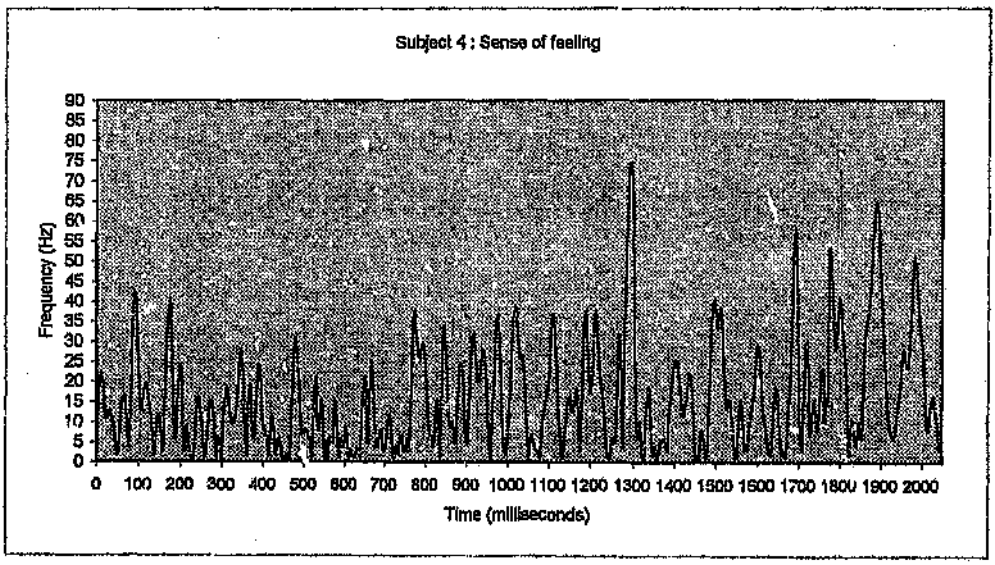

Subject 3 : Image of self
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

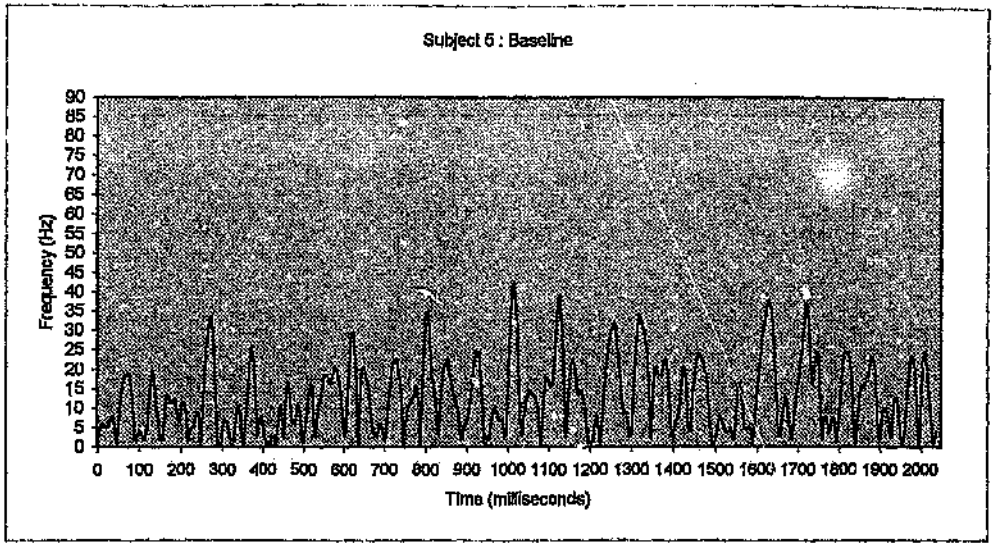

Subject 3 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

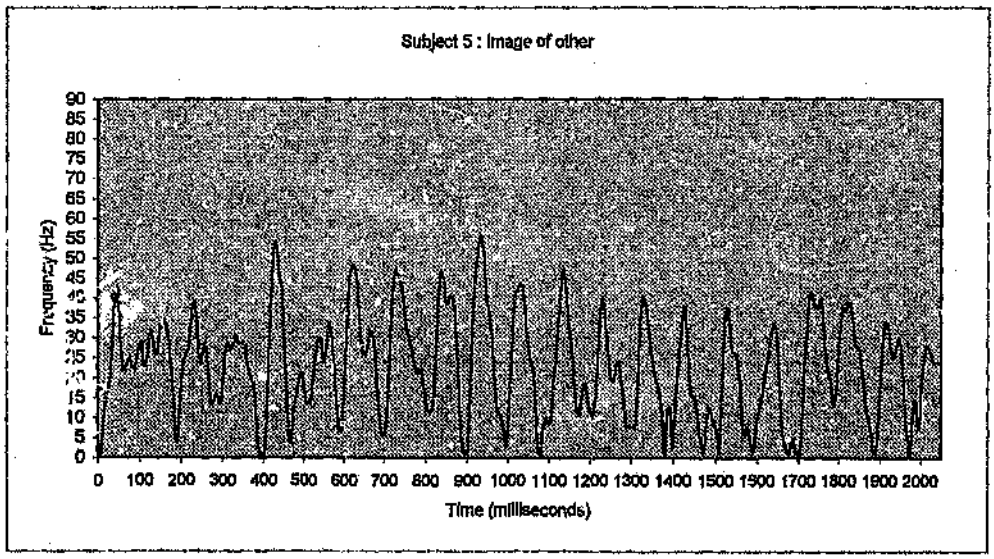

Subject 4 : Baseline
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

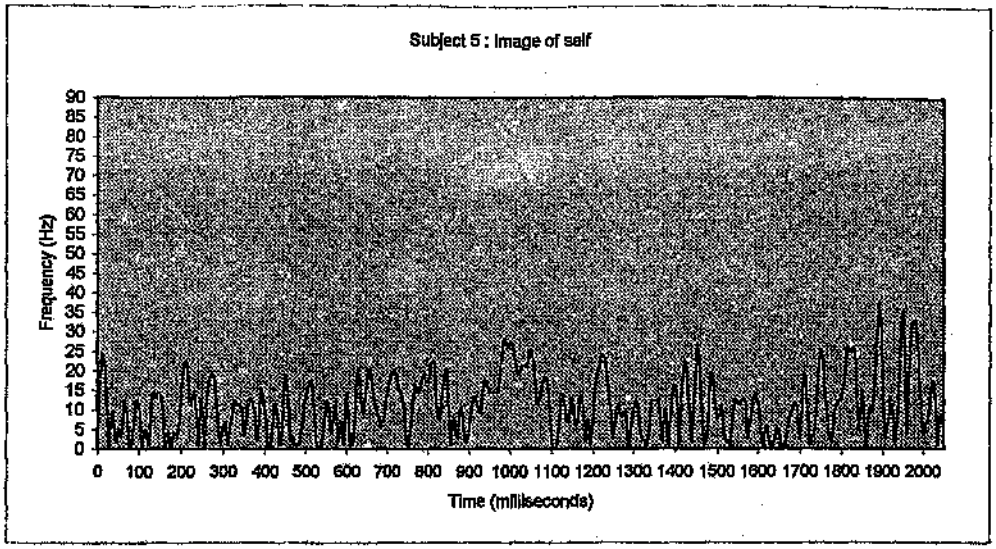

Subject 4 : Image of other
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

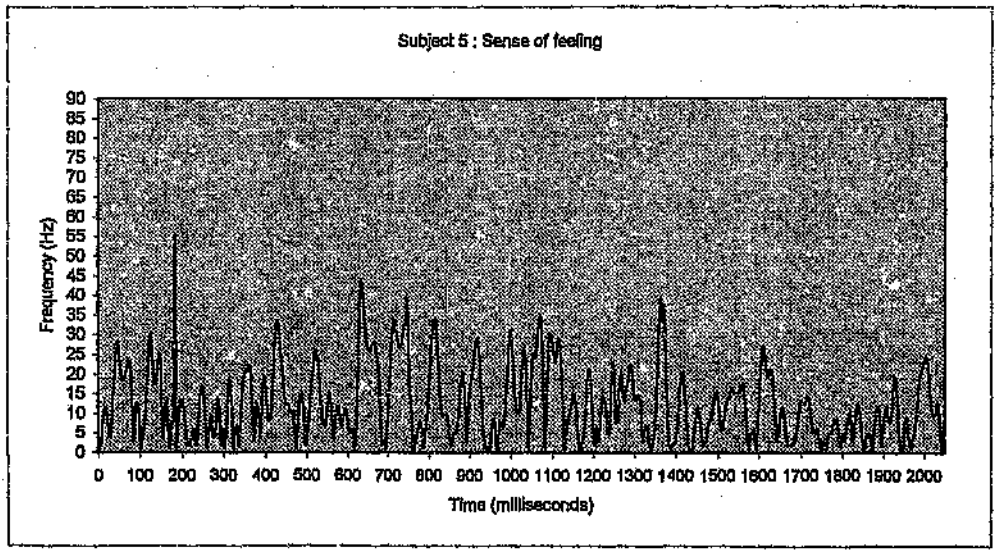

Subject 4 : Image of self
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

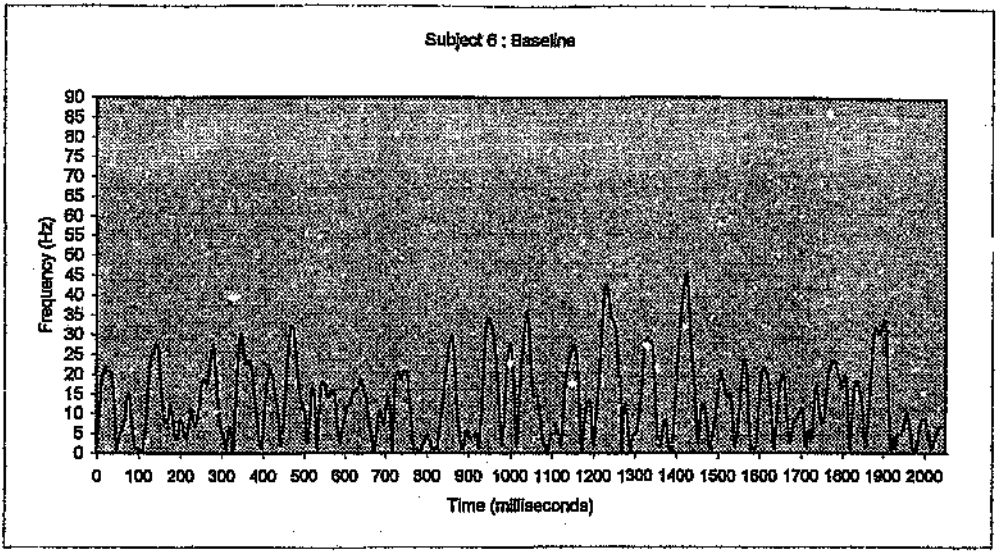

Subject 4 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

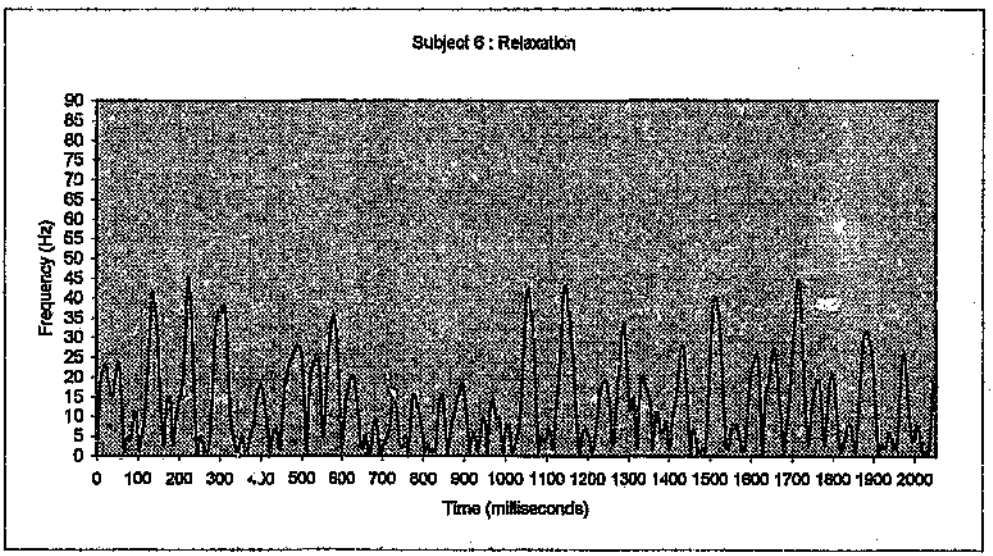

Subject 5 : Baseline
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

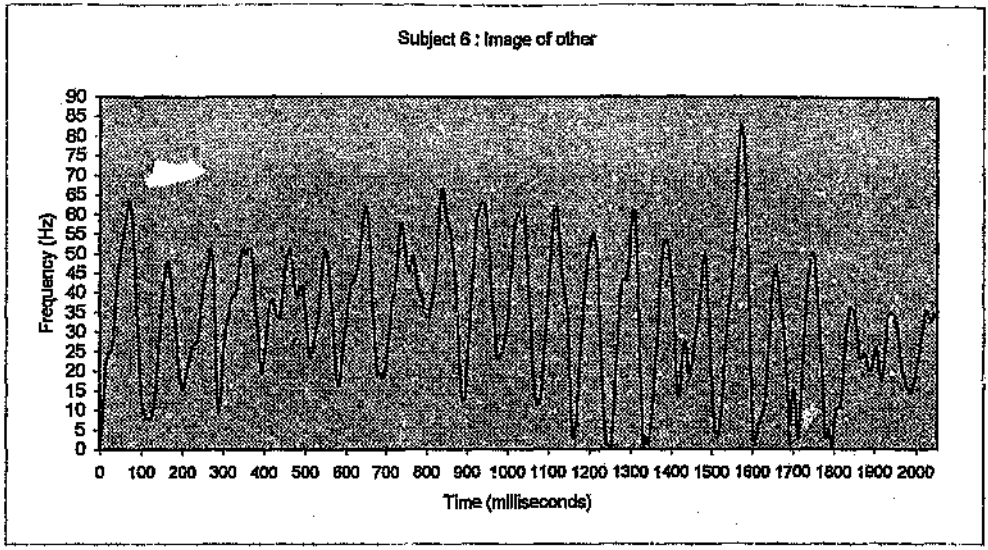

Subject 5 : Image of other
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

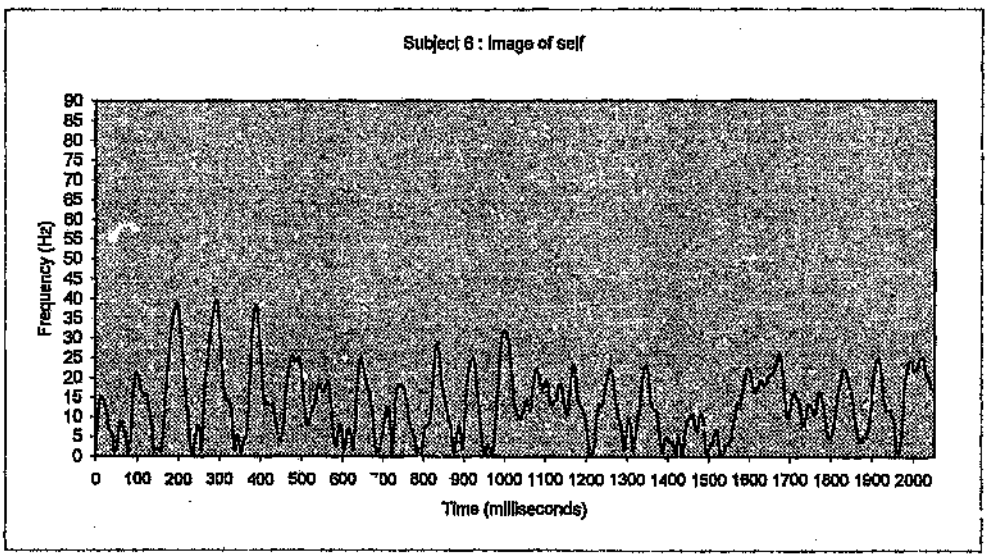

Subject 5 : Image of self
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

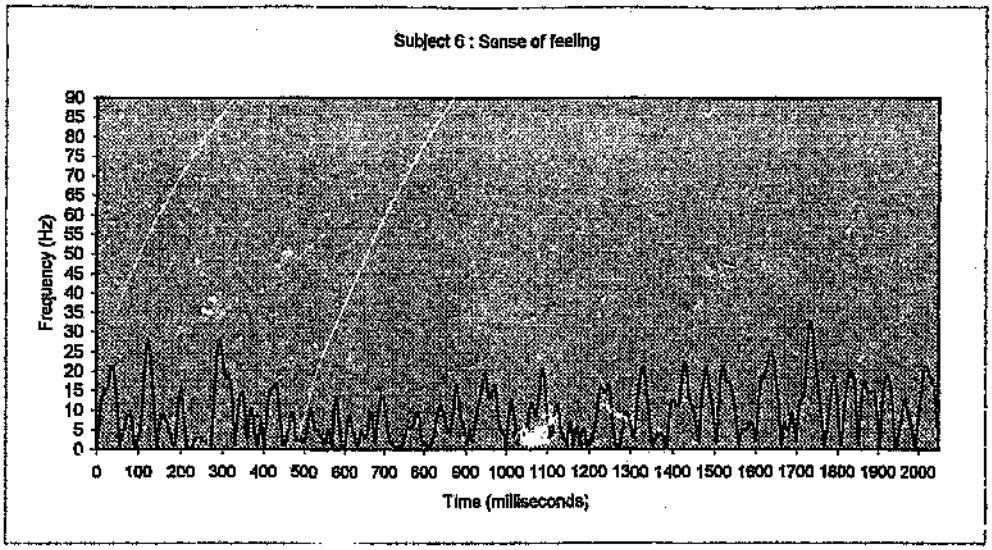

Subject 5 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

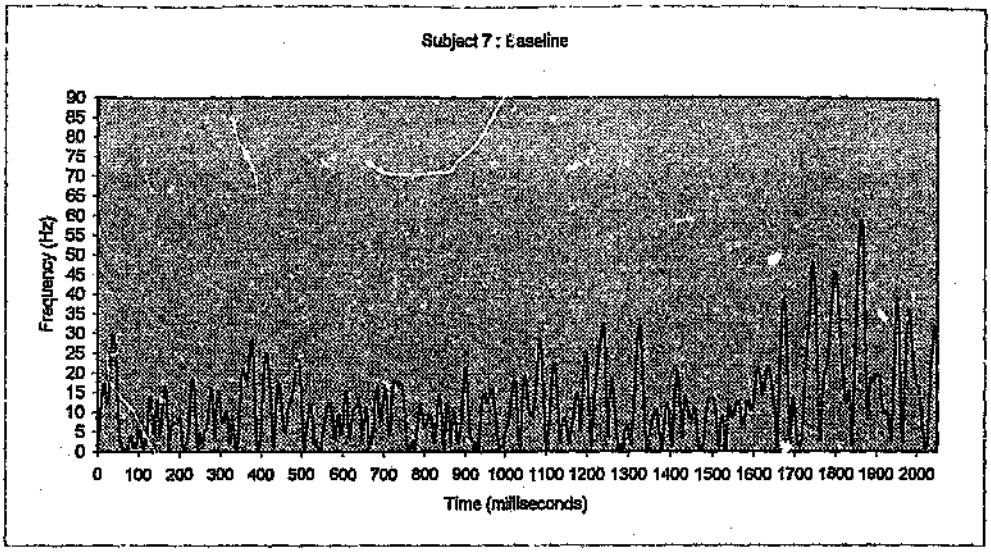

Subject 6 : Baseline
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

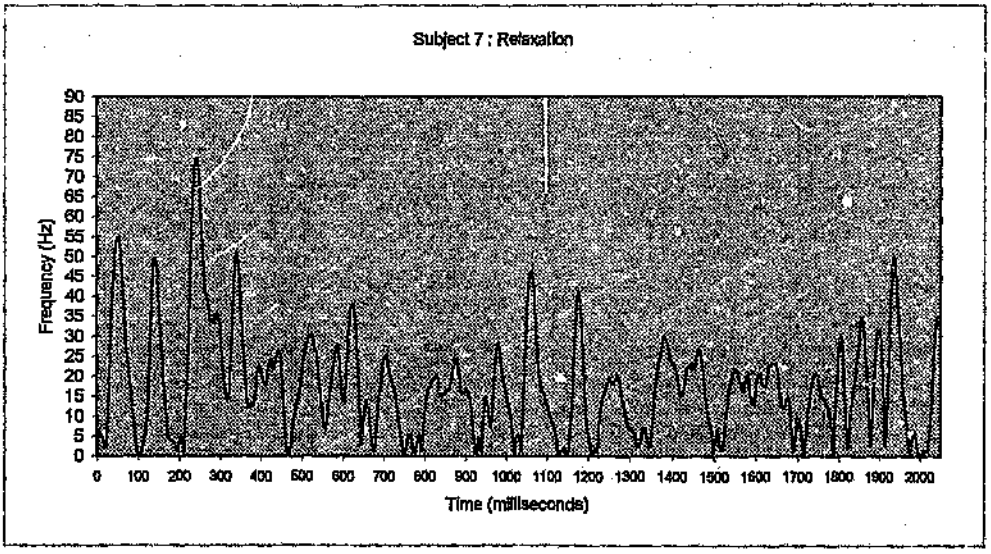

Subject 6 : Relaxation
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

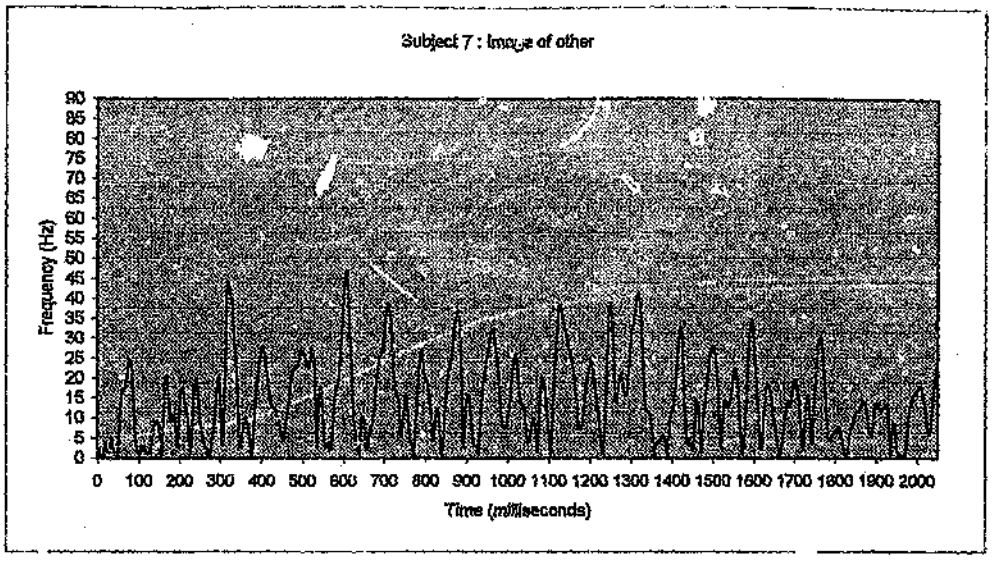

Subject 6 : Image of other
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

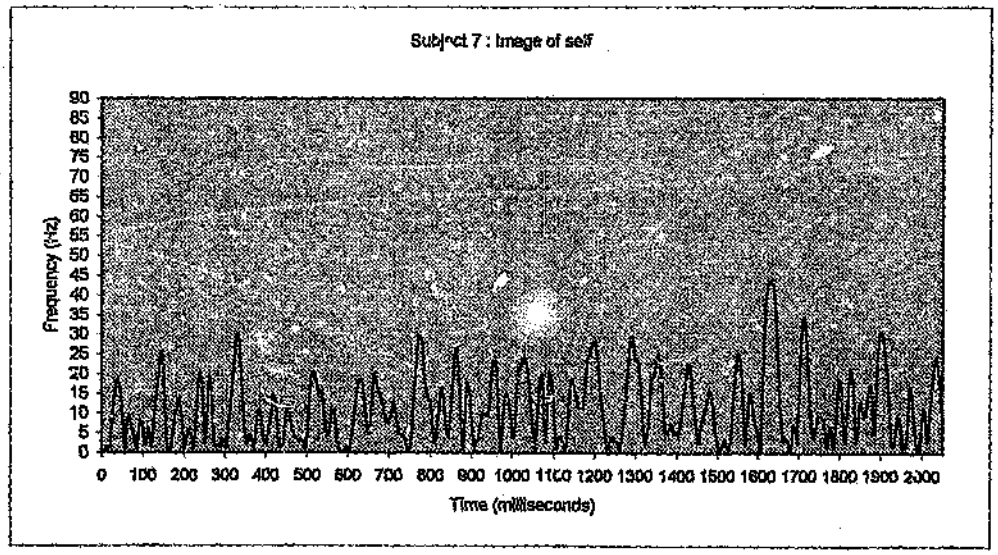

Subject 6 : Image of self
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

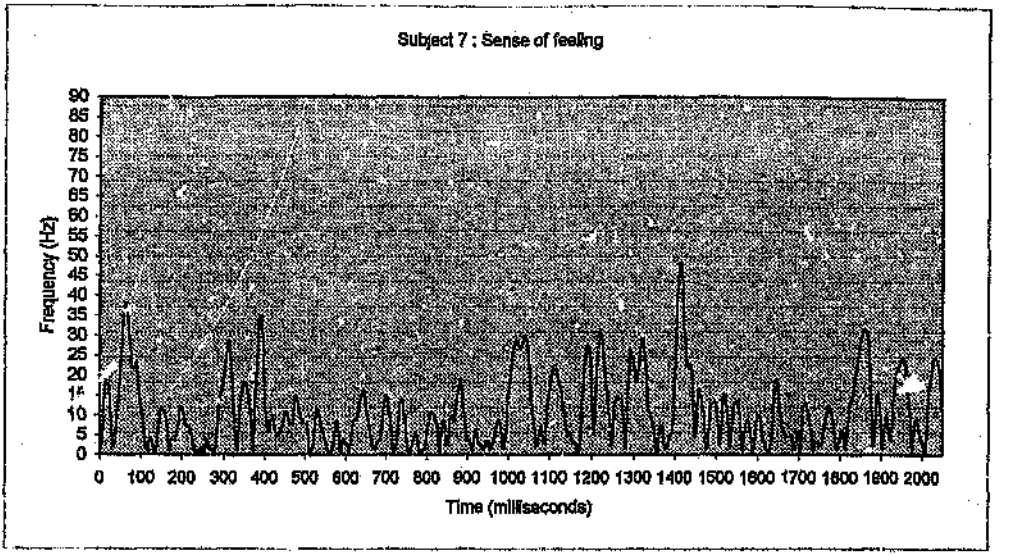

Subject 6 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

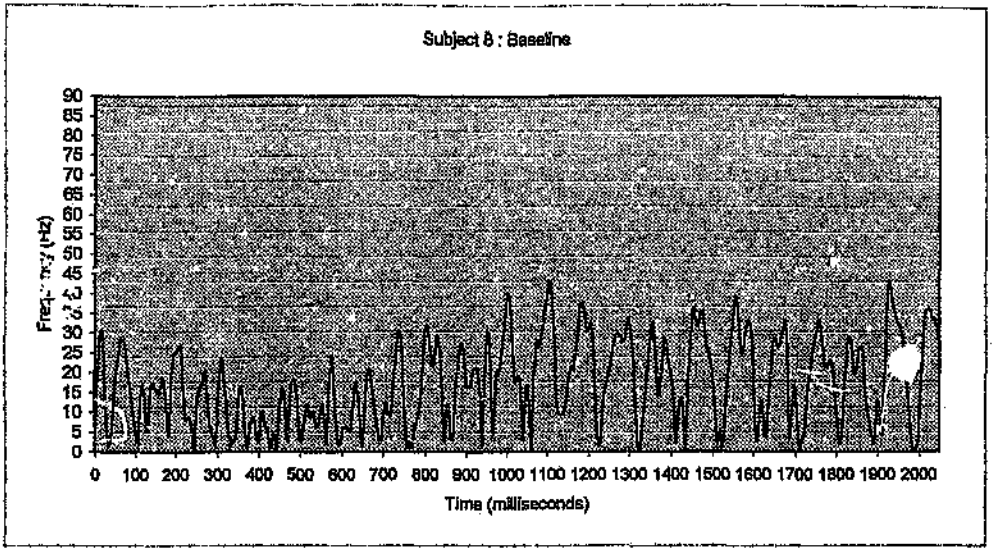

Subject 7 : Baseline
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

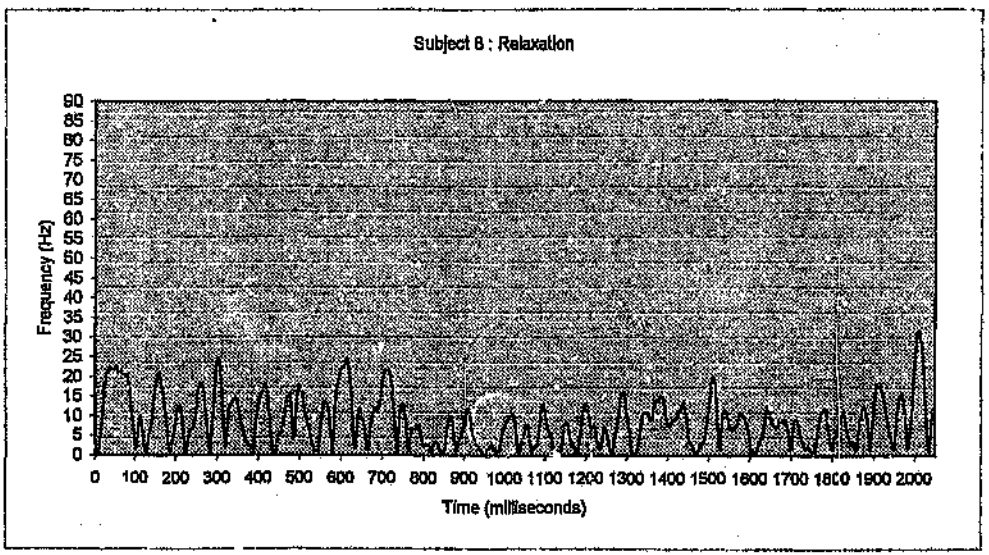

Subject 7 : Relaxation
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

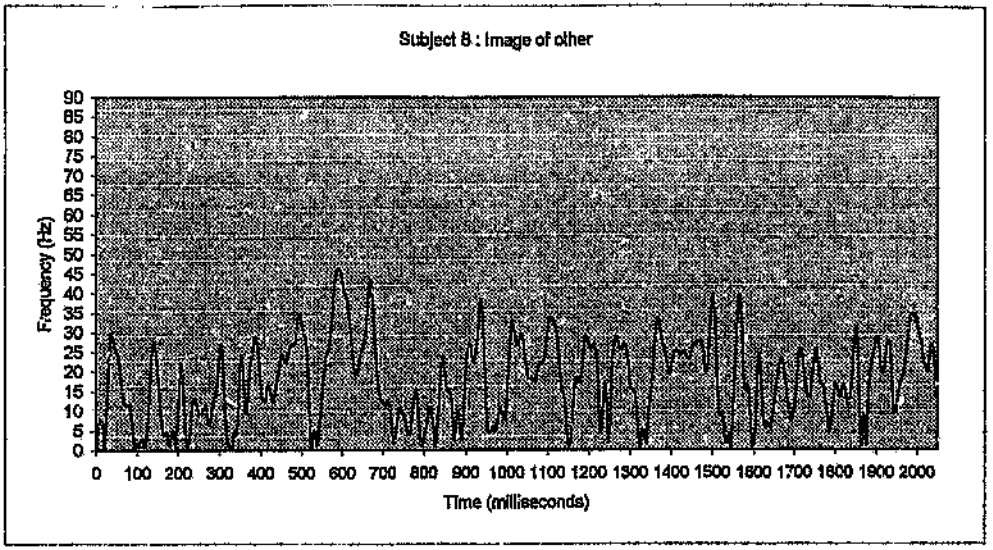

Subject 7 : Image of other
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

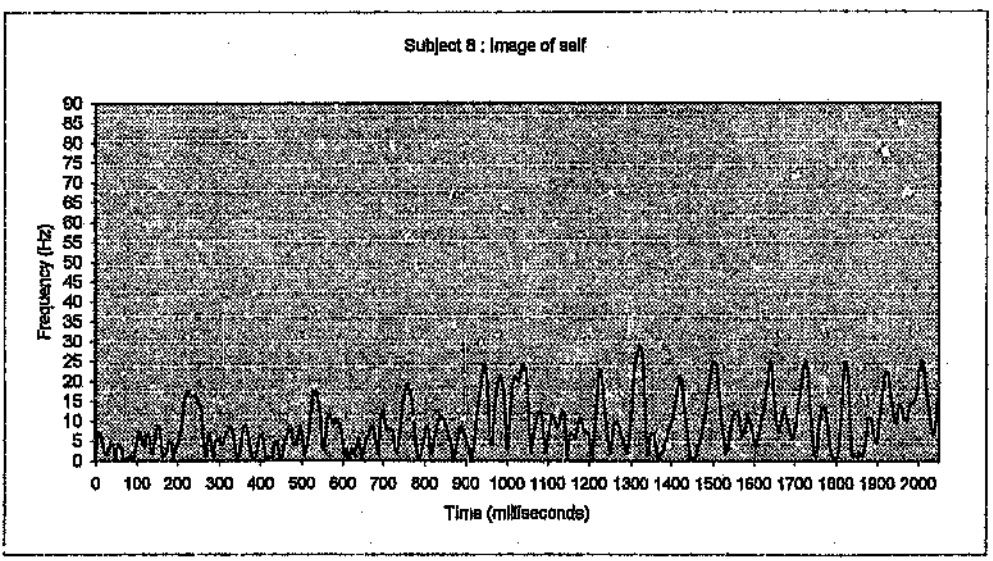

Subject 7 : Image of self
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

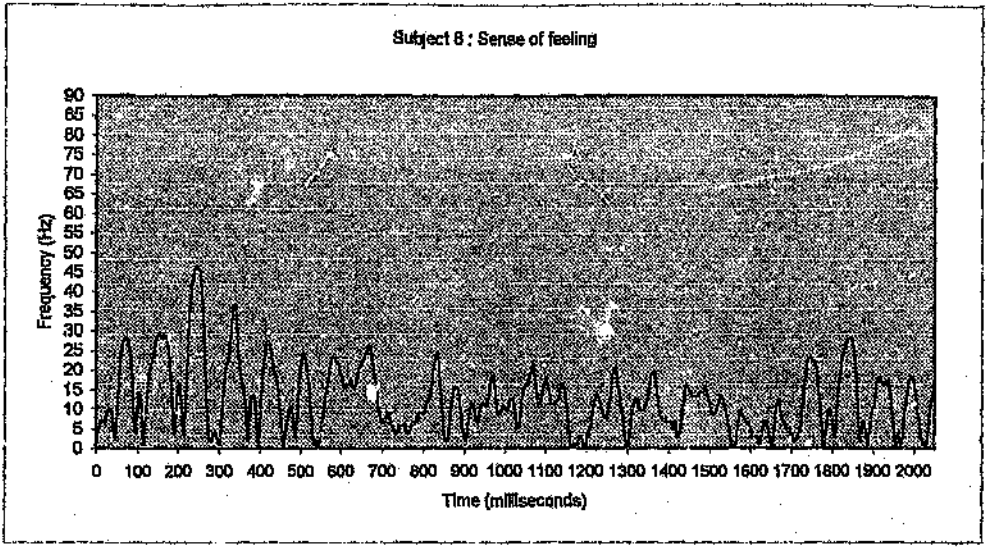

Subject 7 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

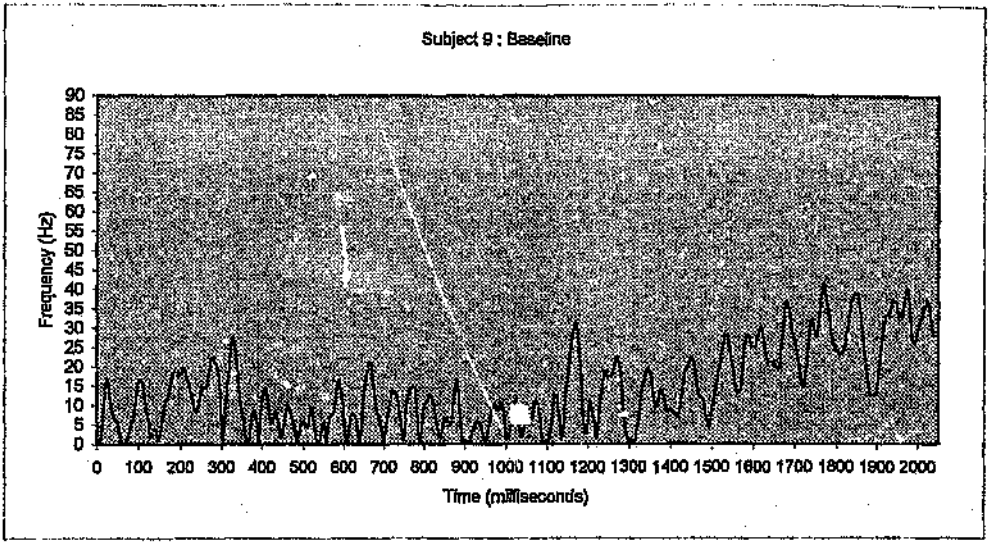

Subject 8 : Baseline
Frequency (Hz)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

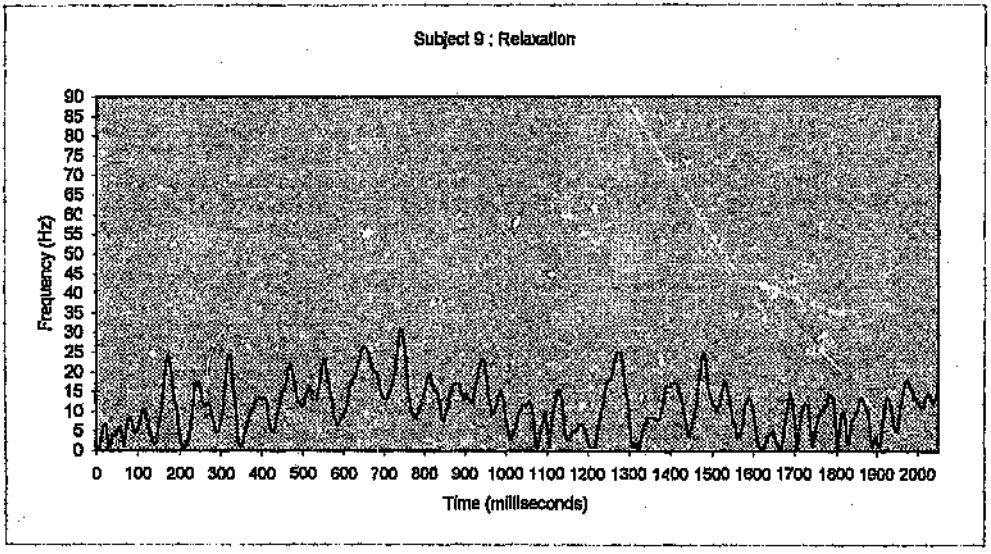

Subject 8 : Relaxation
Frequency (Hz)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)


Subject 8 : Image of other
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

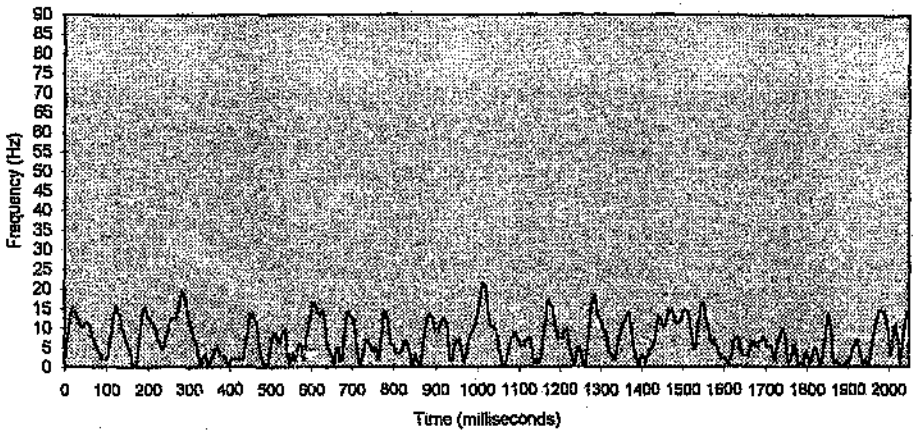

Subject 8 : Image of self
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)


Subject 8 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

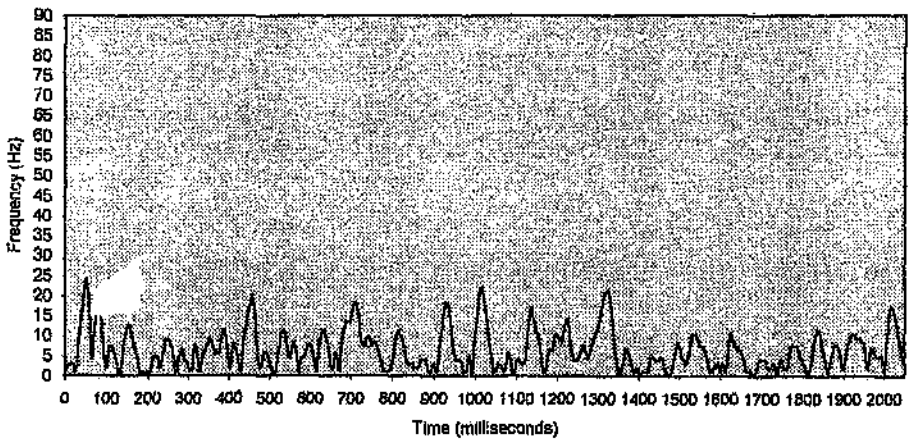

Subject 9 : Baseline
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

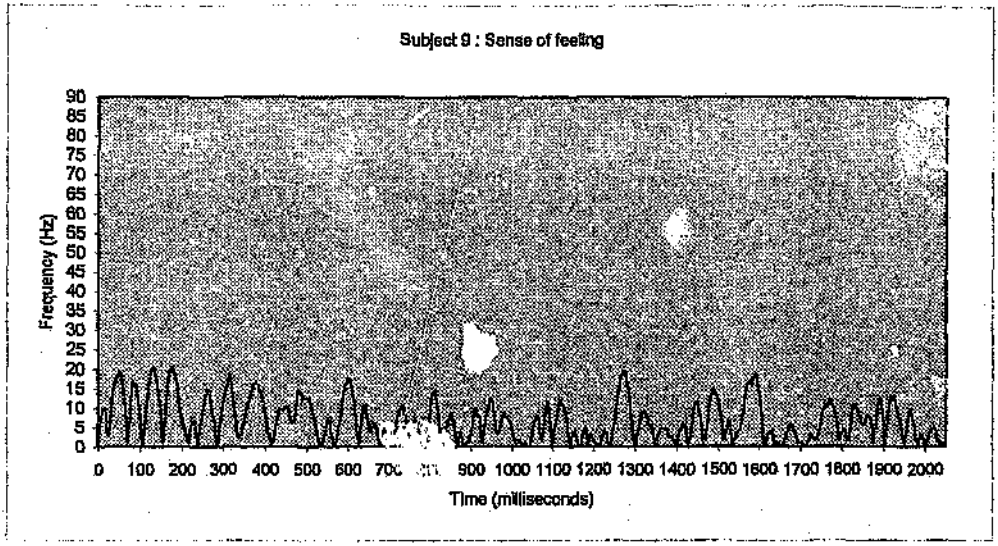

Subject 9 : Relaxation
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

Subject 9 : Image of other

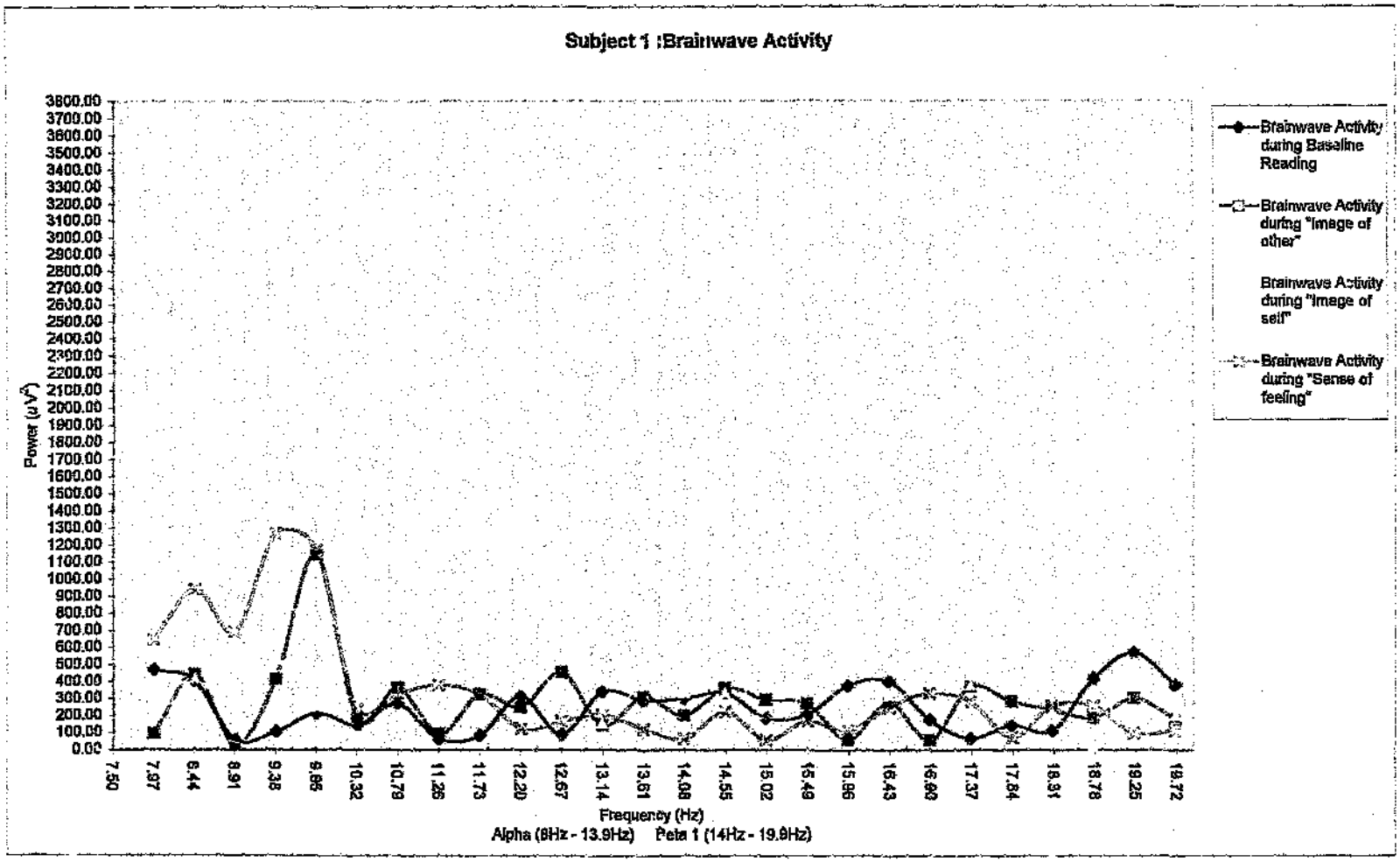


Subject 9 : Image of self

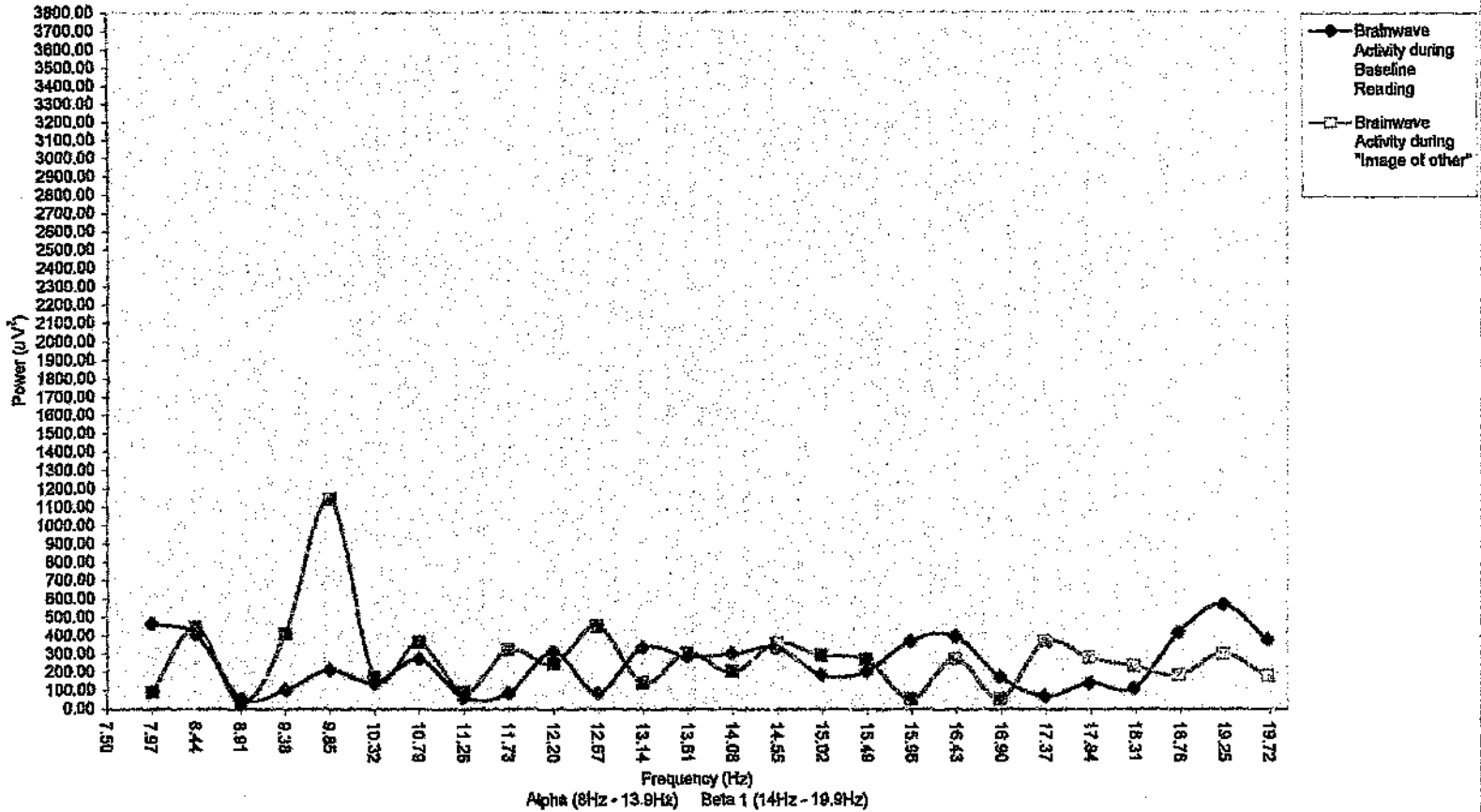



Subject 9 : Sense of feeling
Frequency (Hz)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (milliseconds)

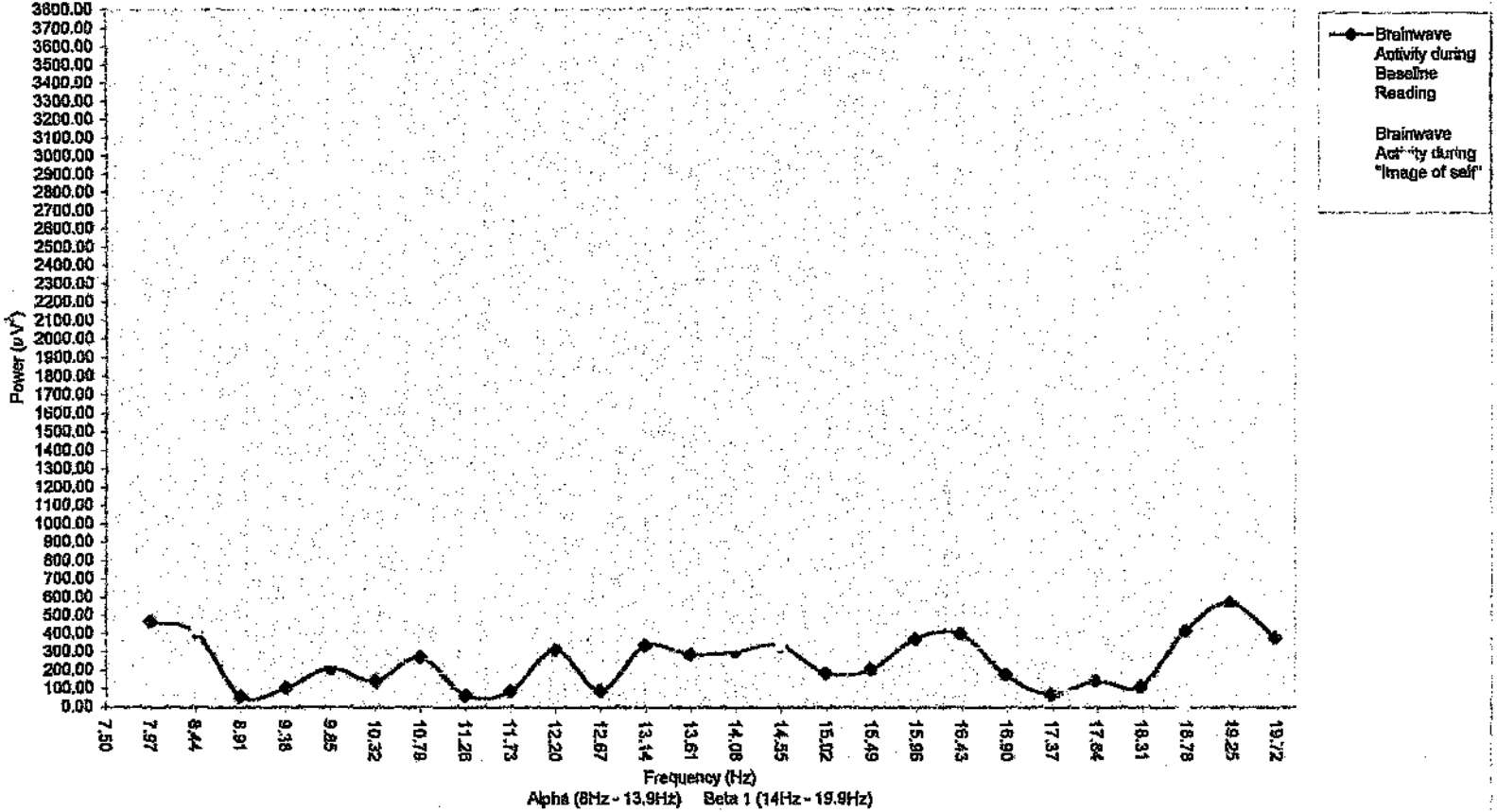
APPENDIX E


Subject 1 :Brainwave Activity
Power (μV²)
3800.00
3700.00
3600.00
3500.00
3400.00
3300.00
3200.00
3100.00
3000.00
2900.00
2800.00
2700.00
2600.00
2500.00
2400.00
2300.00
2200.00
2100.00
2000.00
1900.00
1800.00
1700.00
1600.00
1500.00
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
7.50
7.97
8.44
8.91
9.38
9.85
10.32
10.79
11.26
11.73
12.20
12.67
13.14
13.61
14.08
14.55
15.02
15.49
15.96
16.43
16.90
17.37
17.84
18.31
18.78
19.25
19.72
Frequency (Hz)
Alpha (8Hz - 13.9Hz) Beta 1 (14Hz - 19.9Hz)
Brainwave Activity during Baseline Reading
Brainwave Activity during "Image of other"
Brainwave Activity during "Image of self"
Brainwave Activity during "Sense of feeling"

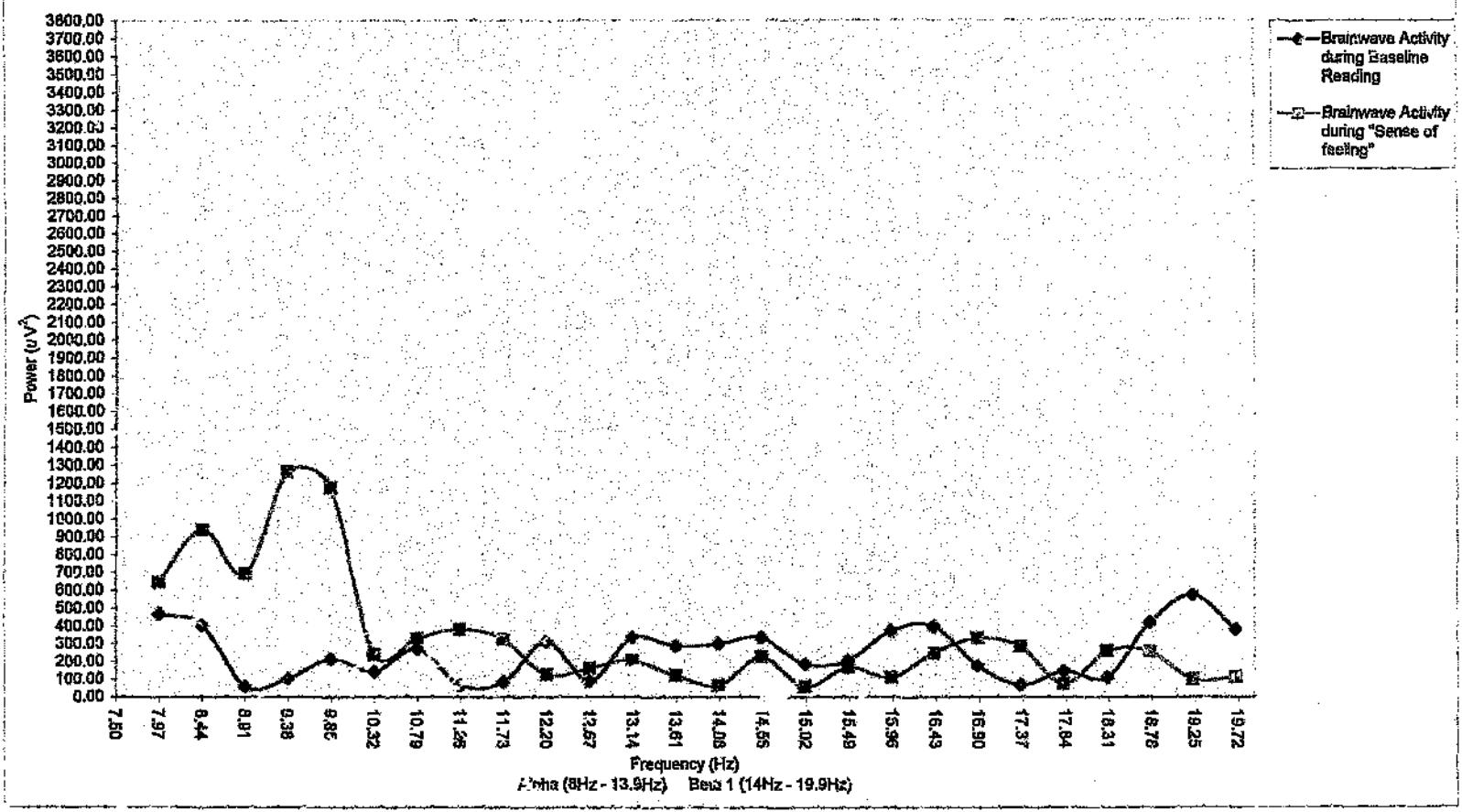
Subject 1 : Brainwave Activity



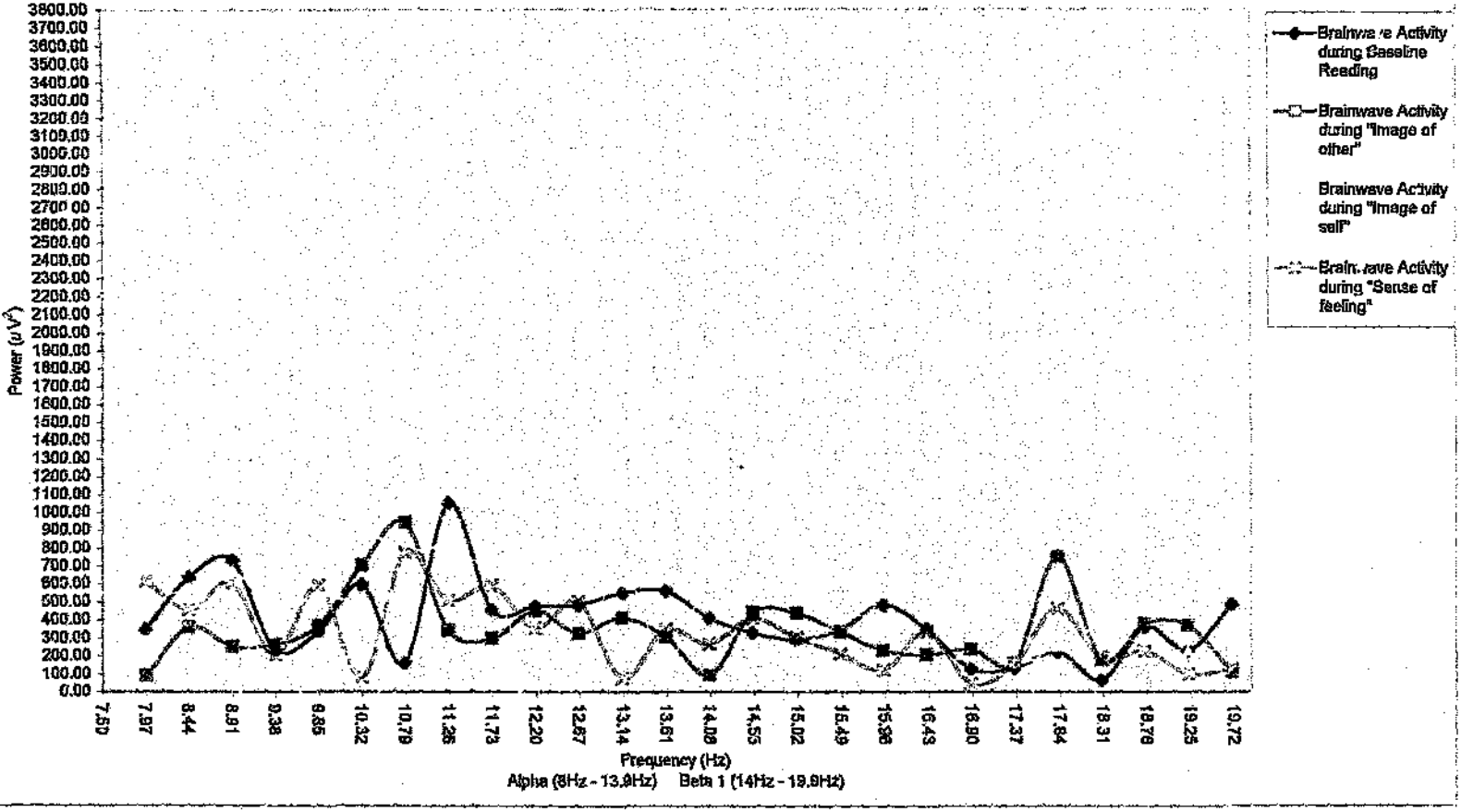
Subject 1 : Brainwave Activity



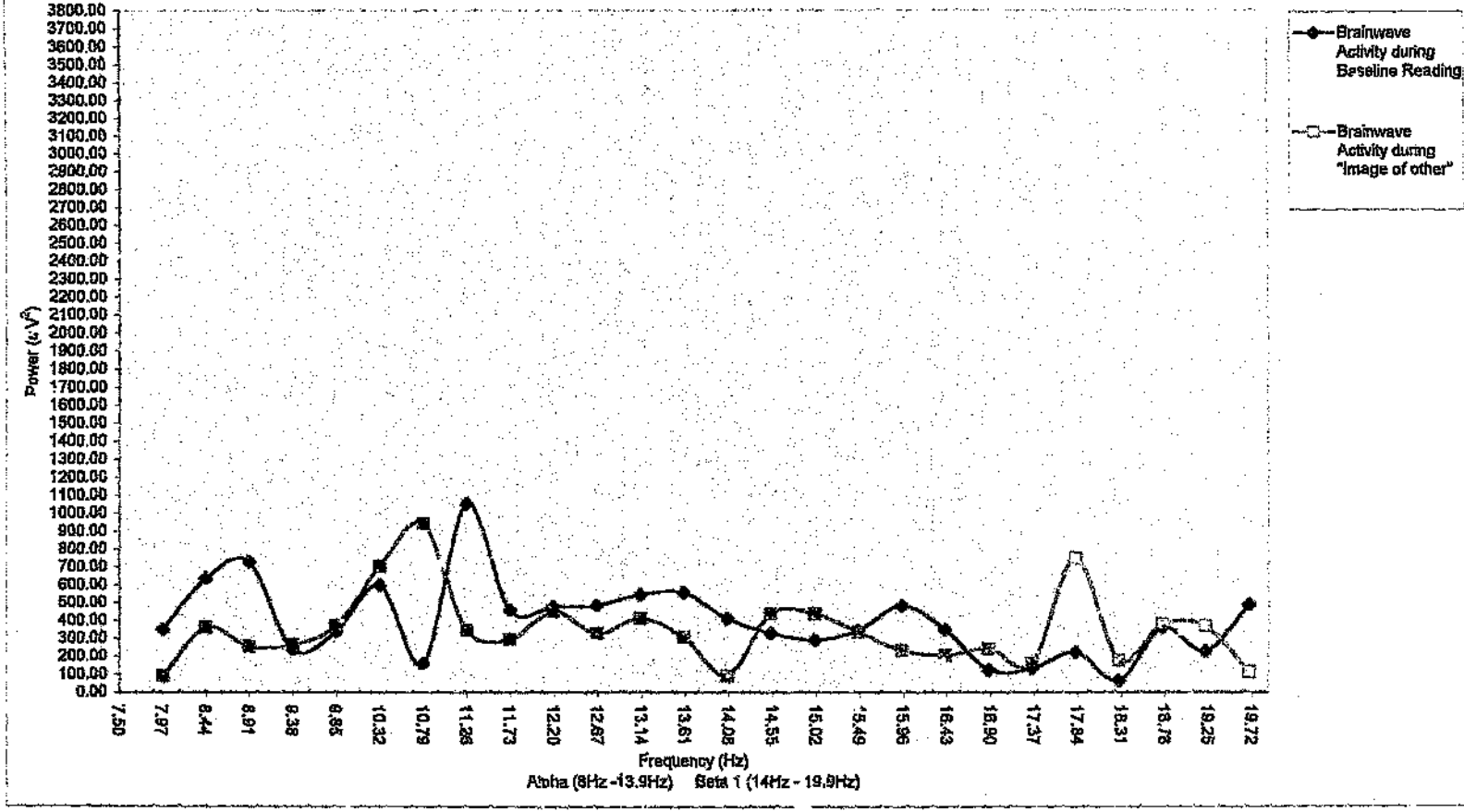
Subject 1 : Brainwave Activity



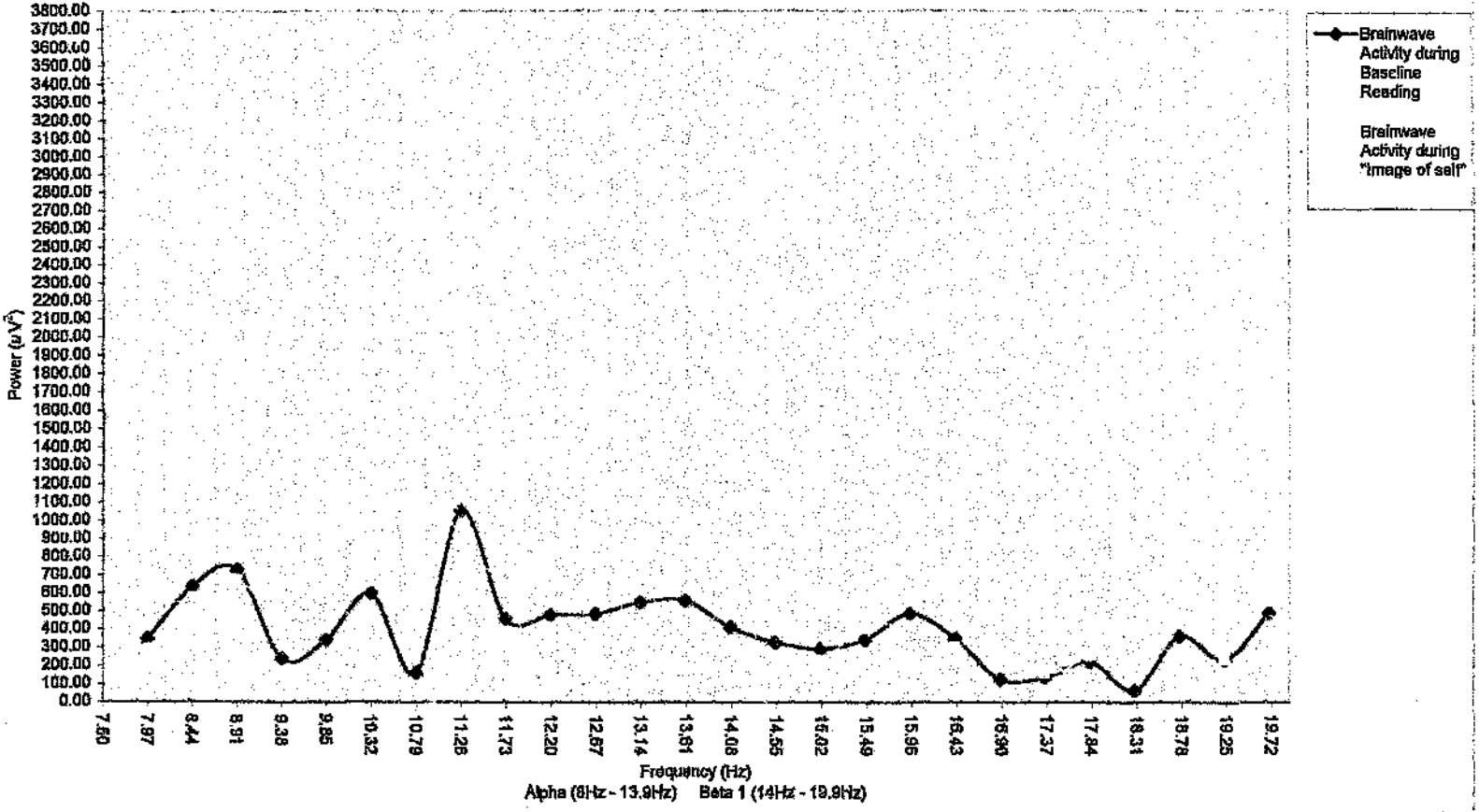
Subject 2 : Brainwave Activity



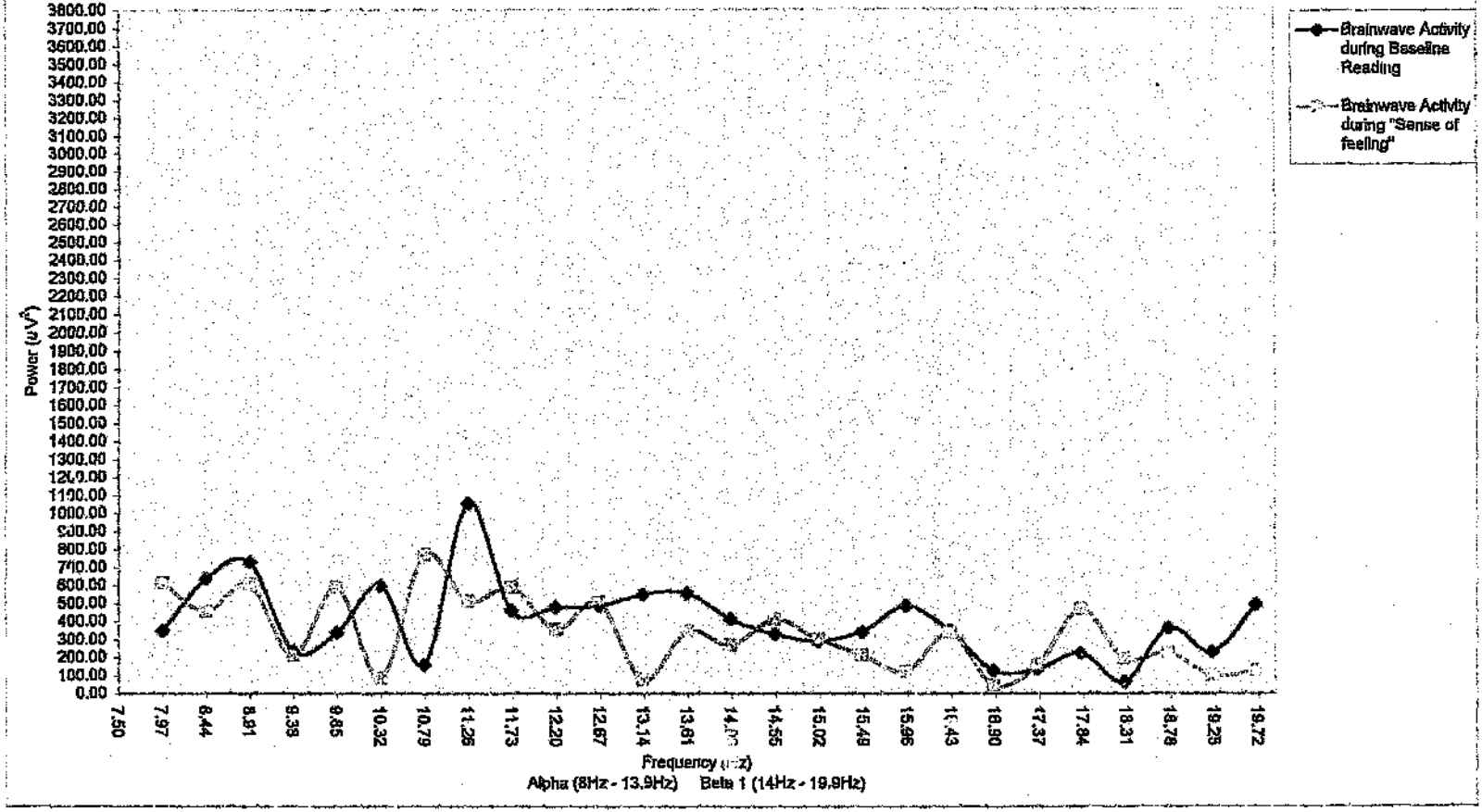
Subject 2 : Brainwave Activity



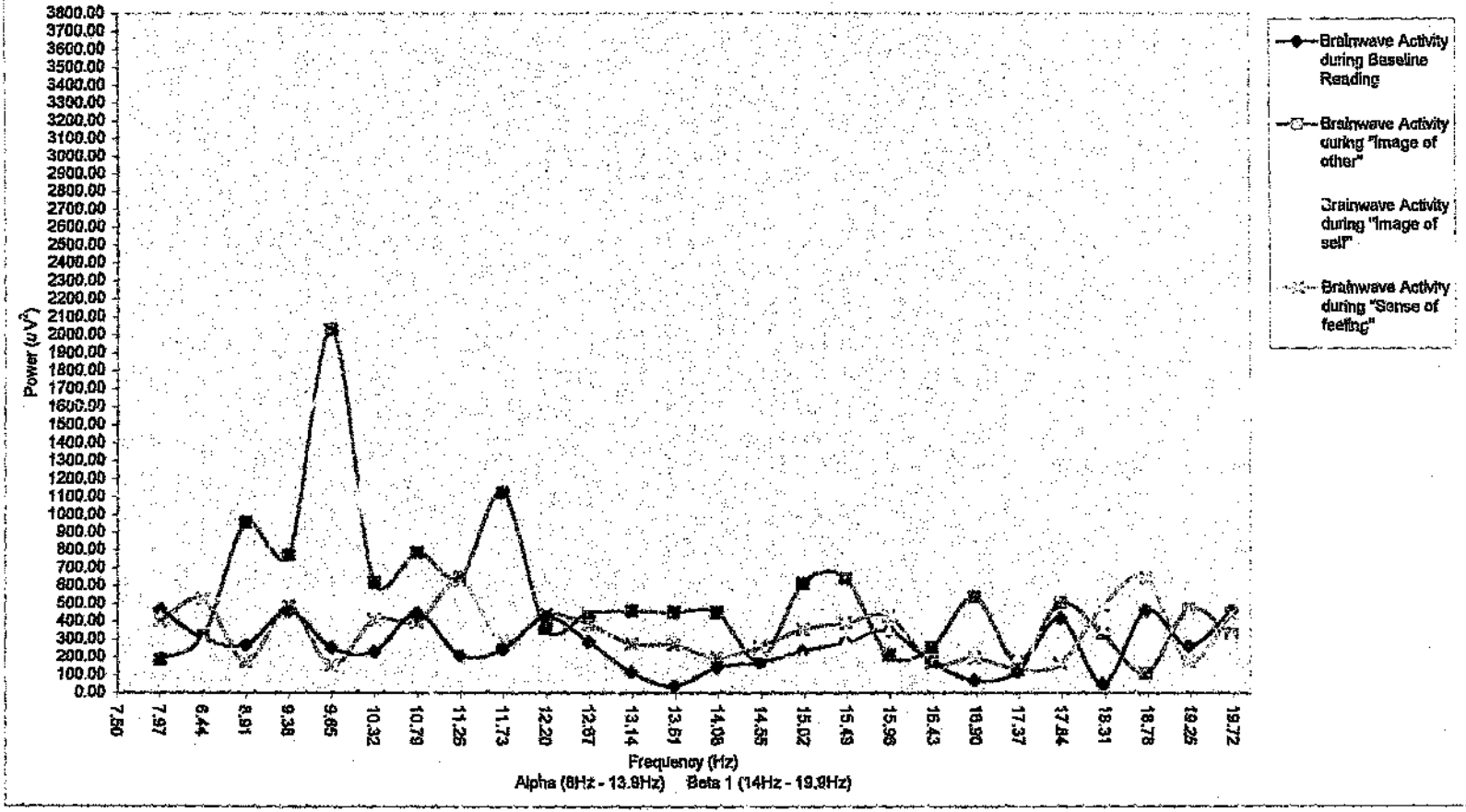
Subject 2 : Brainwave Activity

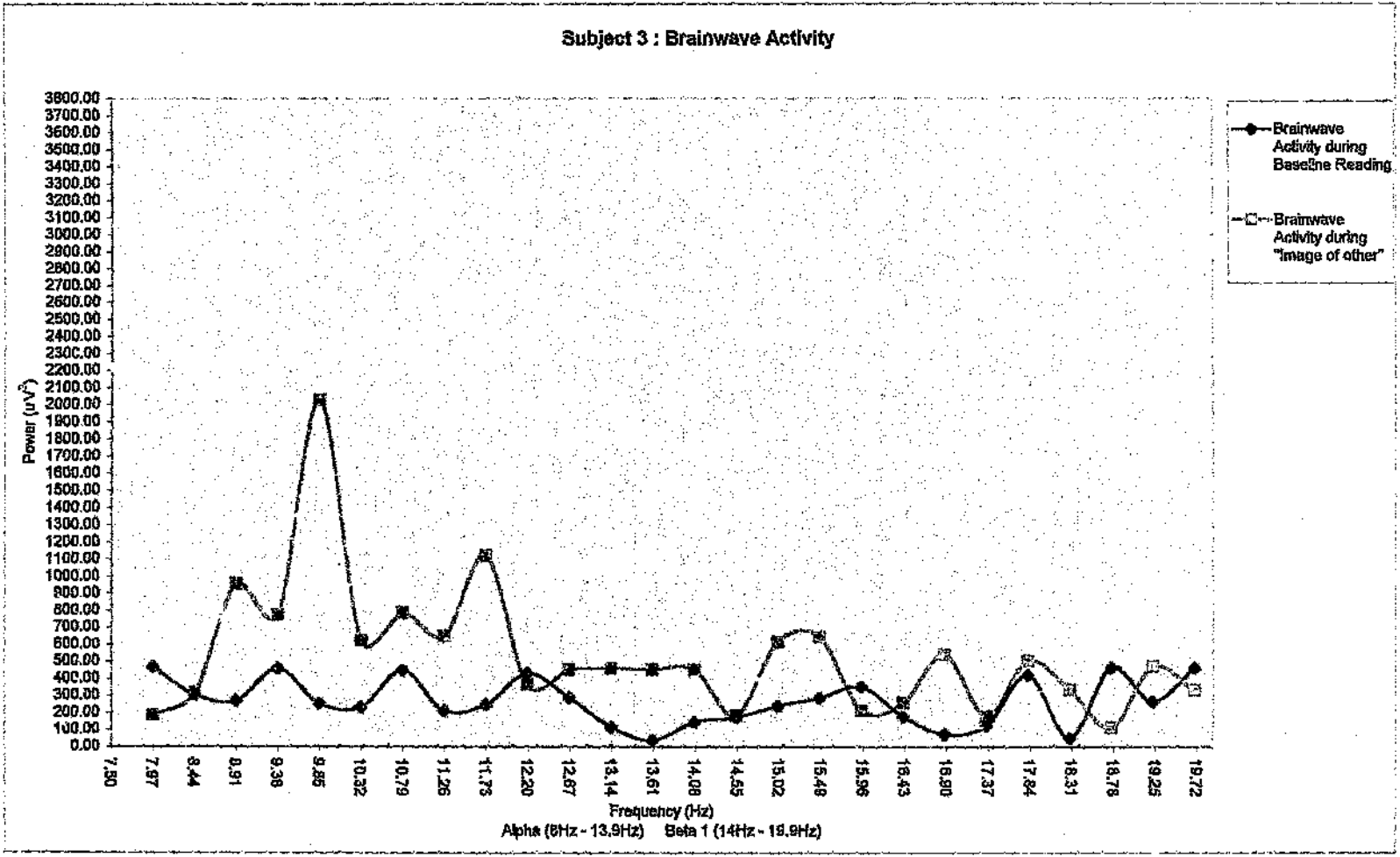


Subject 2 : Brainwave Activity

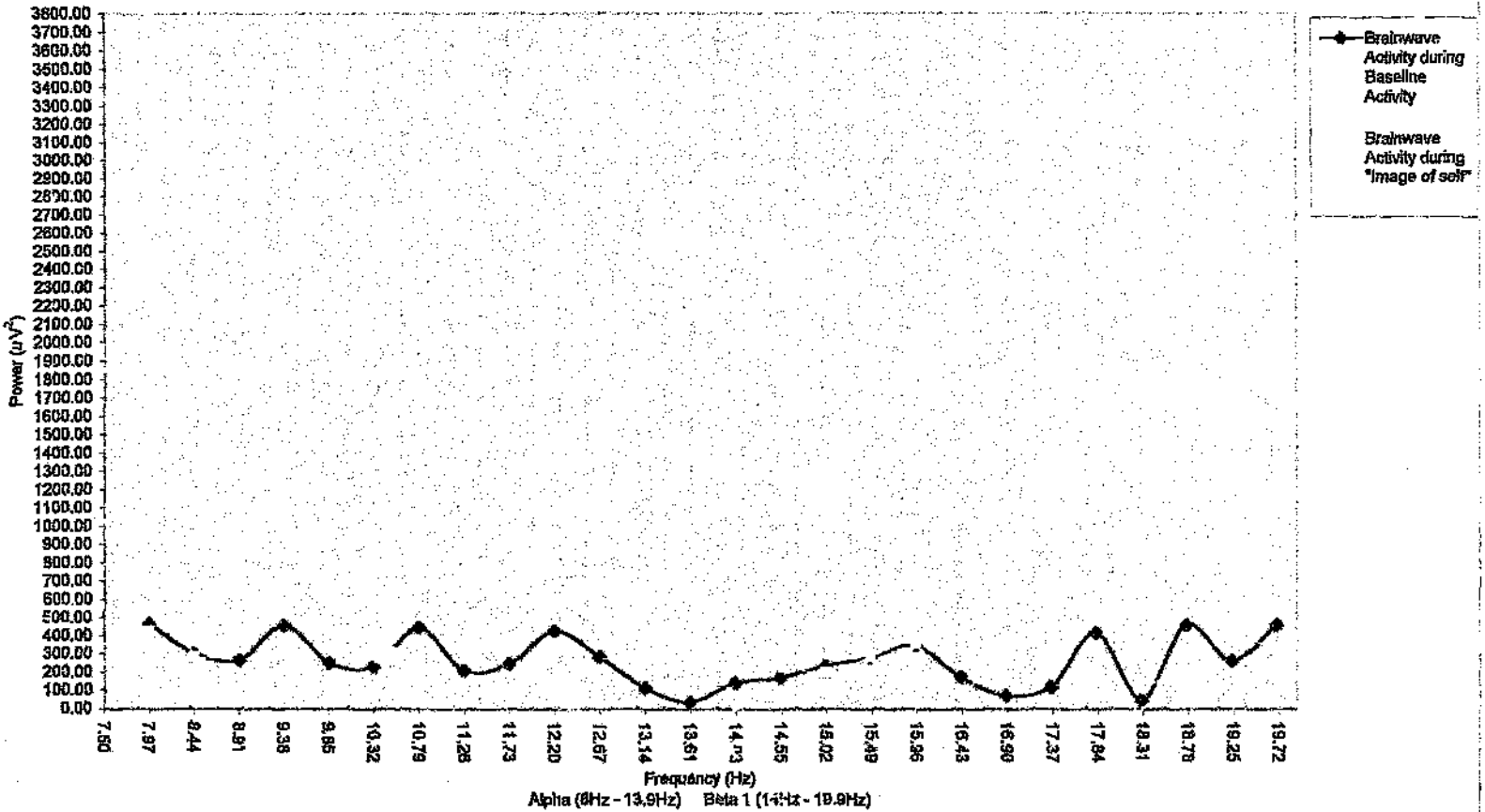


Subject 3: Brainwave Activity

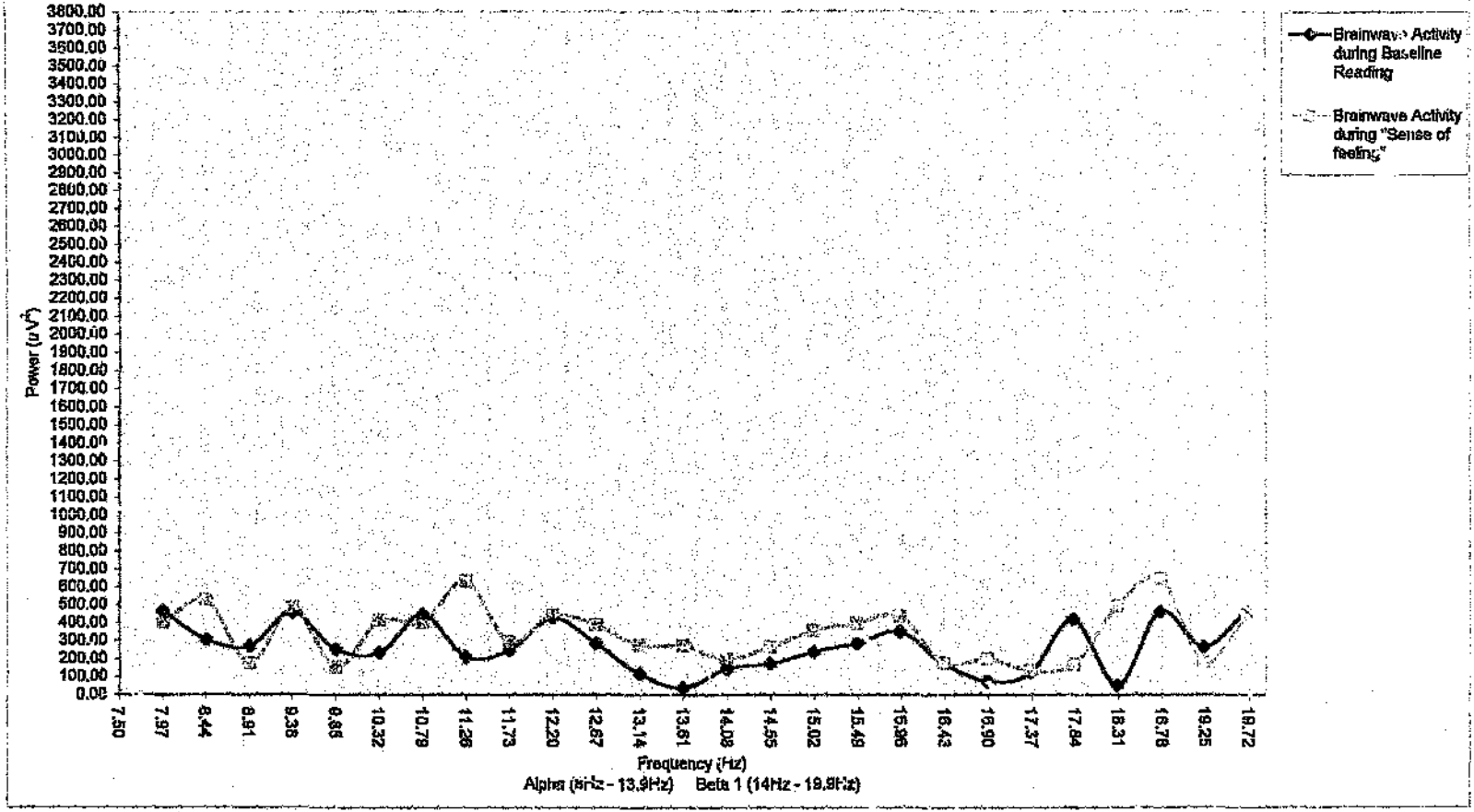



Subject 3 : Brainwave Activity
Power (uV²)
3800.00
3700.00
3600.00
3500.00
3400.00
3300.00
3200.00
3100.00
3000.00
2900.00
2800.00
2700.00
2600.00
2500.00
2400.00
2300.00
2200.00
2100.00
2000.00
1900.00
1800.00
1700.00
1600.00
1500.00
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
7.50
7.97
8.44
8.91
9.38
9.85
10.32
10.79
11.26
11.73
12.20
12.67
13.14
13.61
14.08
14.55
15.02
15.49
15.96
16.43
16.90
17.37
17.84
18.31
18.78
19.25
19.72
Frequency (Hz)
Alpha (8Hz - 13.9Hz) Beta 1 (14Hz - 19.9Hz)
Brainwave Activity during Baseline Reading
Brainwave Activity during "Image of other"

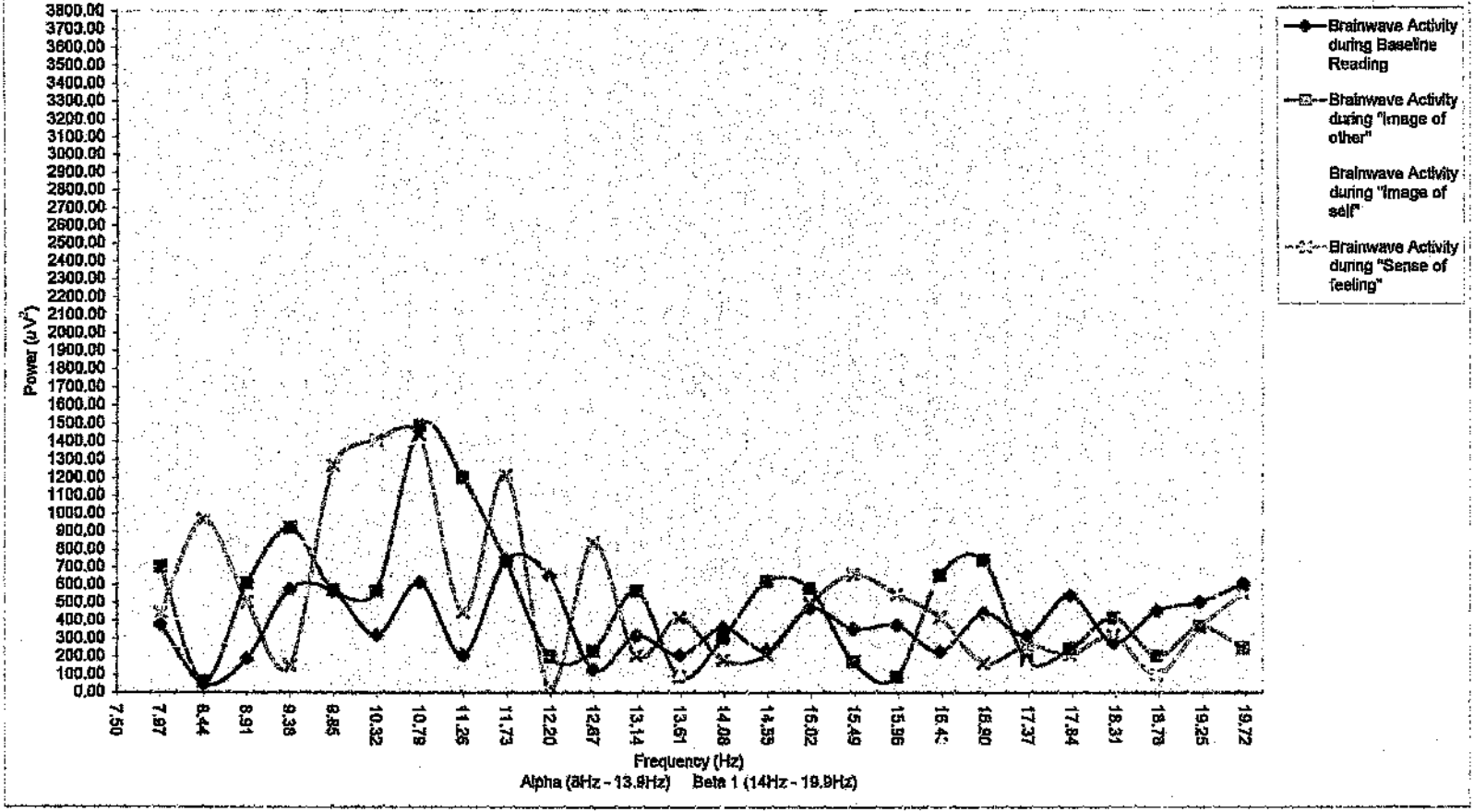
Subject 3 : Brainwave Activity

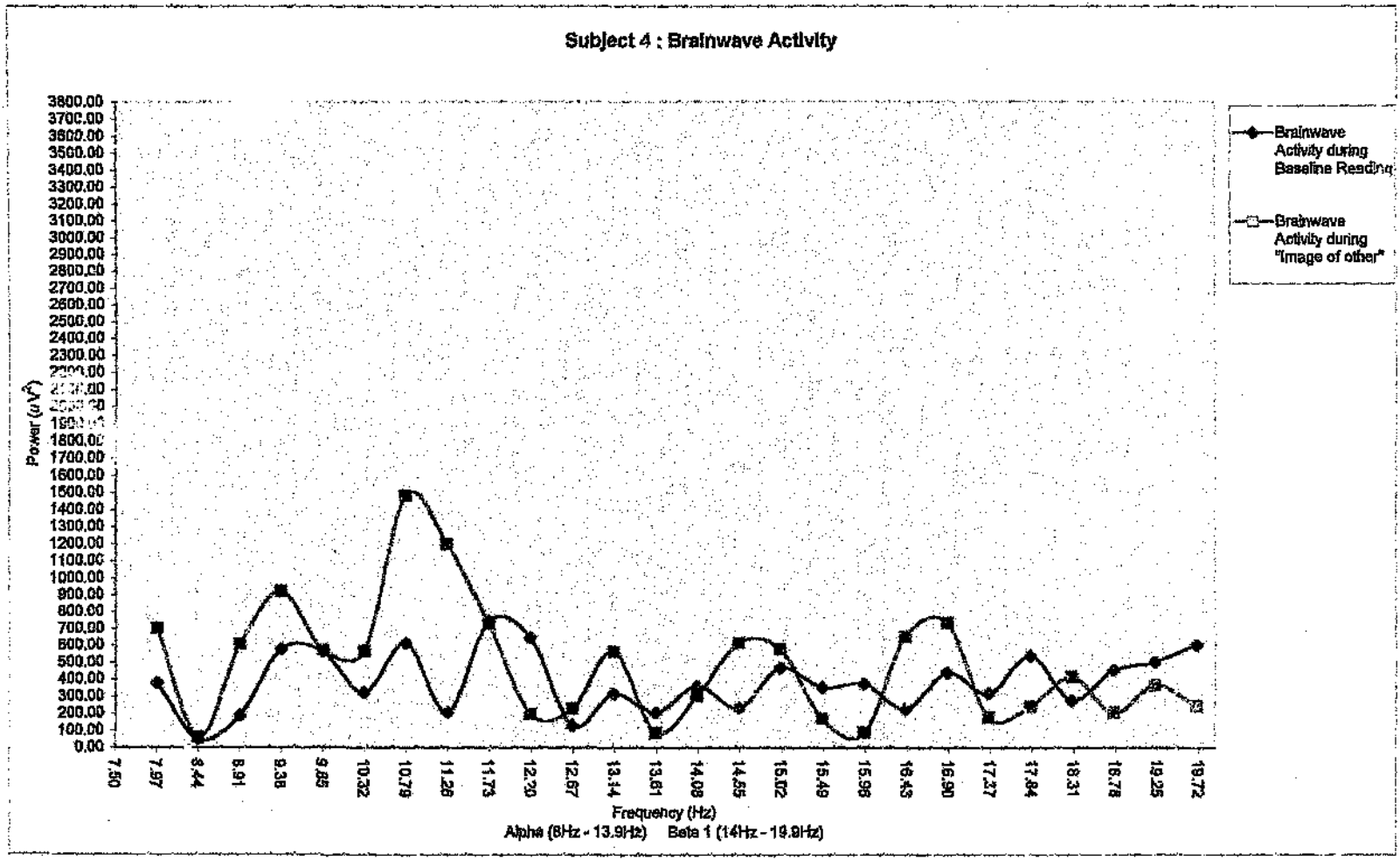


Subject 3 :Brainwave Activity

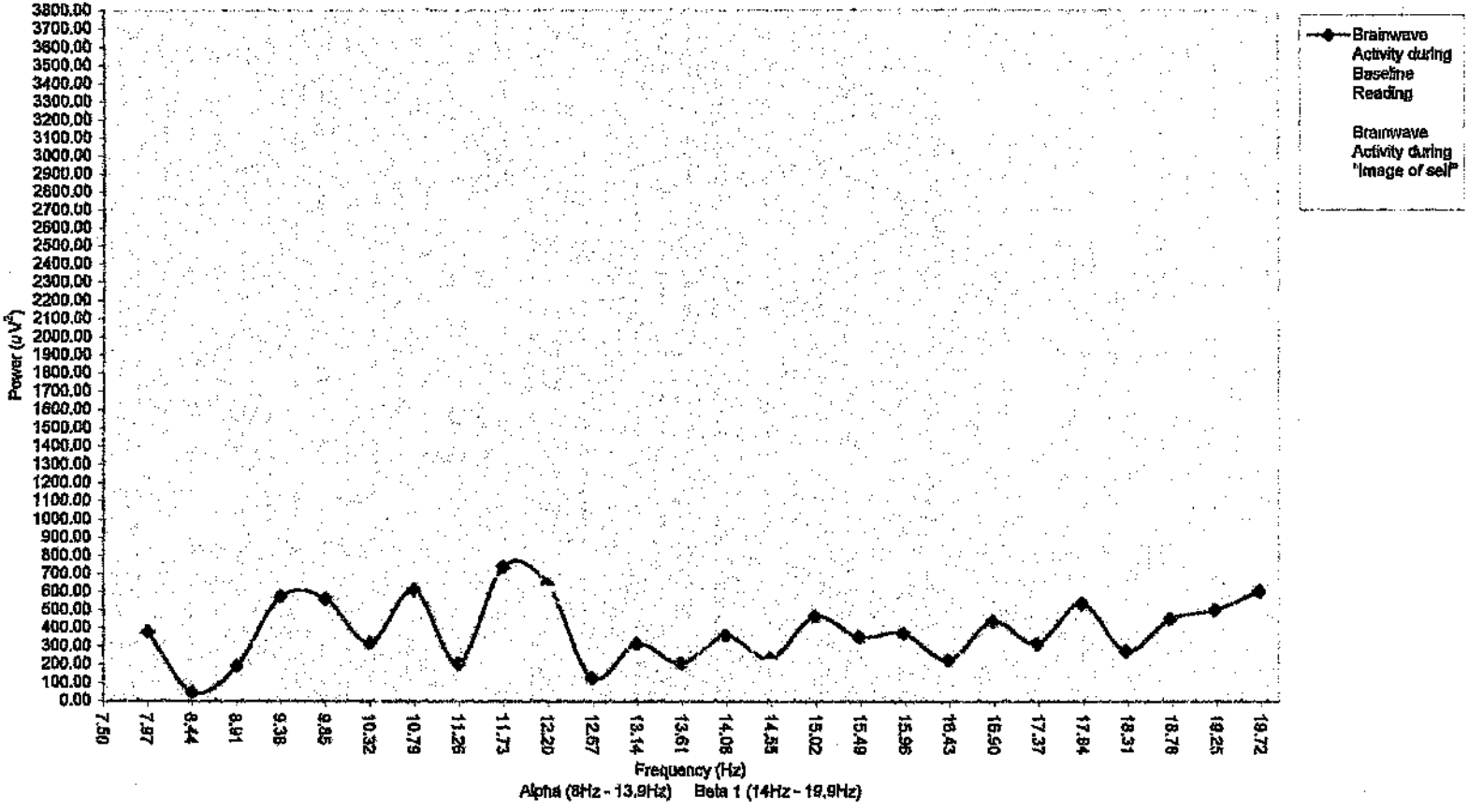


Subject 4 : Brainwave Activity

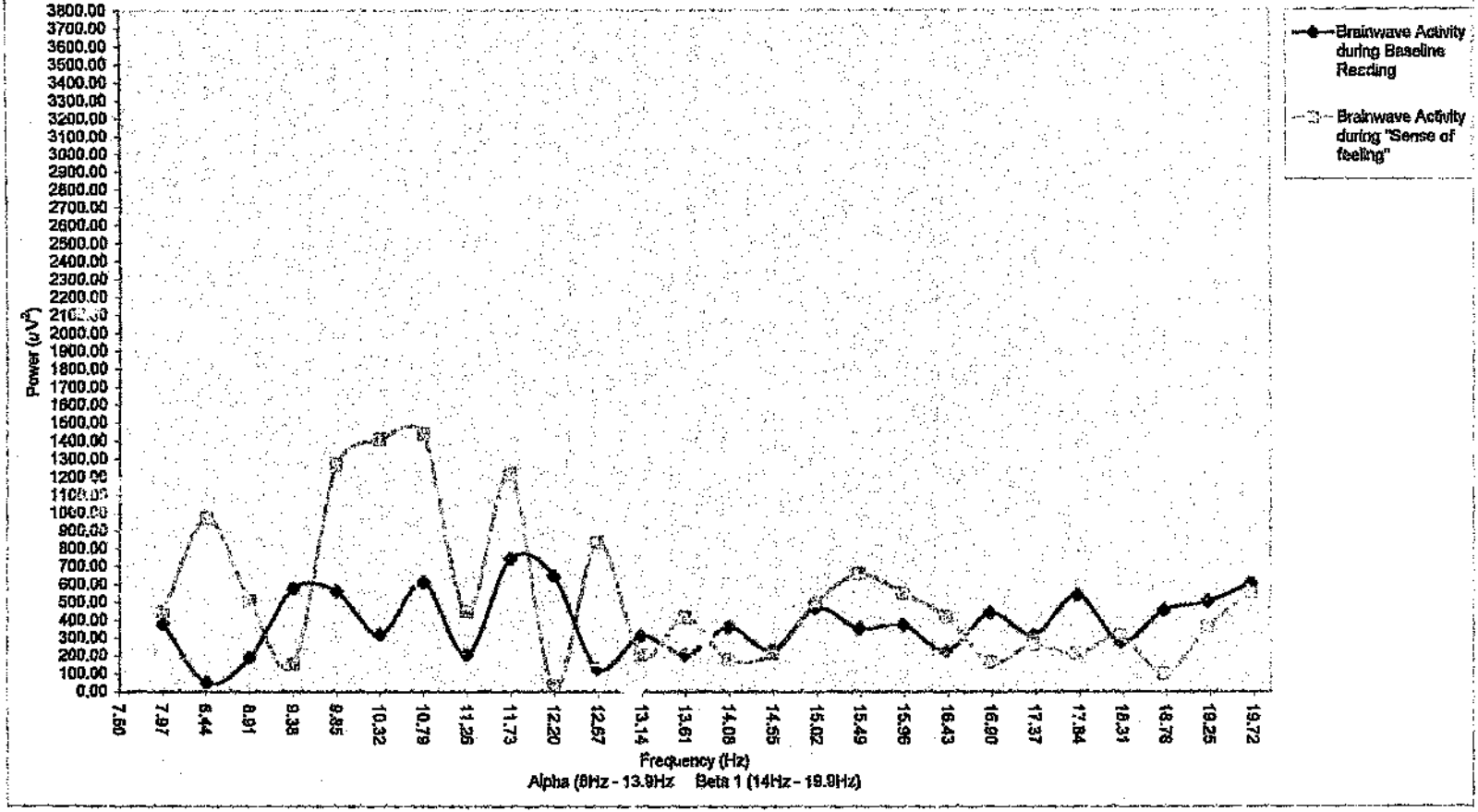



Subject 4 : Brainwave Activity
Brainwave Activity during Baseline Reading
Brainwave Activity during "Image of other"
Power (μV²)
3800.00
3700.00
3600.00
3500.00
3400.00
3300.00
3200.00
3100.00
3000.00
2900.00
2800.00
2700.00
2600.00
2500.00
2400.00
2300.00
1800.00
1700.00
1600.00
1500.00
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
7.50
7.97
8.44
8.91
9.38
9.85
10.32
10.79
11.26
11.73
12.20
12.67
13.14
13.61
14.08
14.55
15.02
15.49
15.96
16.43
16.90
17.37
17.84
18.31
18.78
19.25
19.72
Frequency (Hz)
Alpha (8Hz - 13.9Hz)
Beta 1 (14Hz - 19.9Hz)

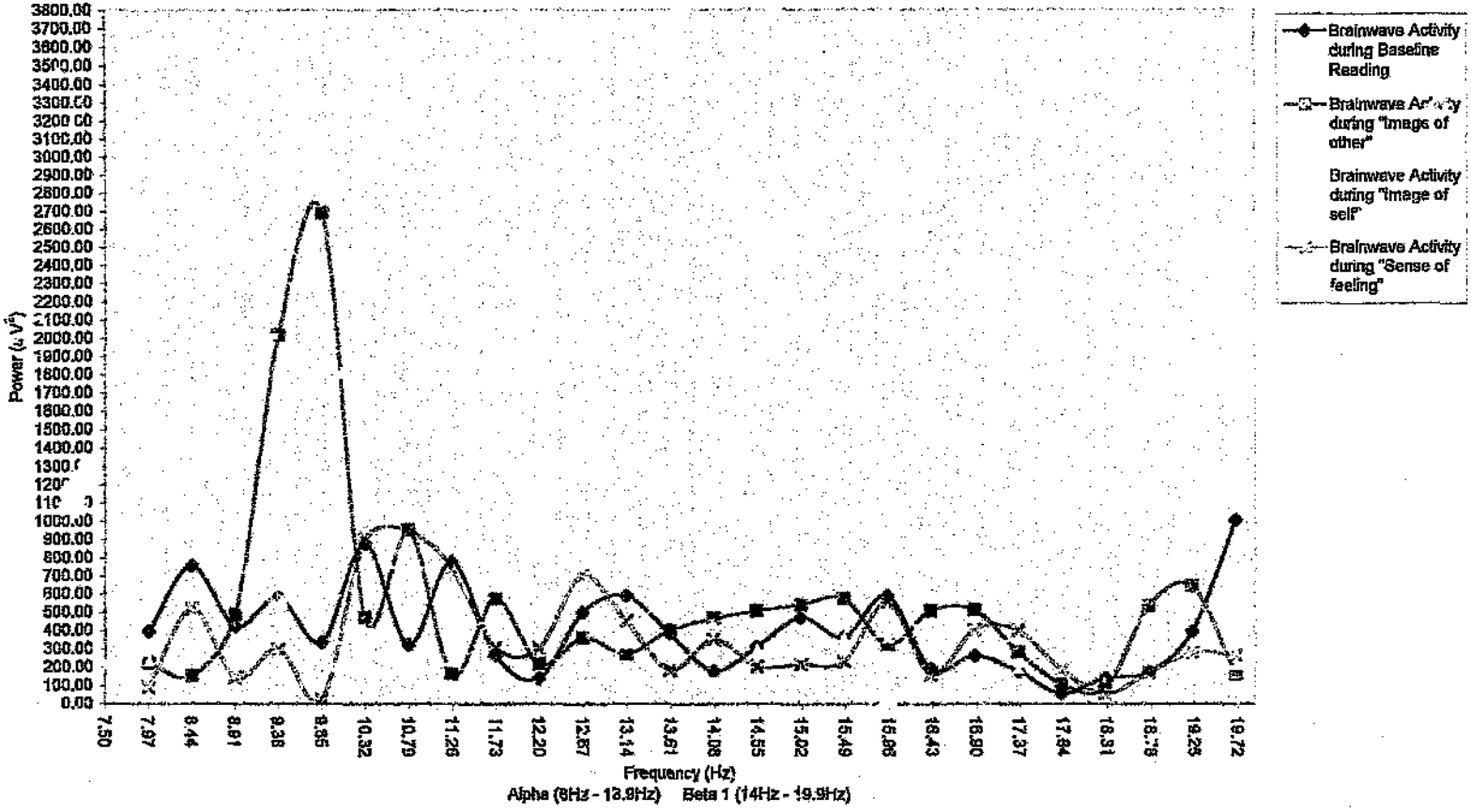
Subject 4 : Brainwave Activity



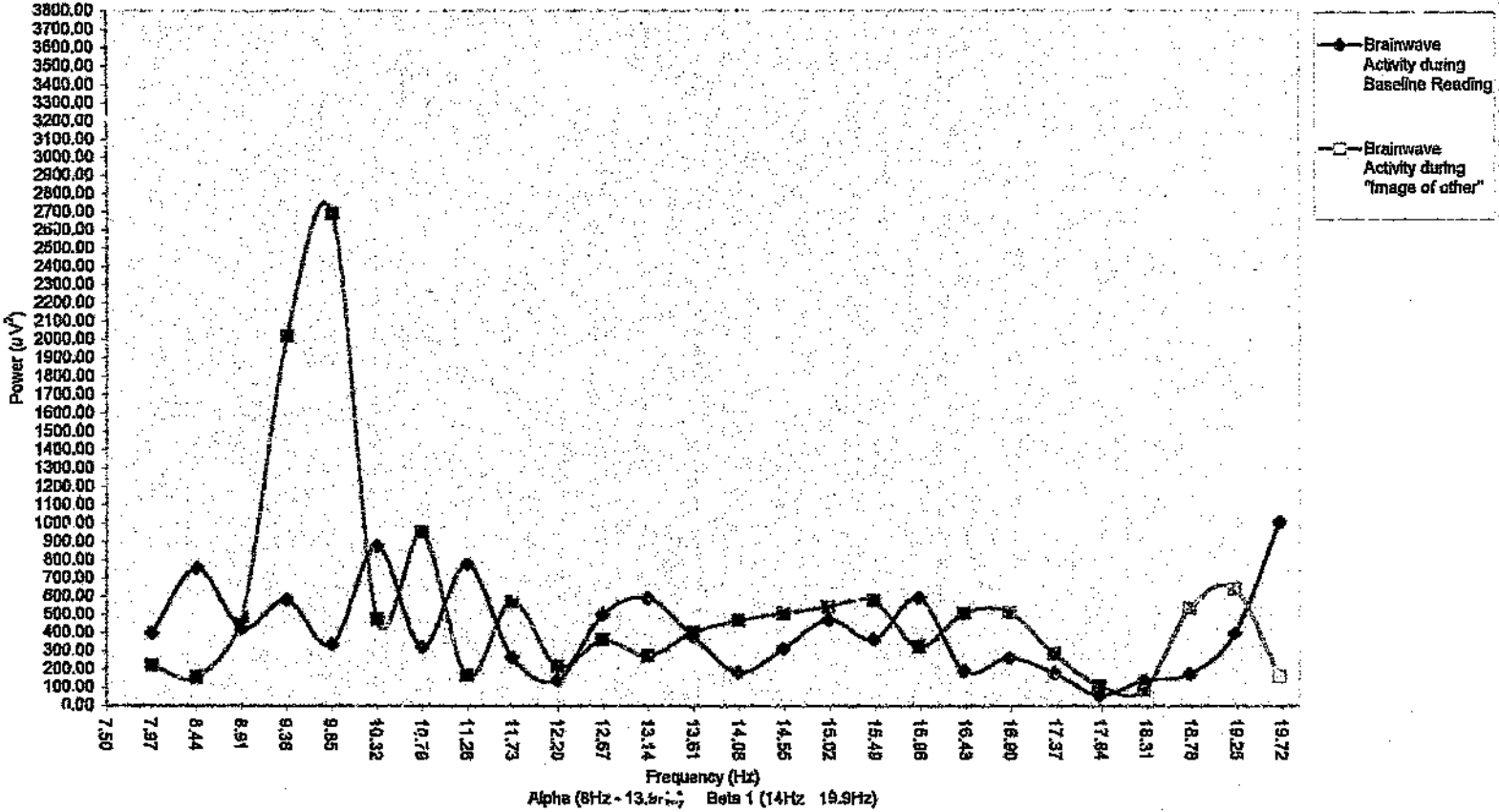
Subject 4 : Brainwave Activity



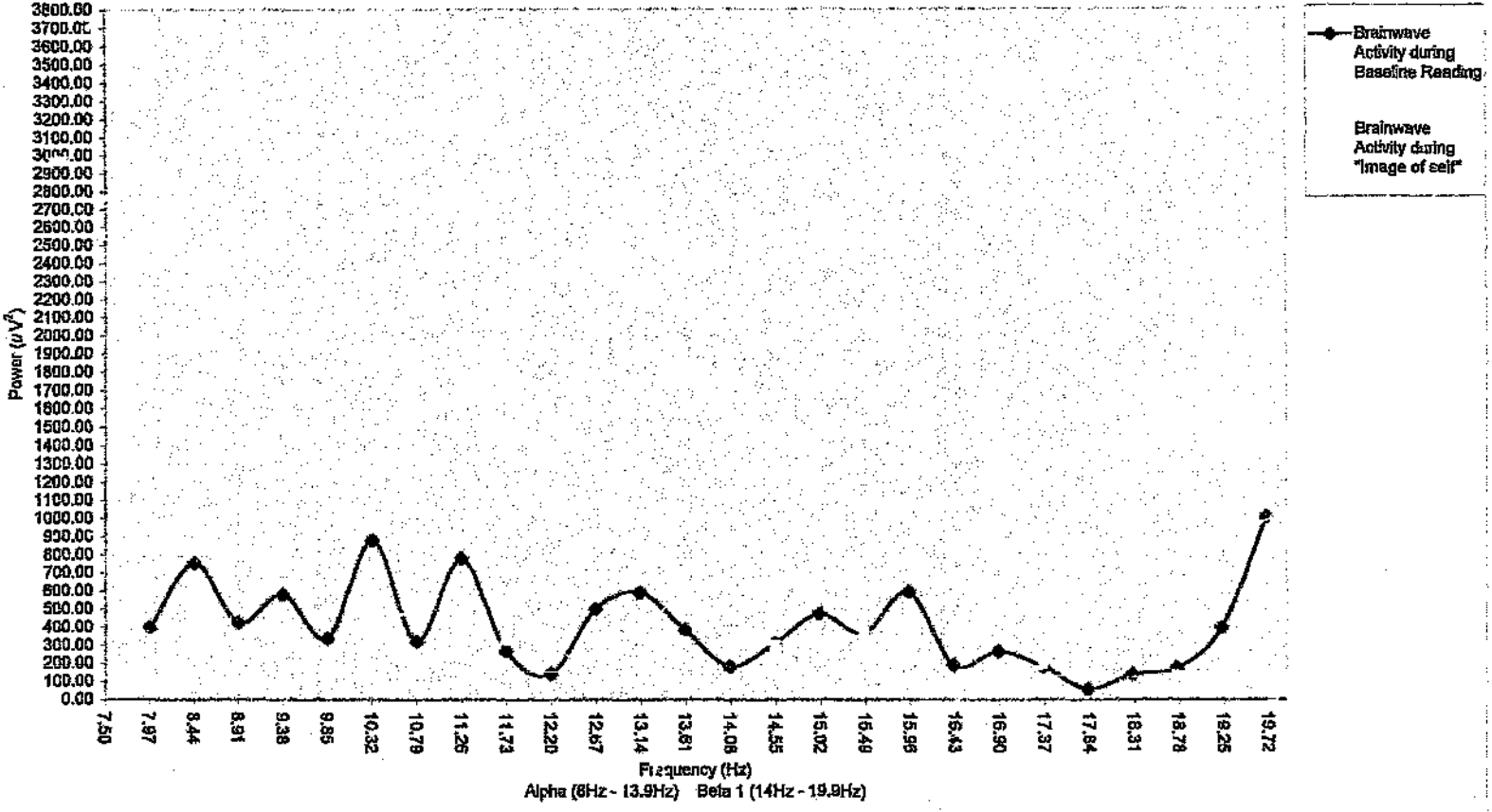
Subject 5 : Brainwave Activity



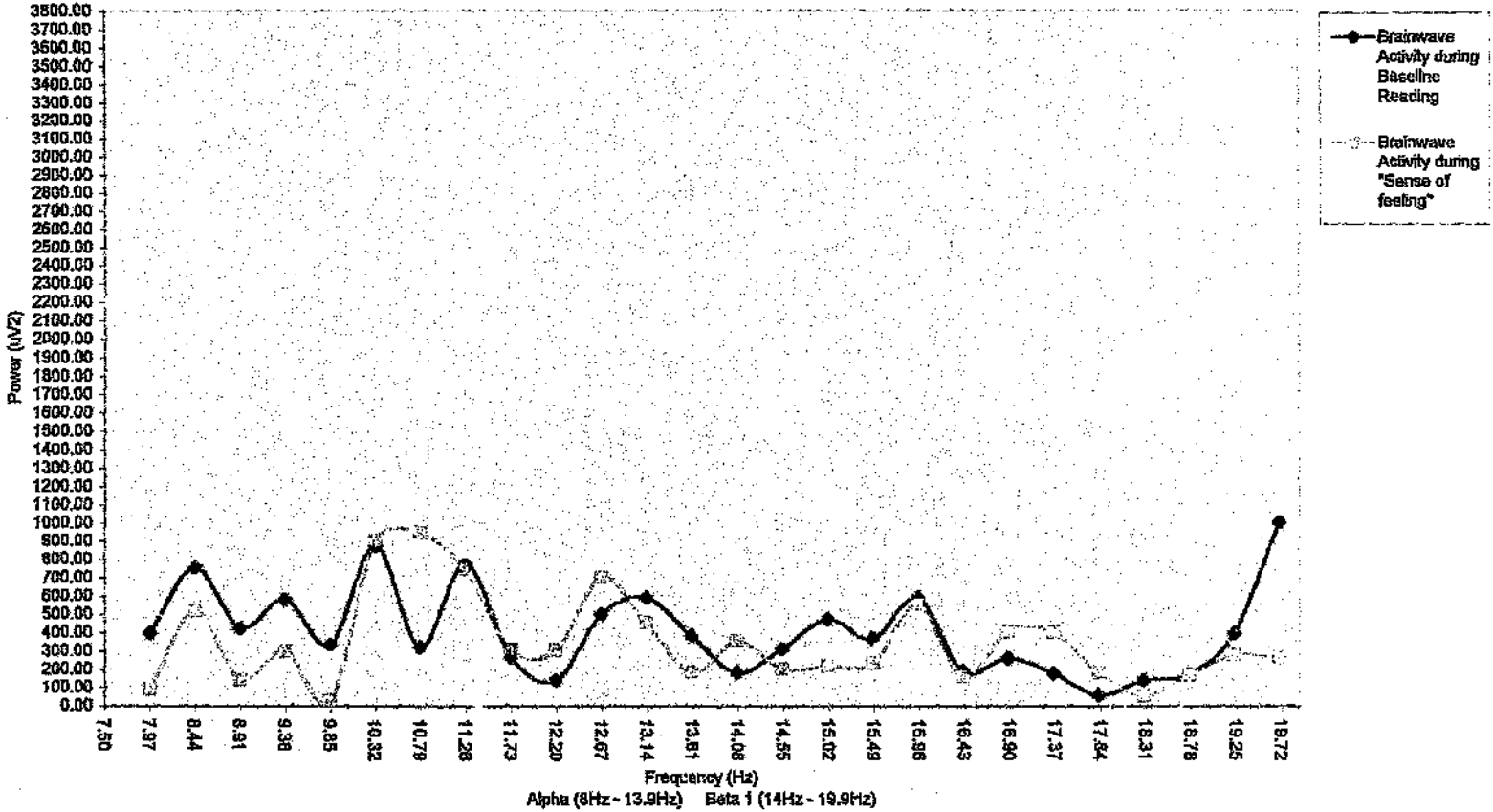
Subject 5 : Brainwave Activity



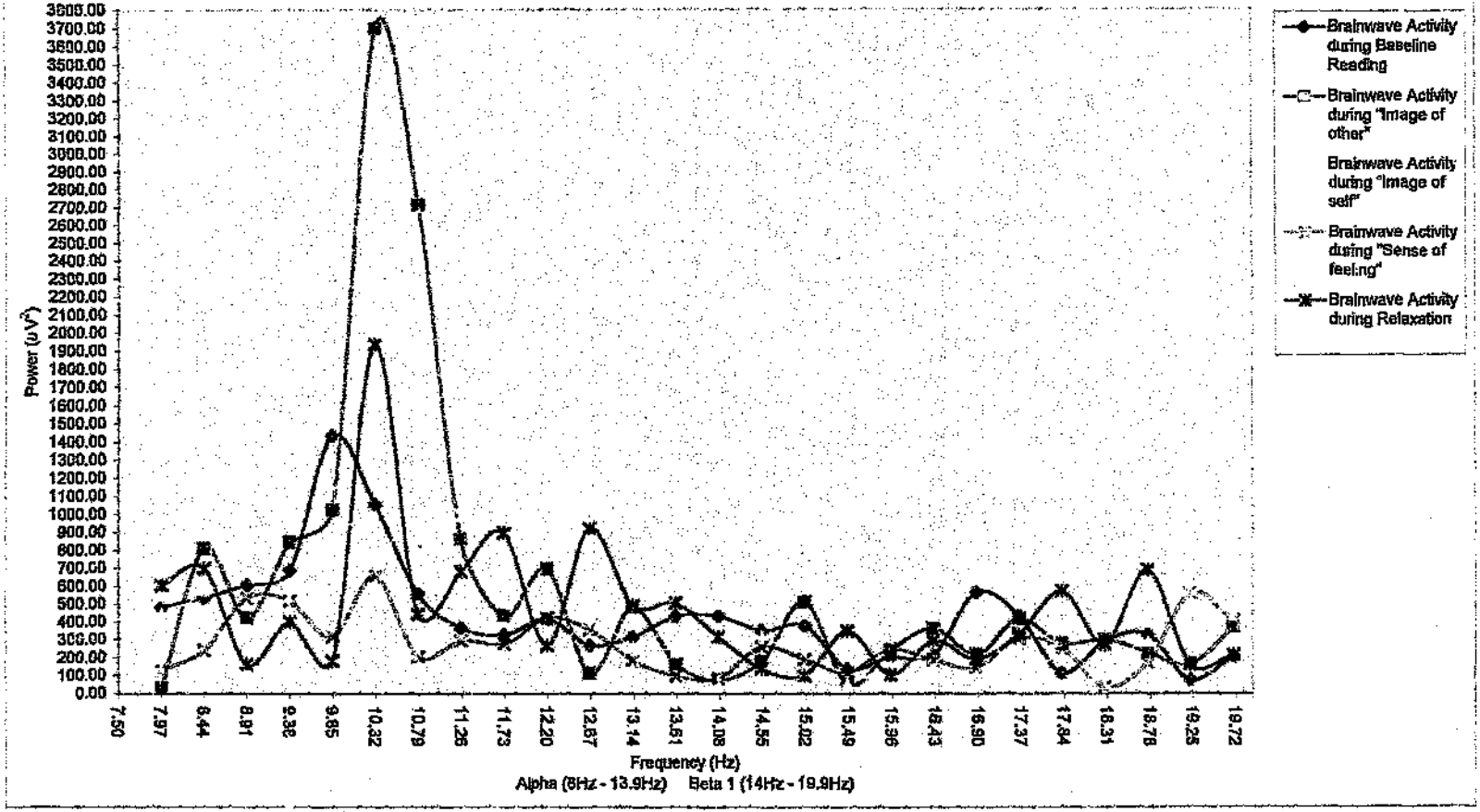
Subject 5 : Brainwave Activity



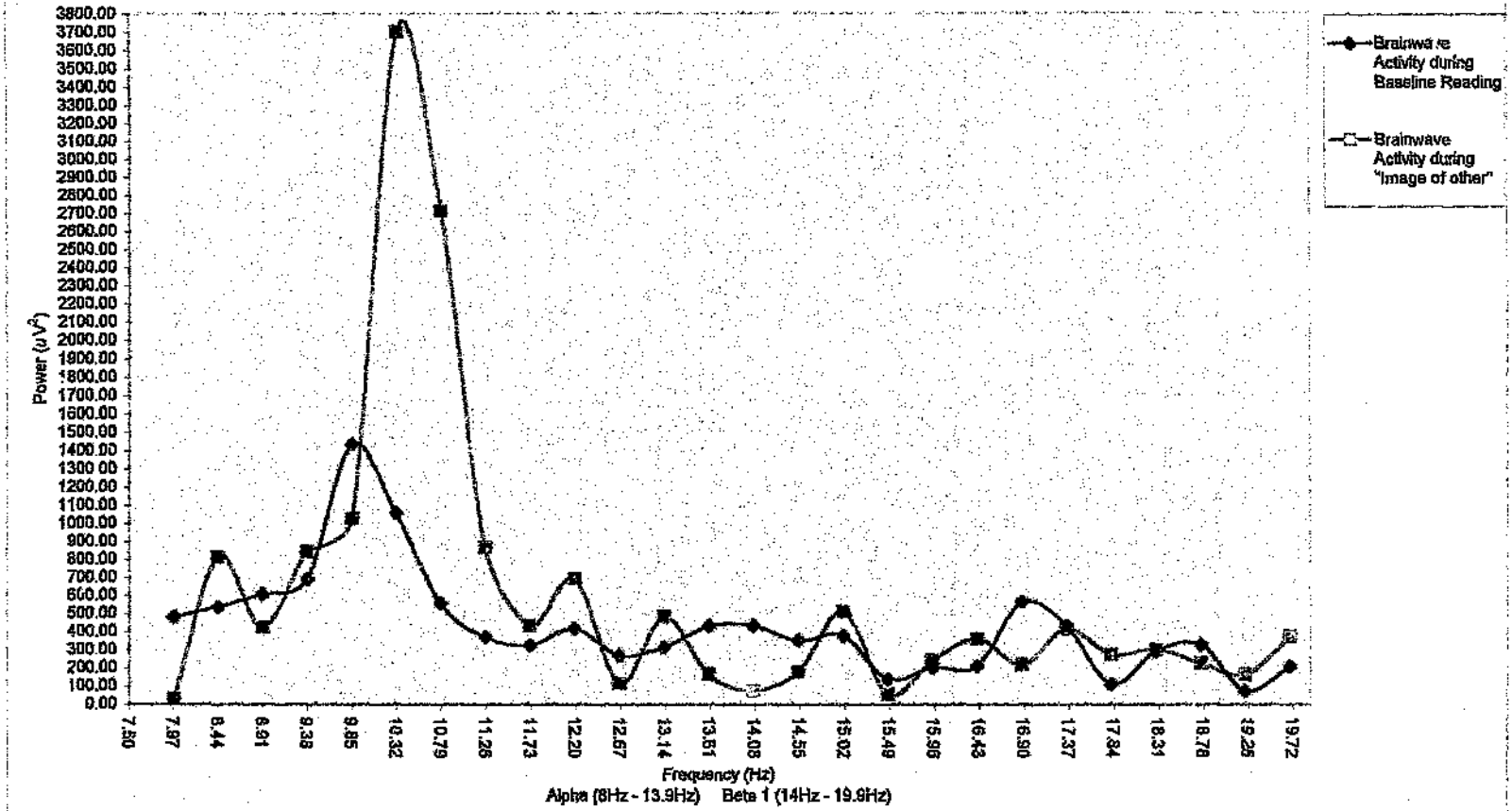
Subject 5 : Brainwave Activity



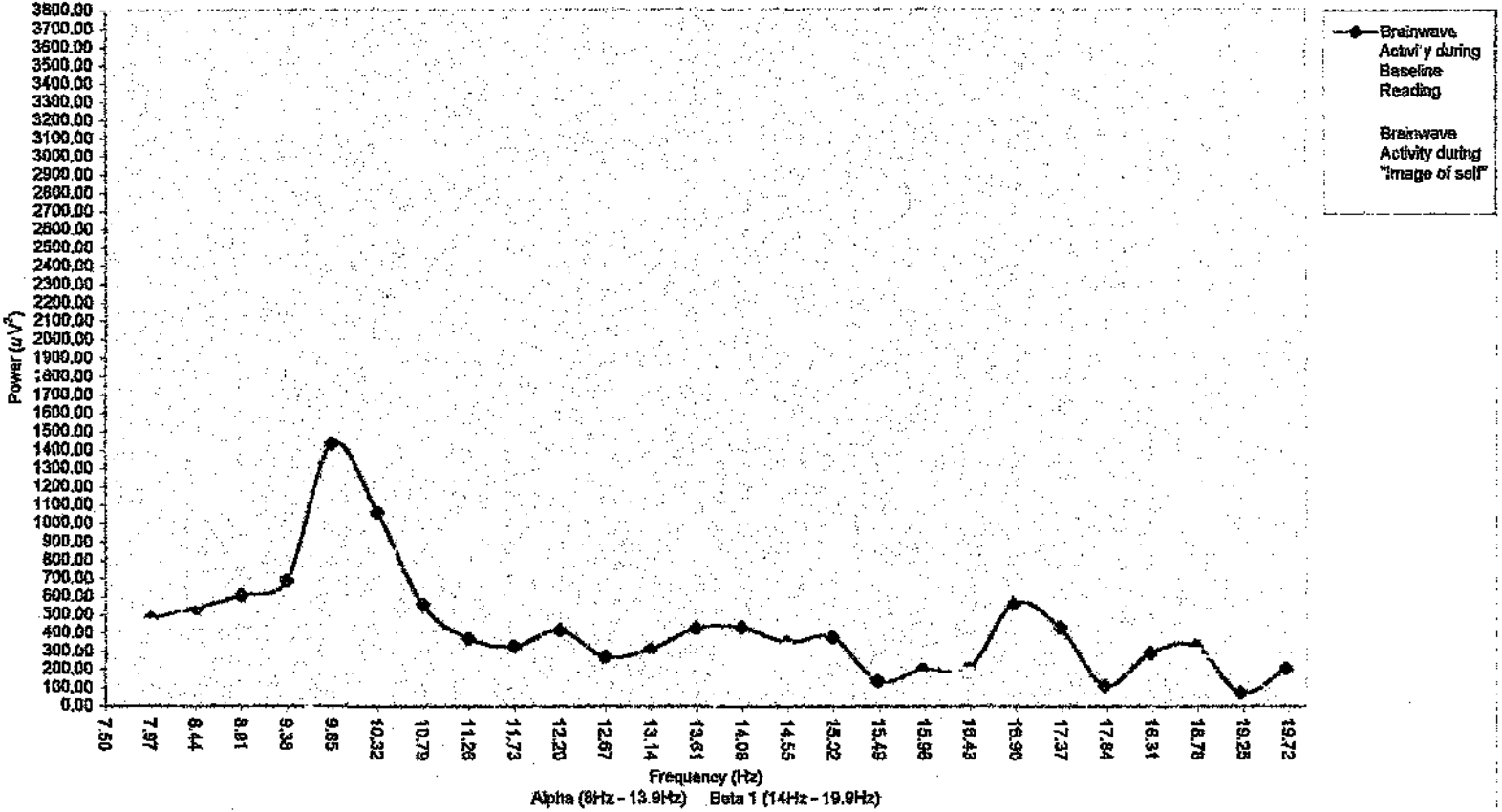
Subject 6: Brainwave Activity



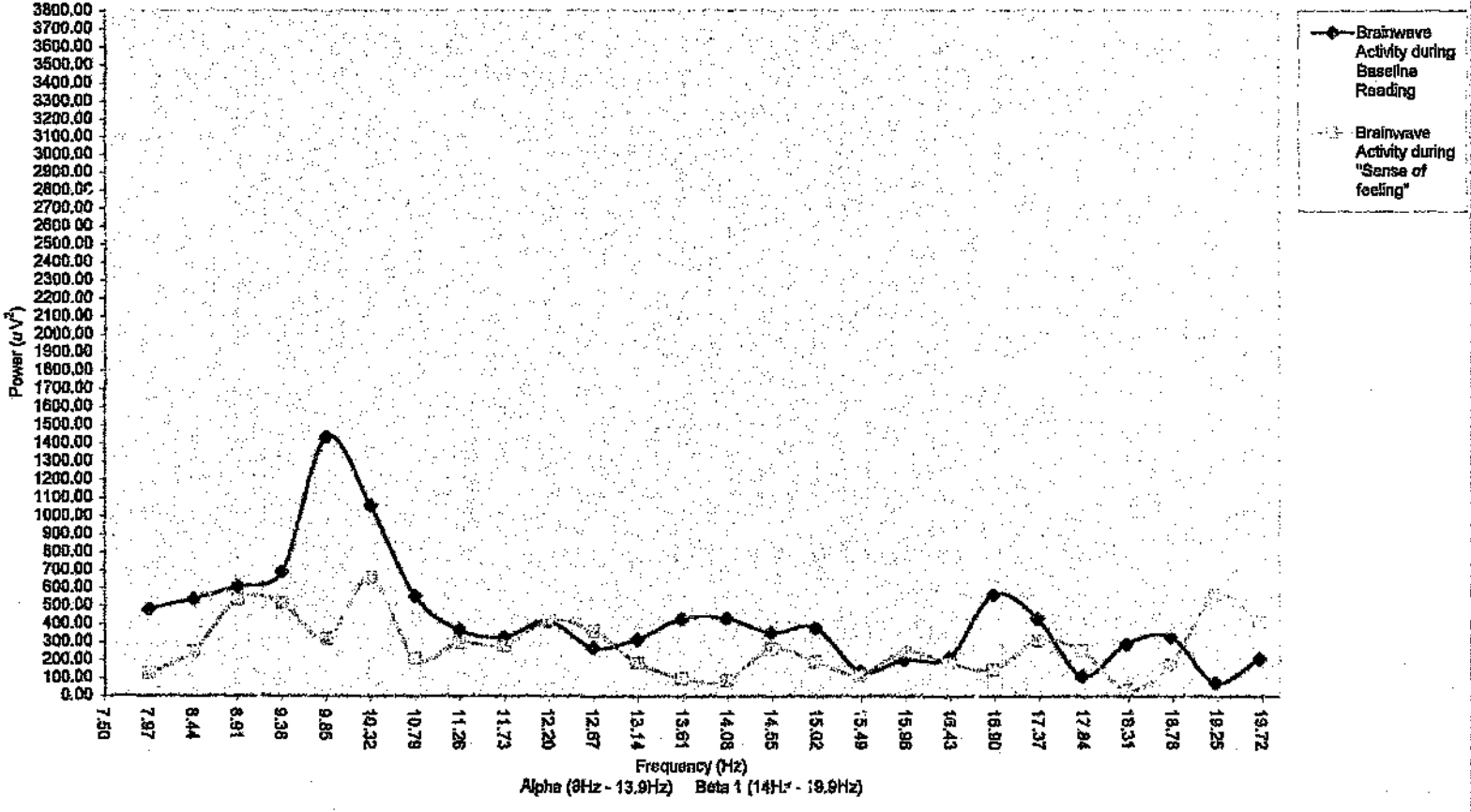
Subject 6 : Brainwave Activity



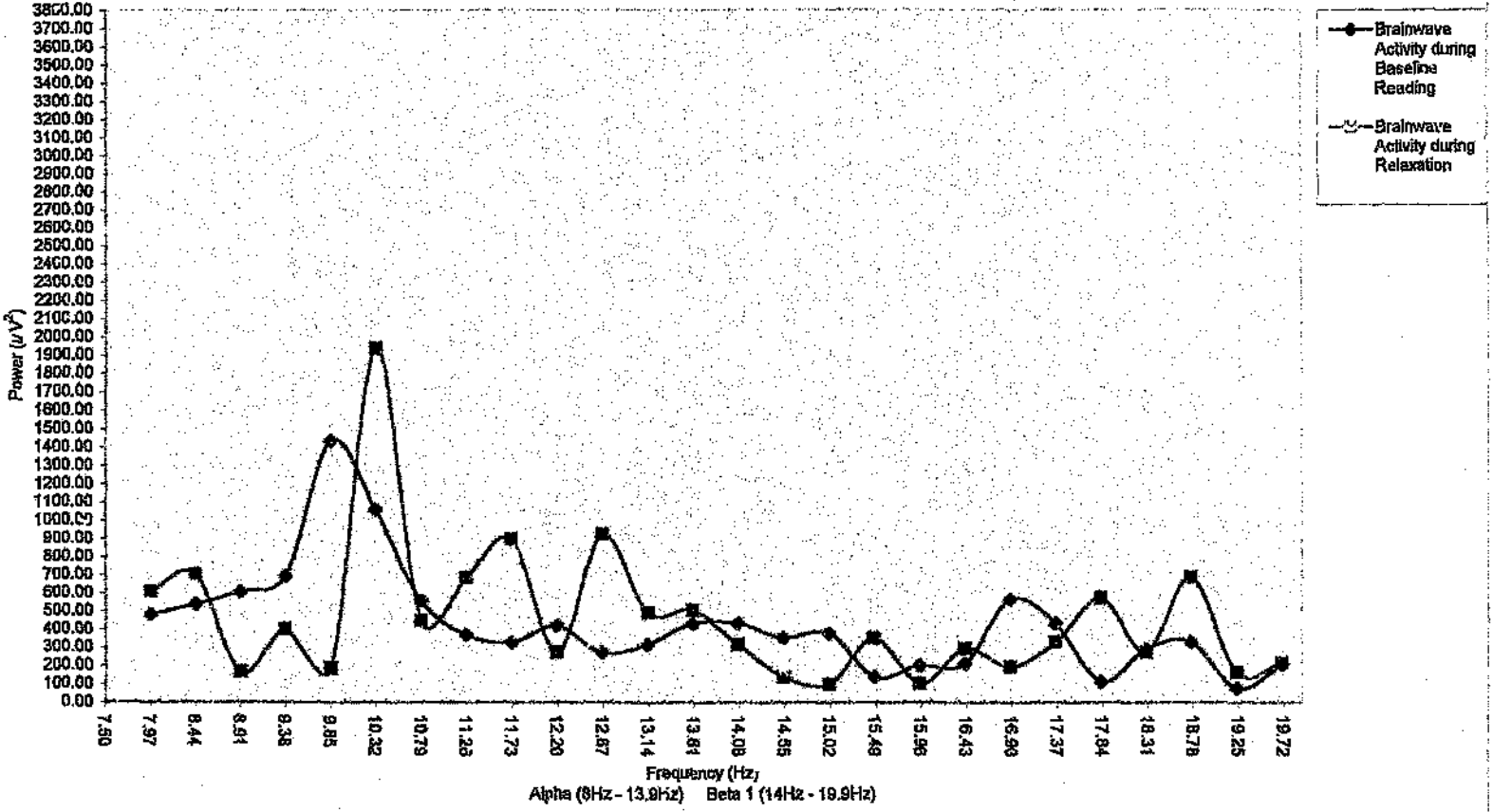
Subject 6 : Brainwave Activity



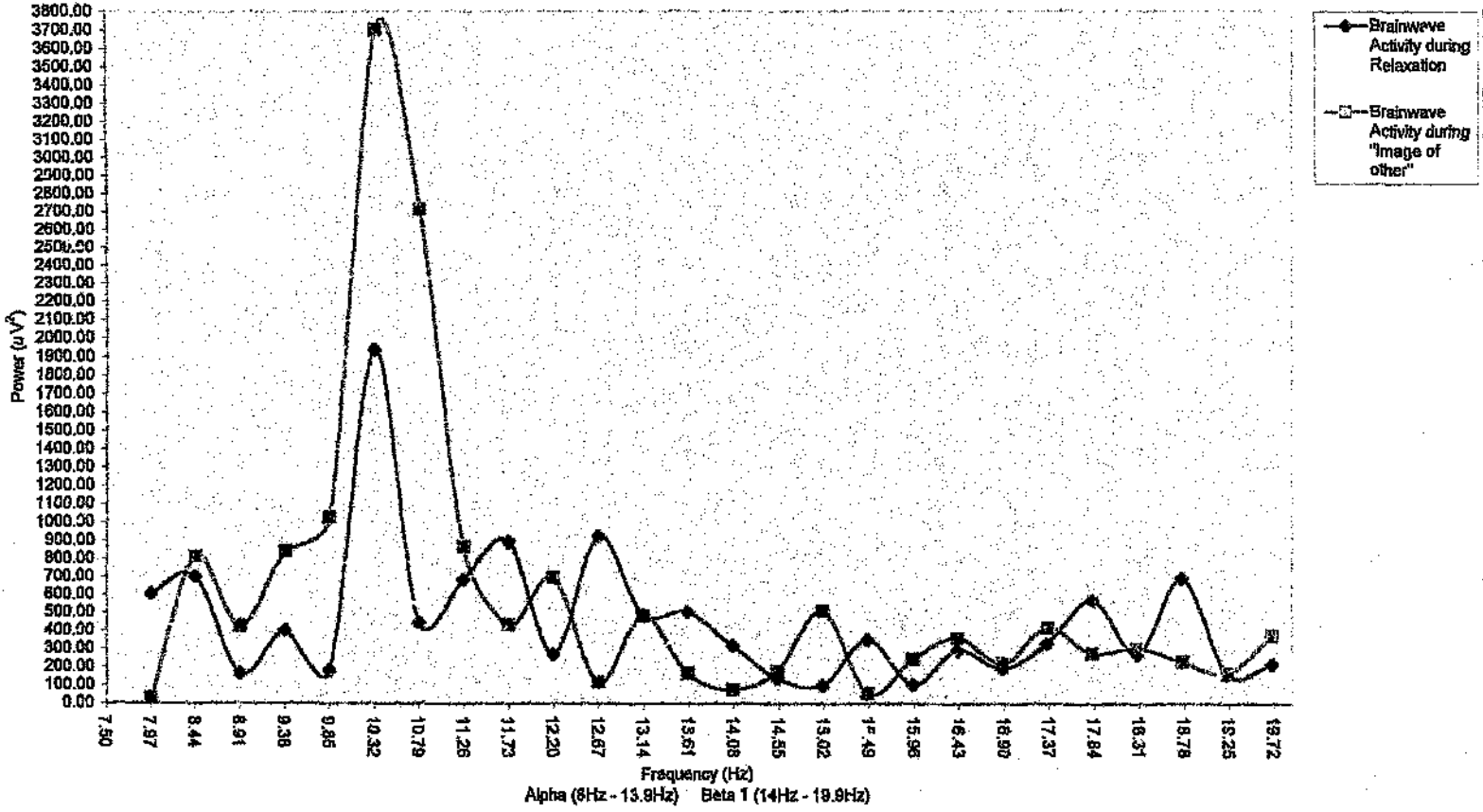
Subject 6 : Brainwave Activity



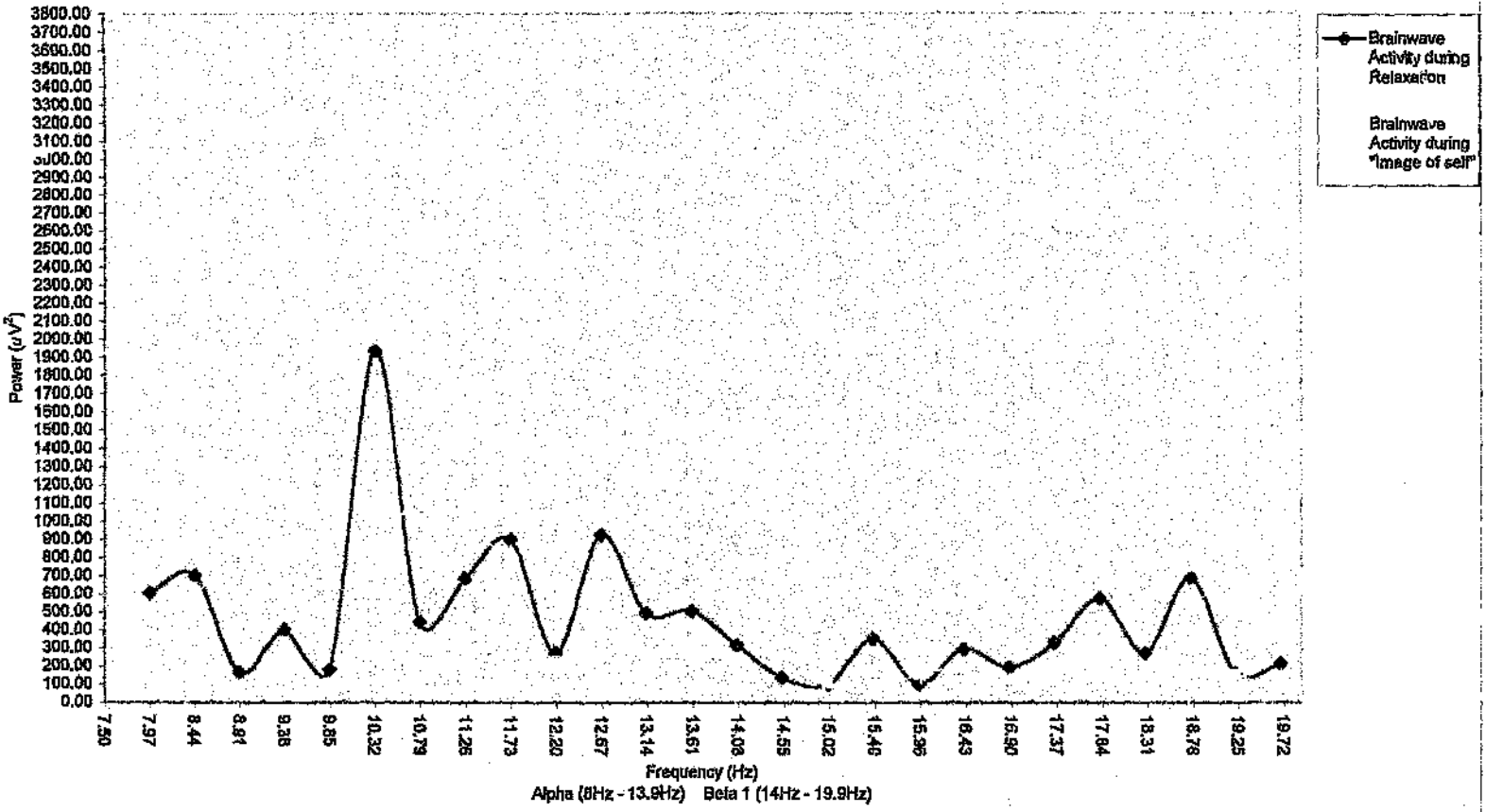
Subject 6 : Brainwave Activity



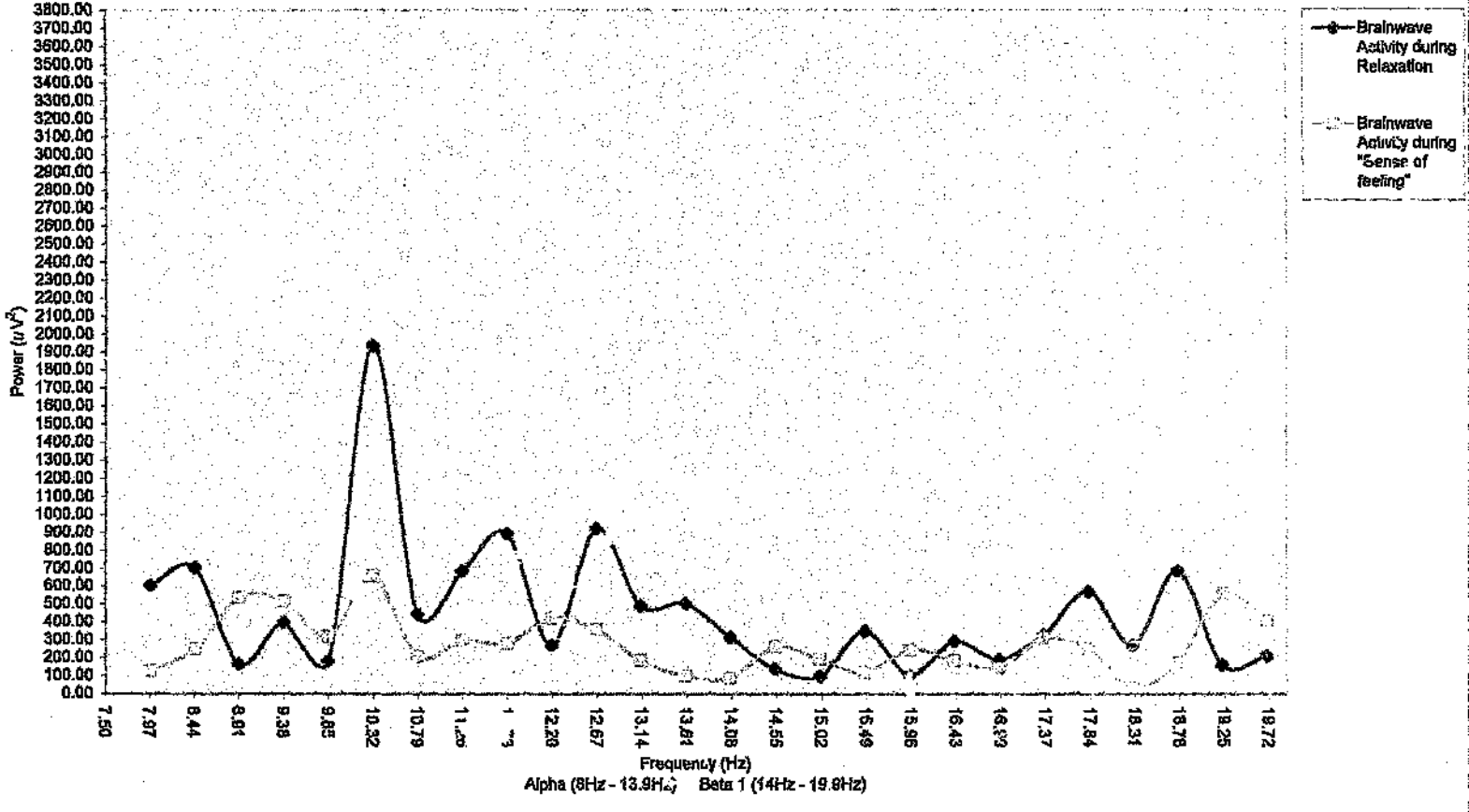
Subject 6 : Brainwave Activity

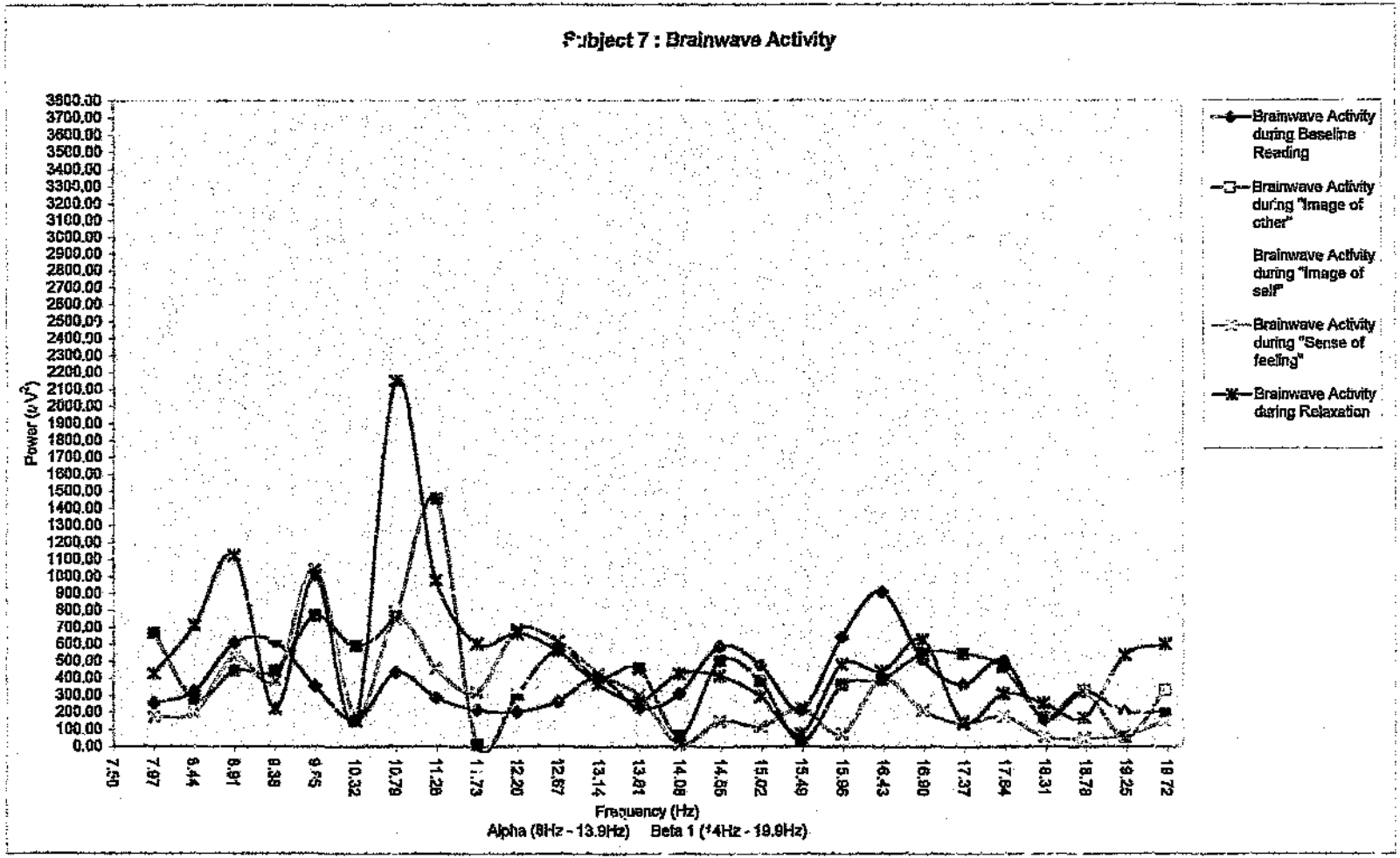


Subject 6 : Brainwave Activity

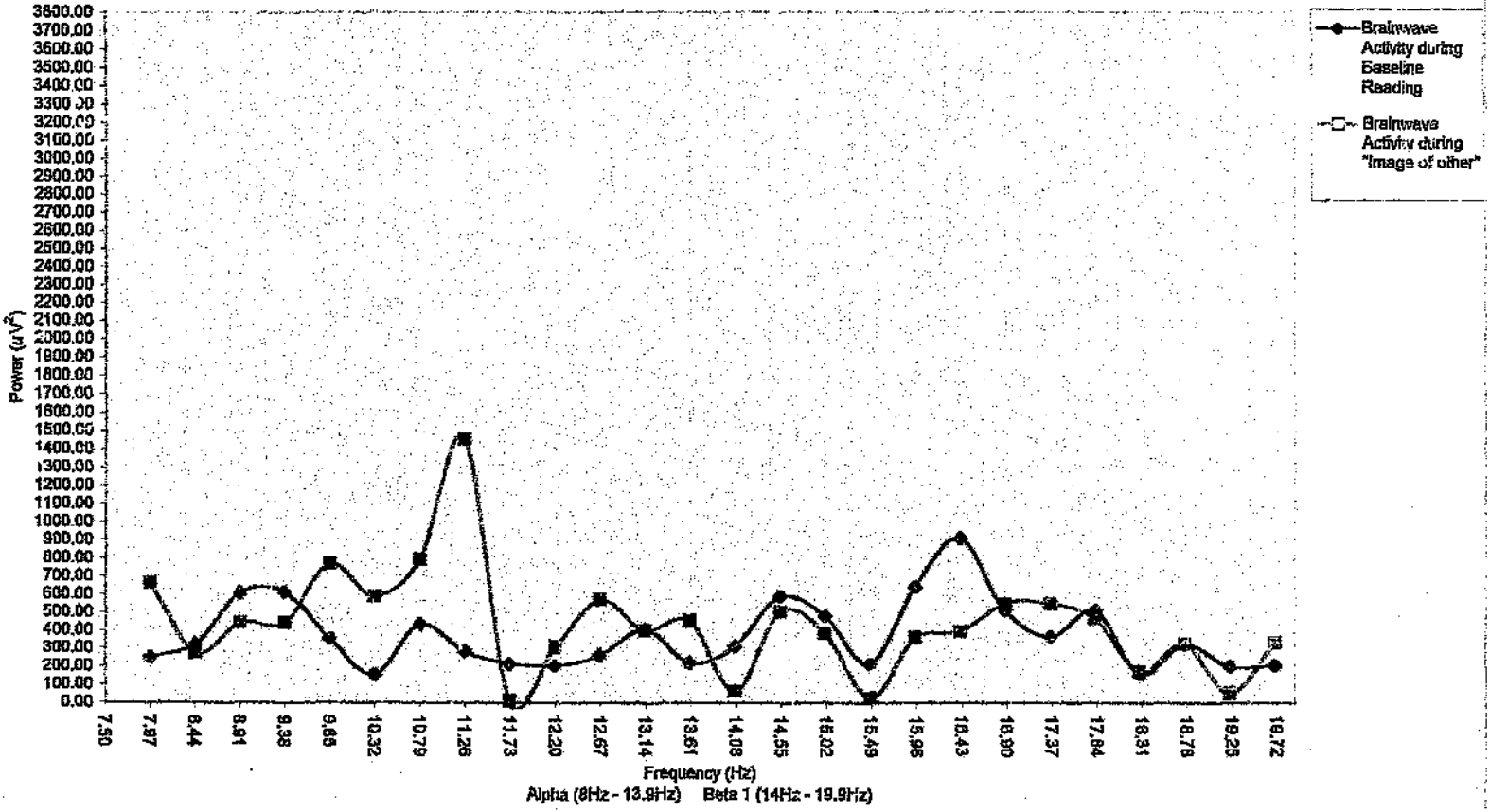


Subject 6 : Brainwave Activity

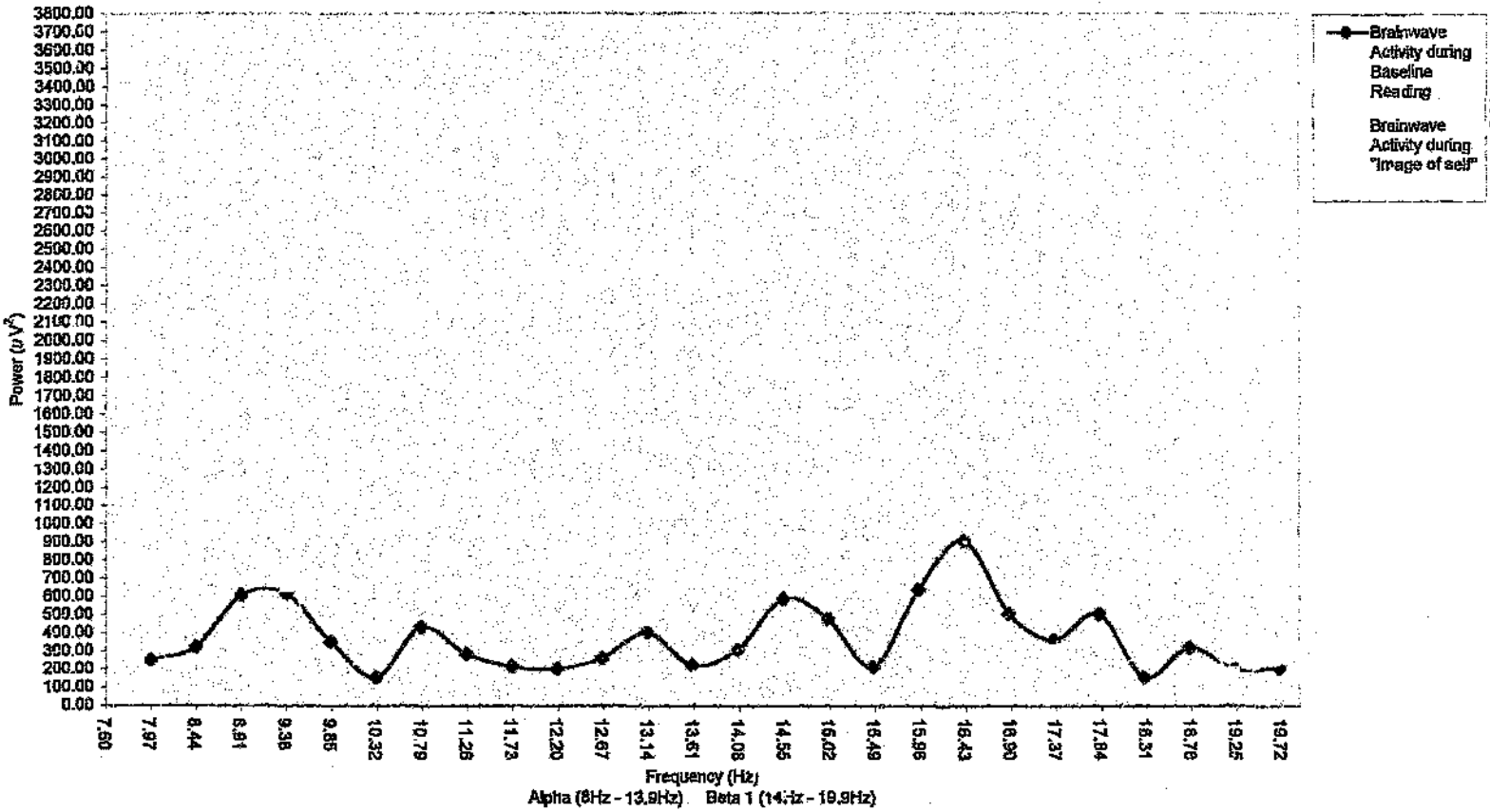



Subject 7 : Brainwave Activity
Power (μV²)
3900.00
3700.00
3600.00
3500.00
3400.00
3300.00
3200.00
3100.00
3000.00
2900.00
2800.00
2700.00
2600.00
2500.00
2400.00
2300.00
2200.00
2100.00
2000.00
1900.00
1800.00
1700.00
1600.00
1500.00
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
7.50
7.97
8.44
8.91
9.38
9.85
10.32
10.79
11.26
11.73
12.20
12.67
13.14
13.61
14.08
14.55
15.02
15.49
15.96
16.43
16.90
17.37
17.84
18.31
18.78
19.25
19.72
Frequency (Hz)
Alpha (8Hz - 13.9Hz)
Beta 1 (14Hz - 19.9Hz)
Brainwave Activity during Baseline Reading
Brainwave Activity during "Image of other"
Brainwave Activity during "Image of self"
Brainwave Activity during "Sense of feeling"
Brainwave Activity during Relaxation

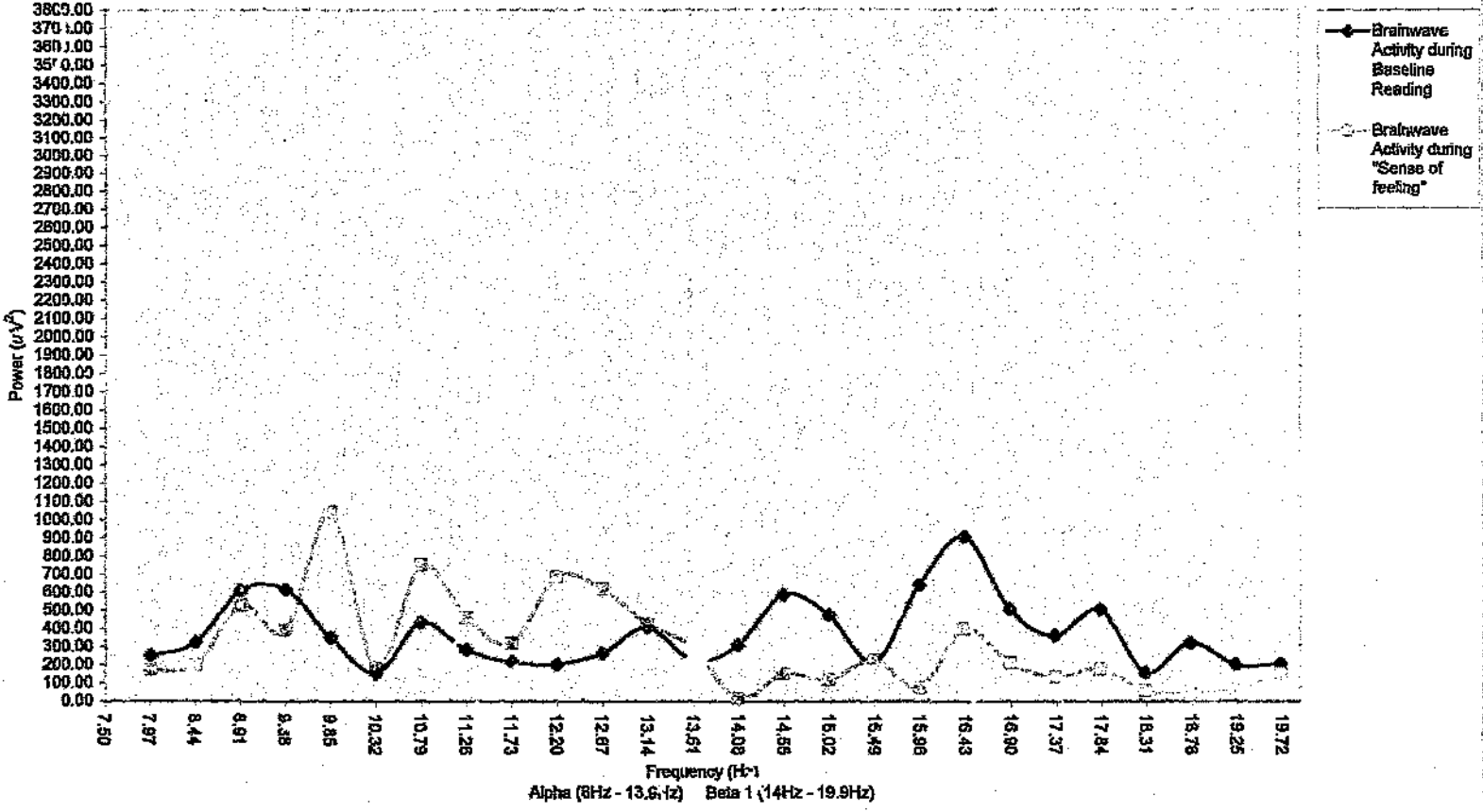
Subject 7 : Brainwave Activity



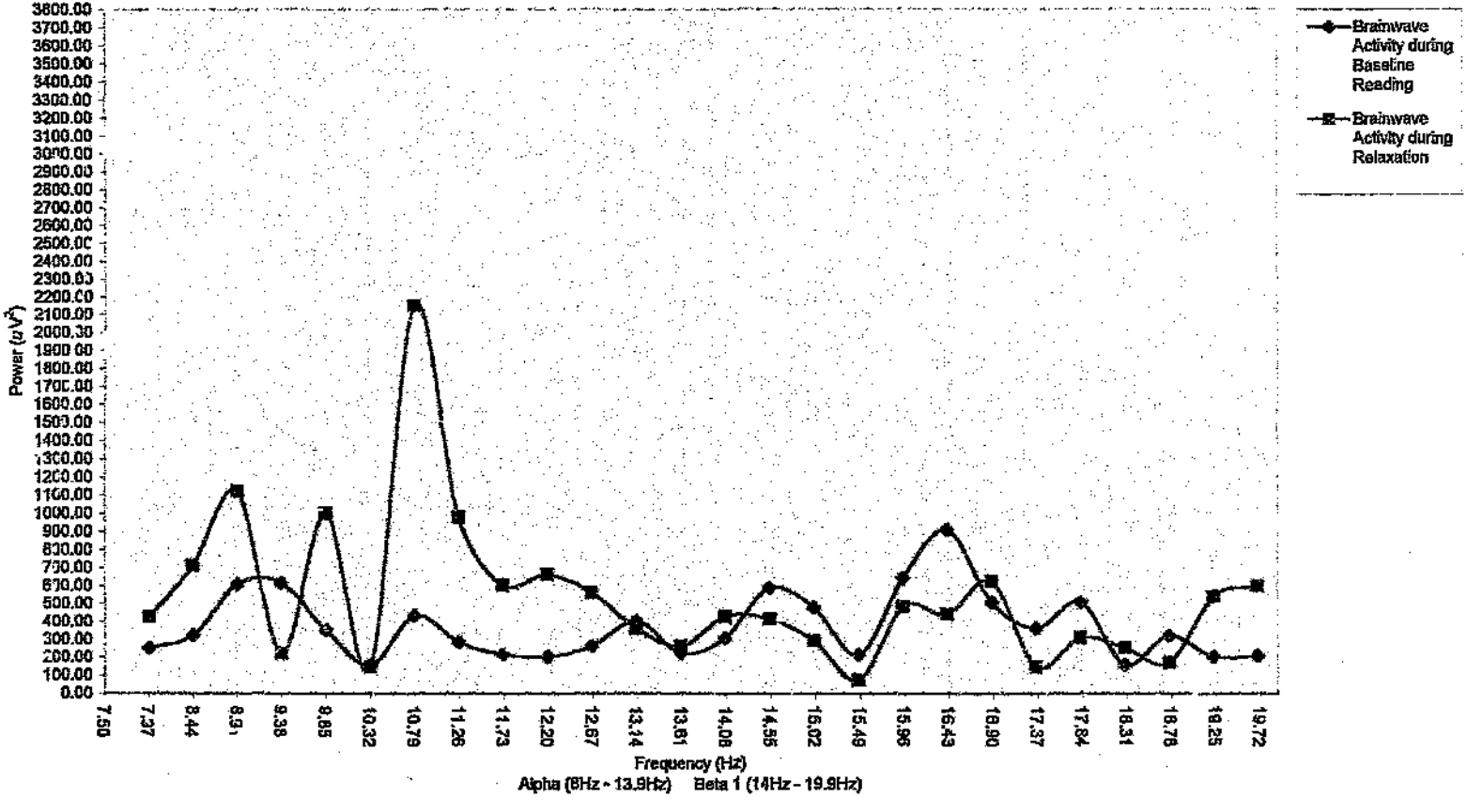
Subject 7 : Brainwave Activity



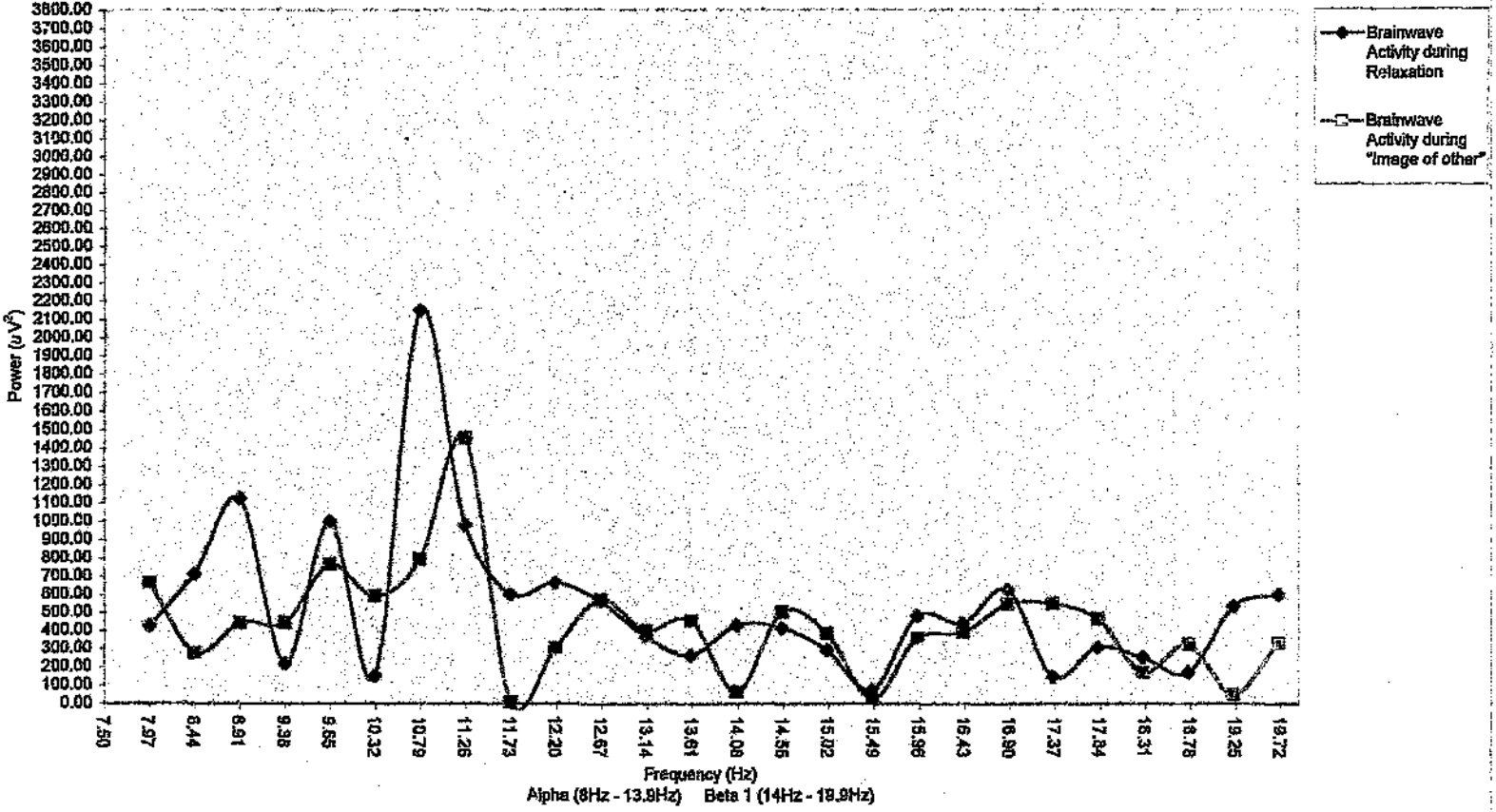
Subject 7 : Brainwave Activity



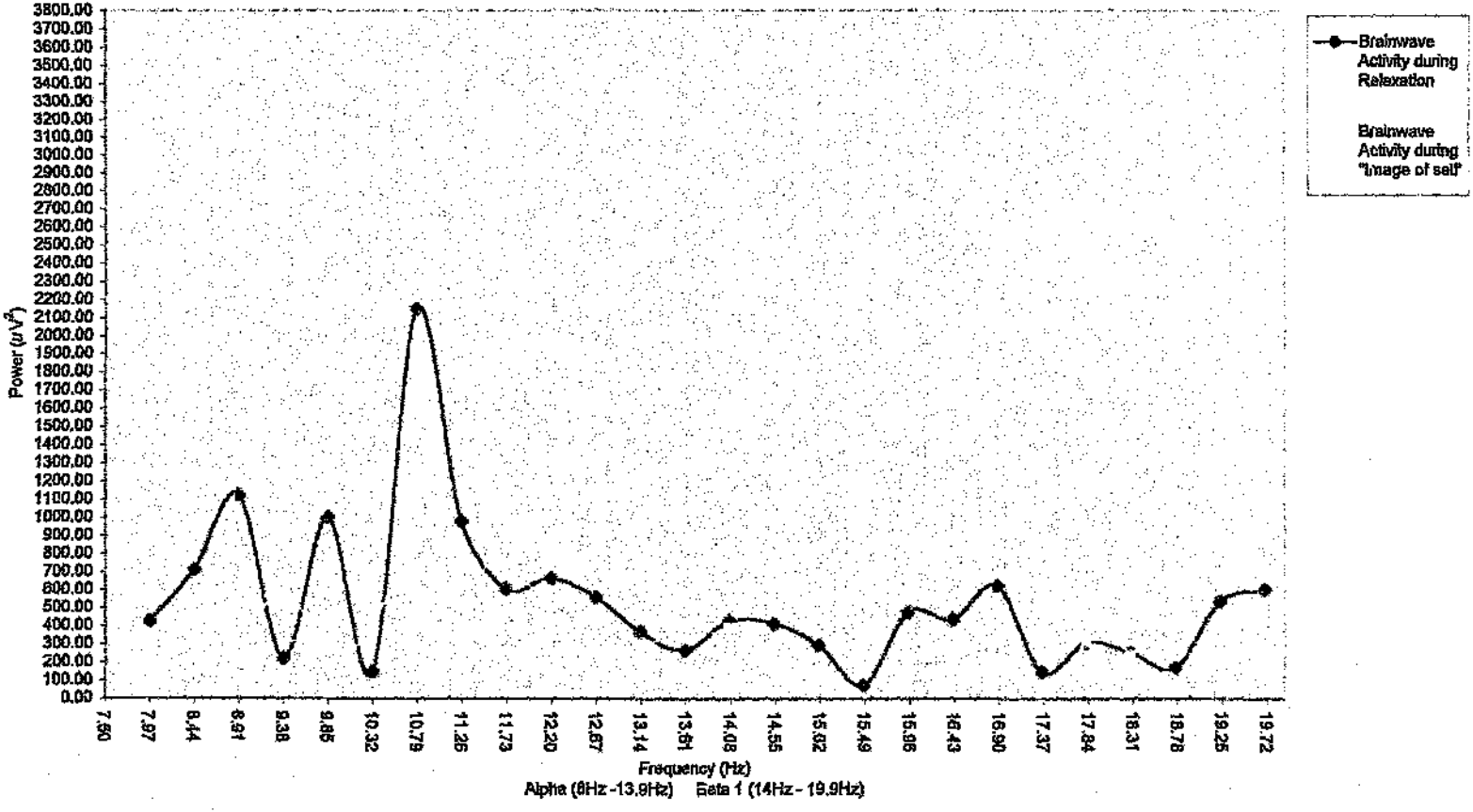
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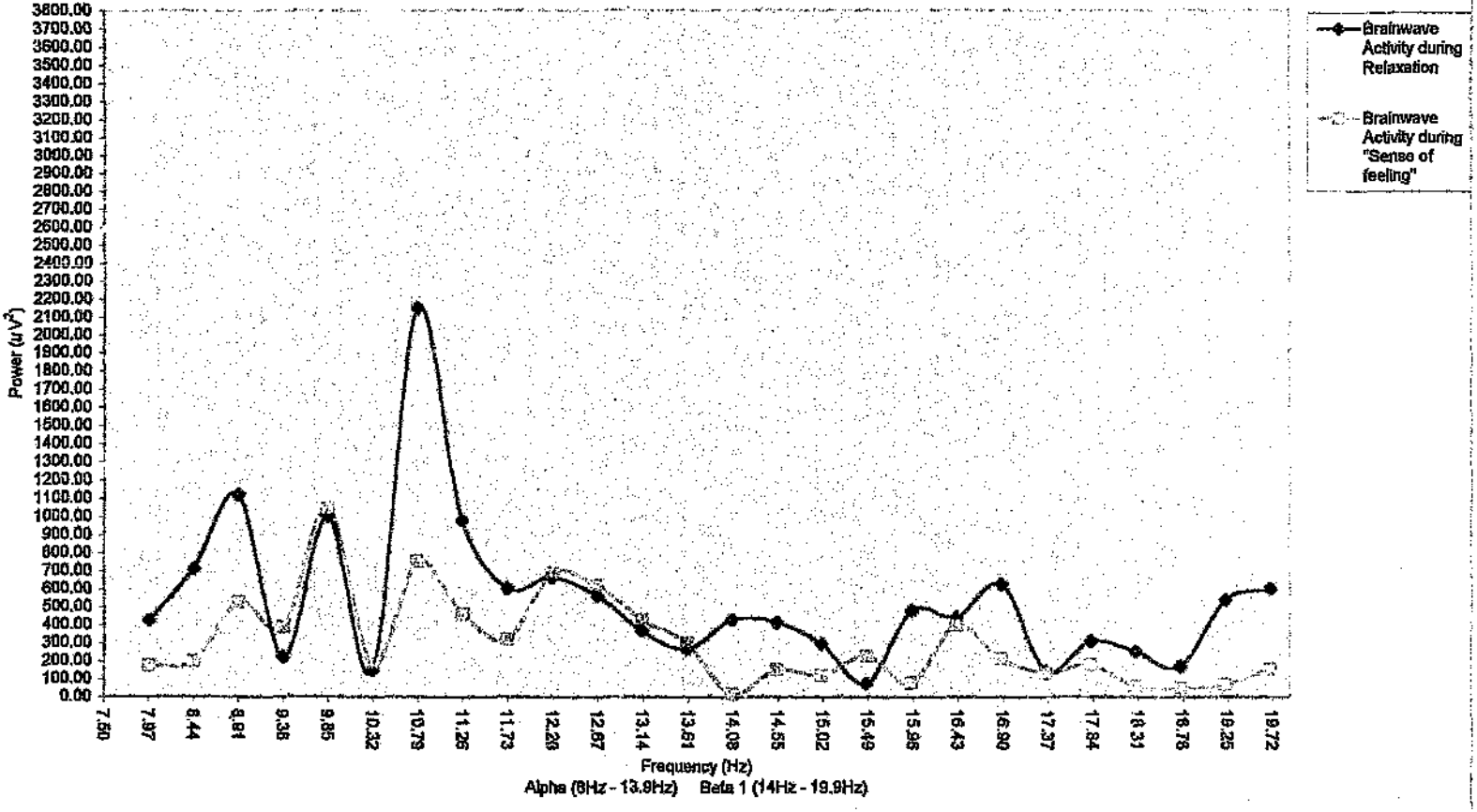
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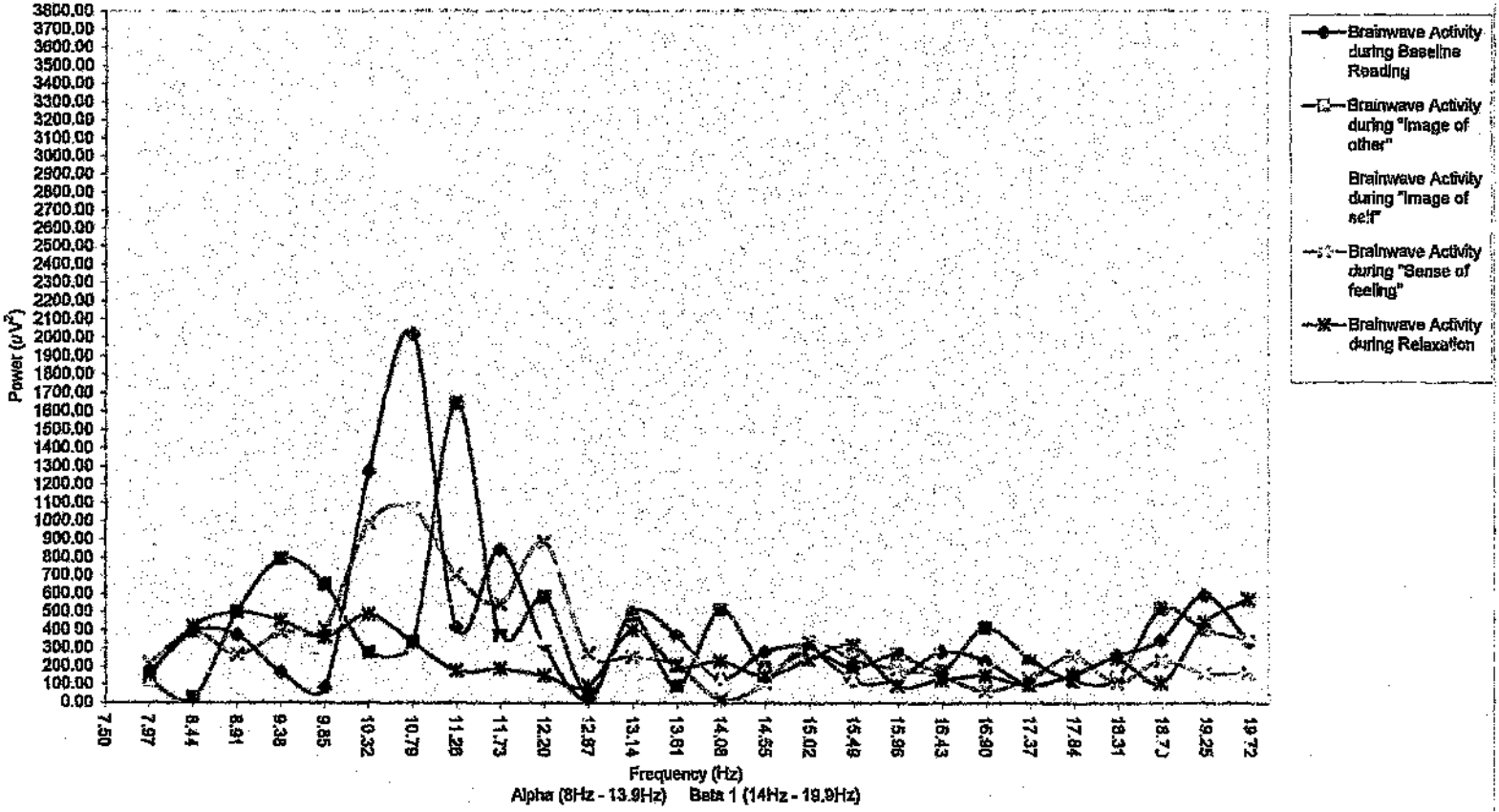
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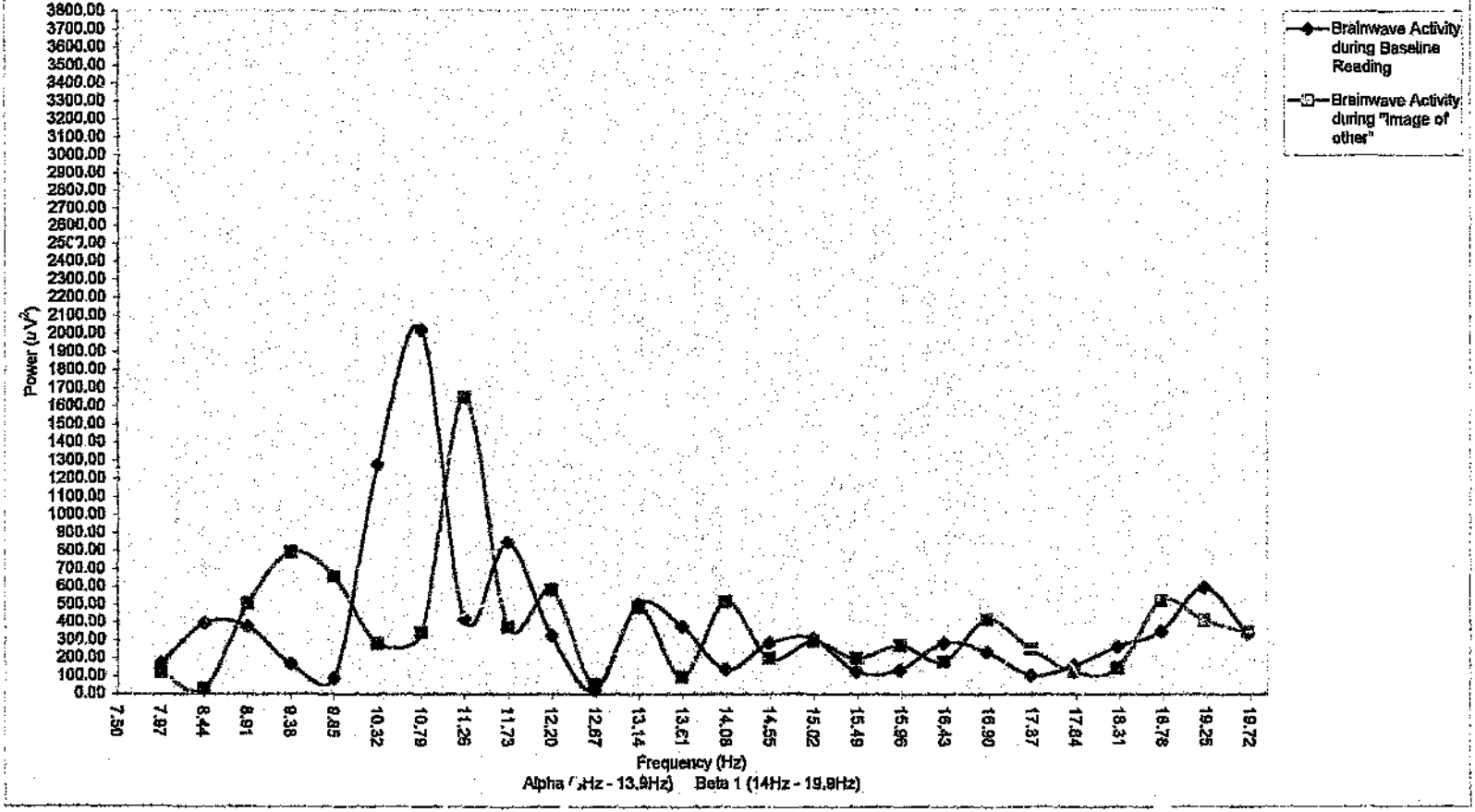
Subject 7 : Brainwave Activity



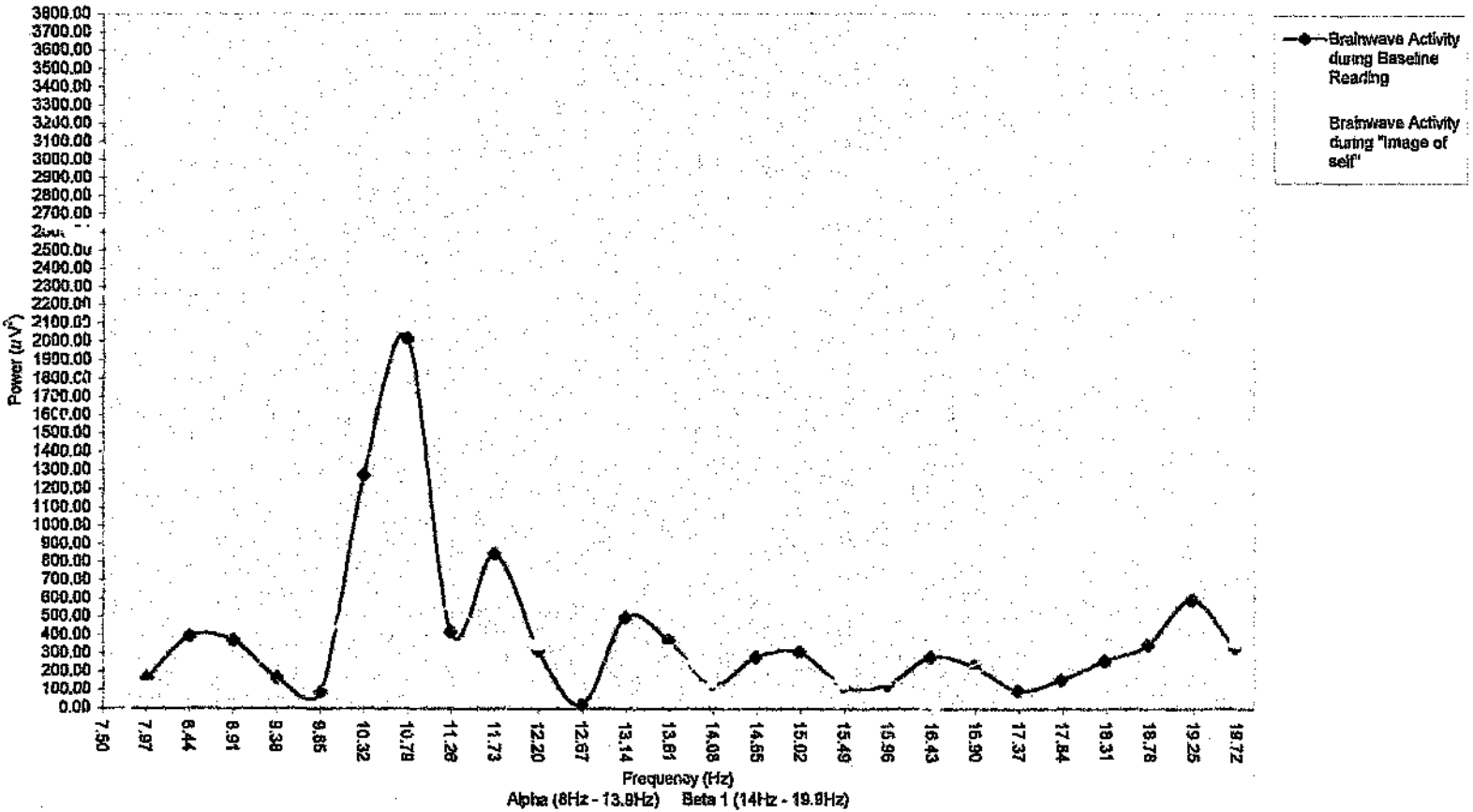
Subject 8 : Brainwave Activity

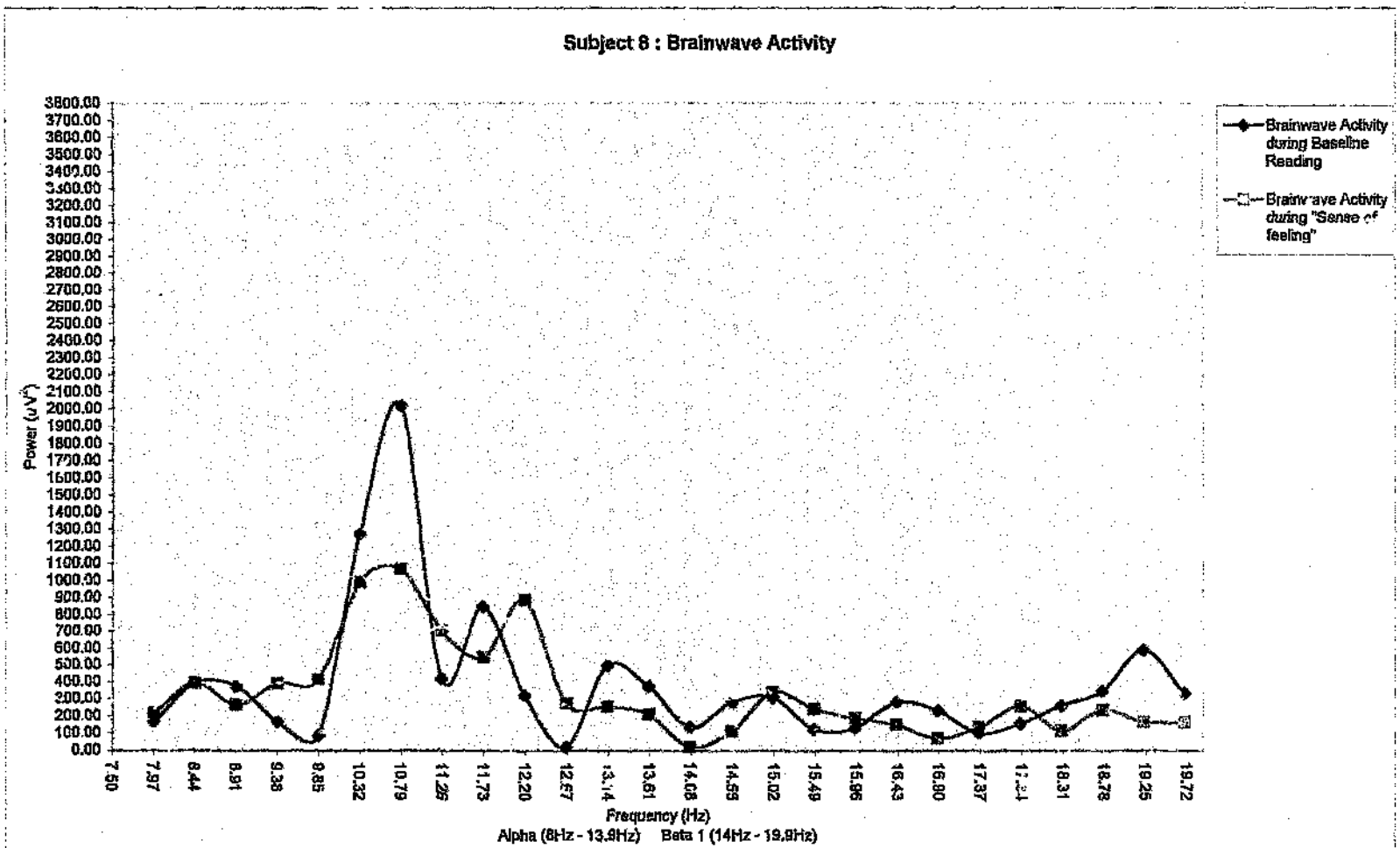


Subject 8 : Brainwave Activity

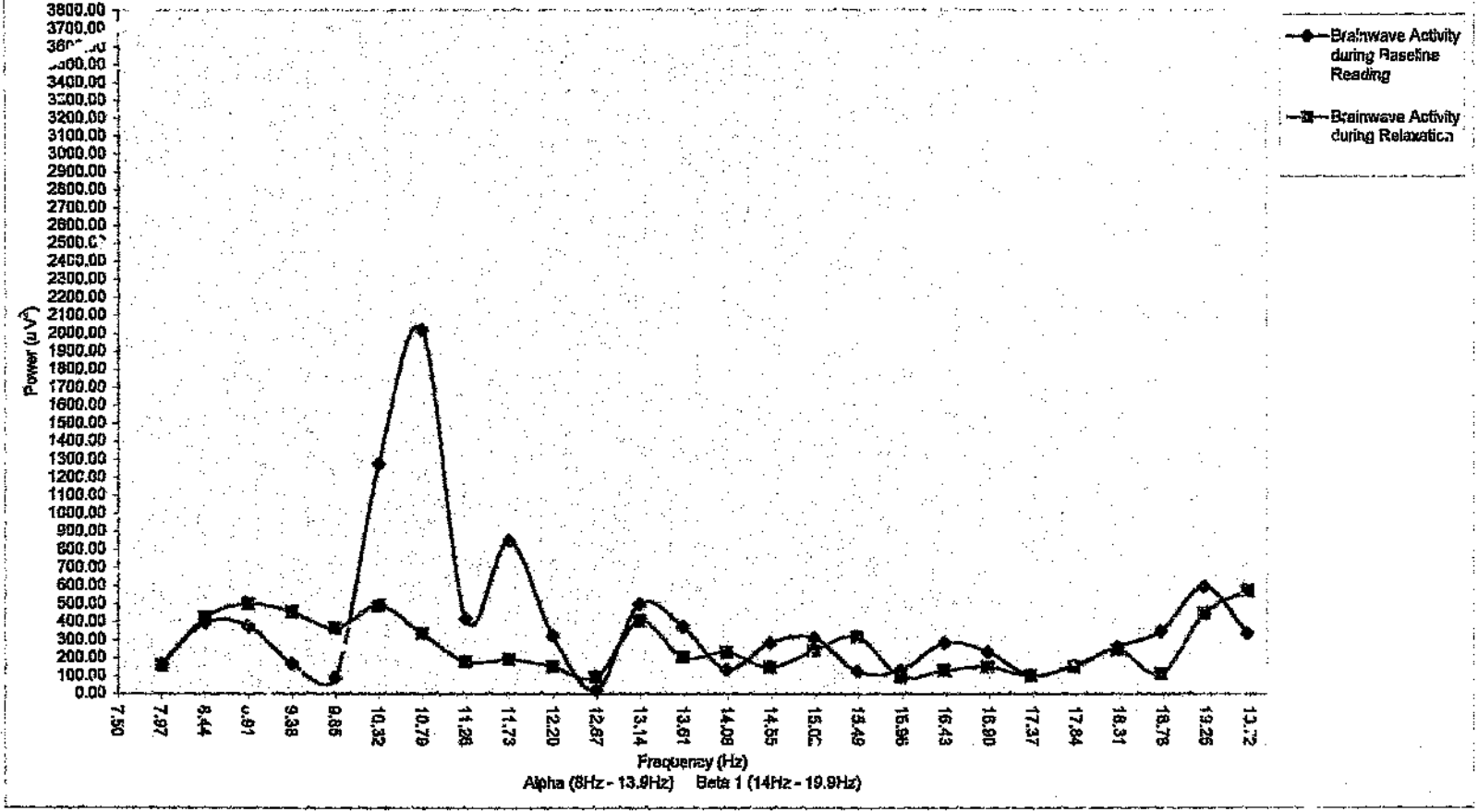


Subject 8 :Brainwave Activity

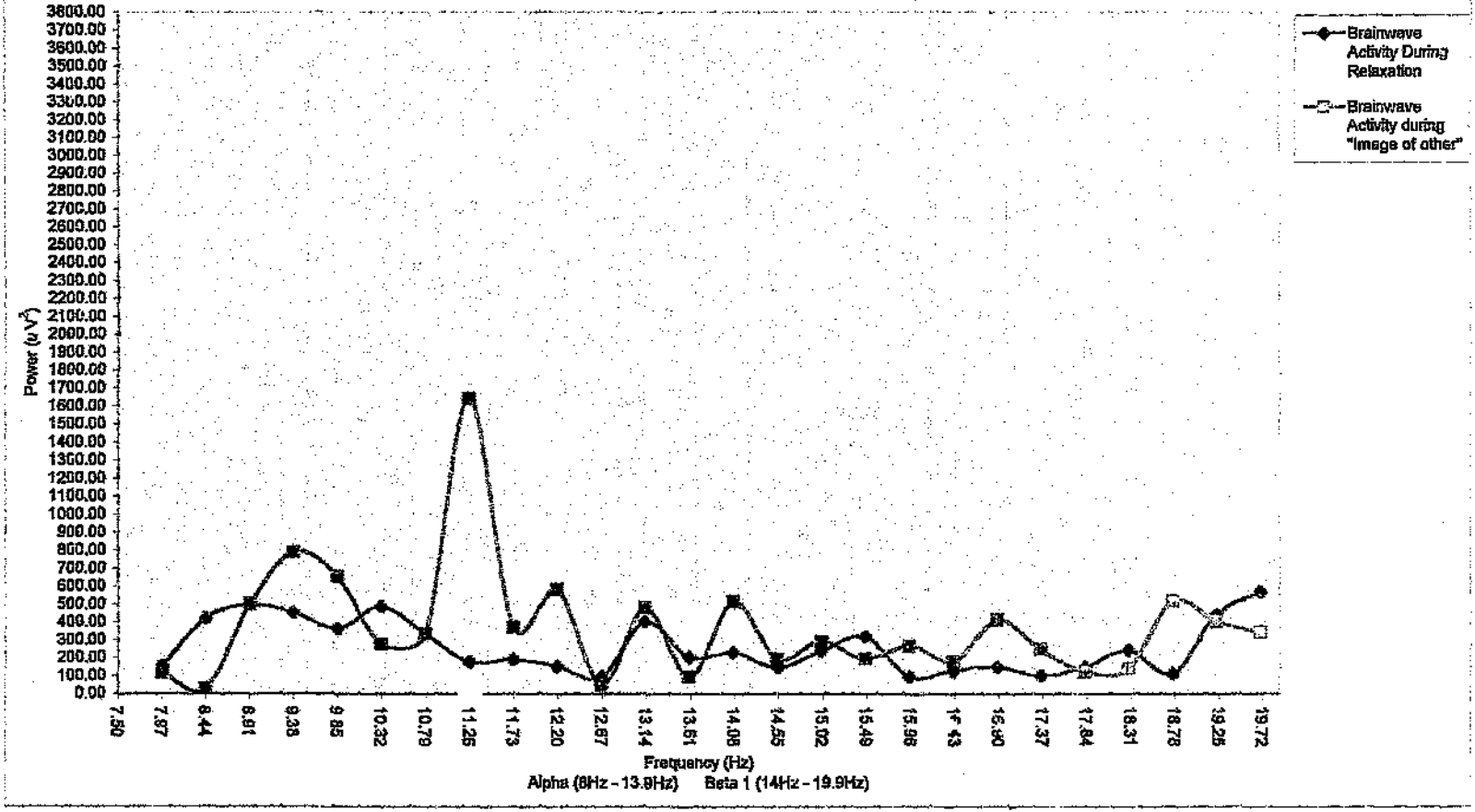


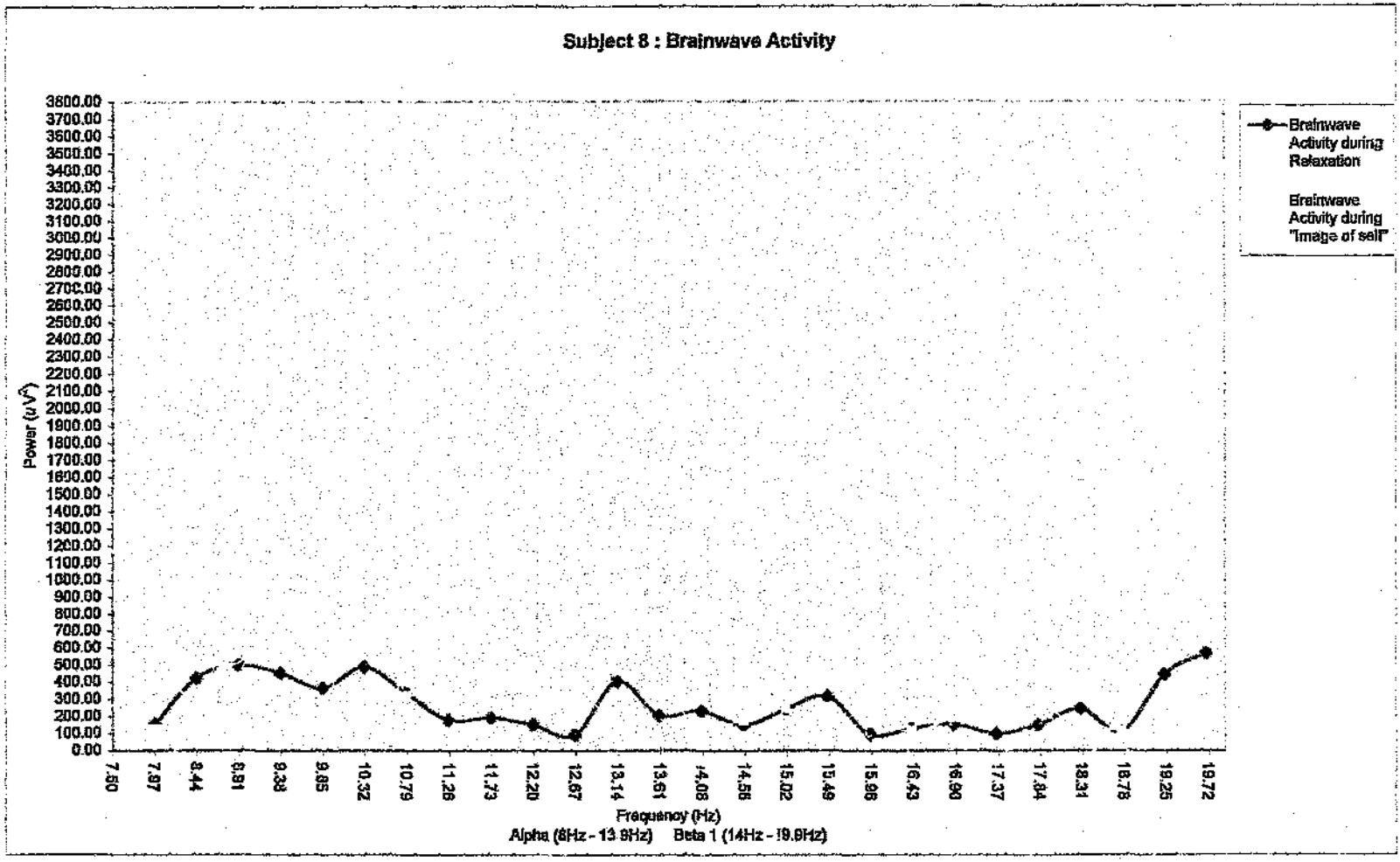

Subject 8 : Brainwave Activity
Power (uV²)
Frequency (Hz)
Alpha (8Hz - 13.9Hz)
Beta 1 (14Hz - 19.9Hz)
Brainwave Activity during Baseline Reading
Brainwave Activity during "Sense of feeling"

Subject 8 : Brainwave Activity

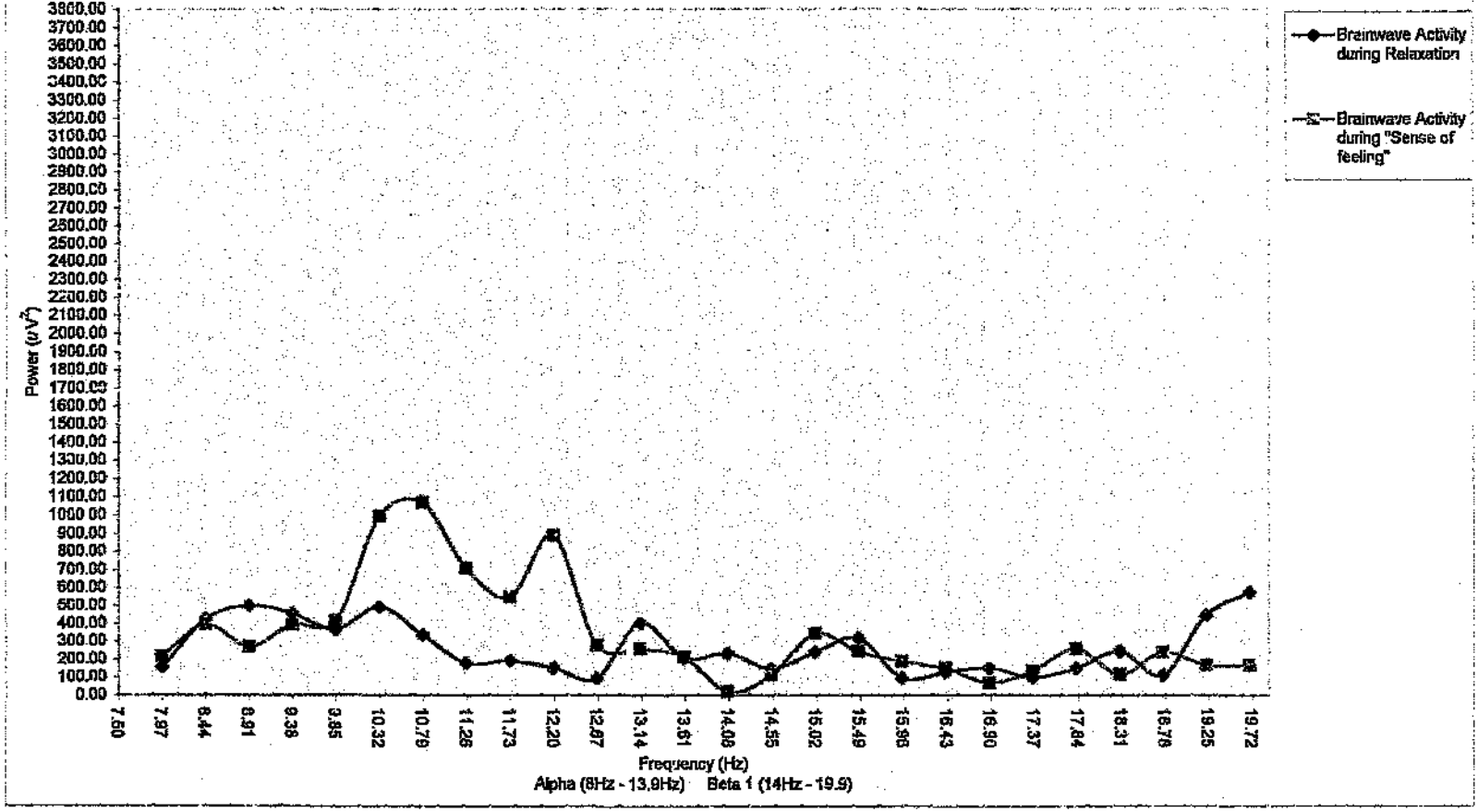


Subject 8 : Brainwave Activity

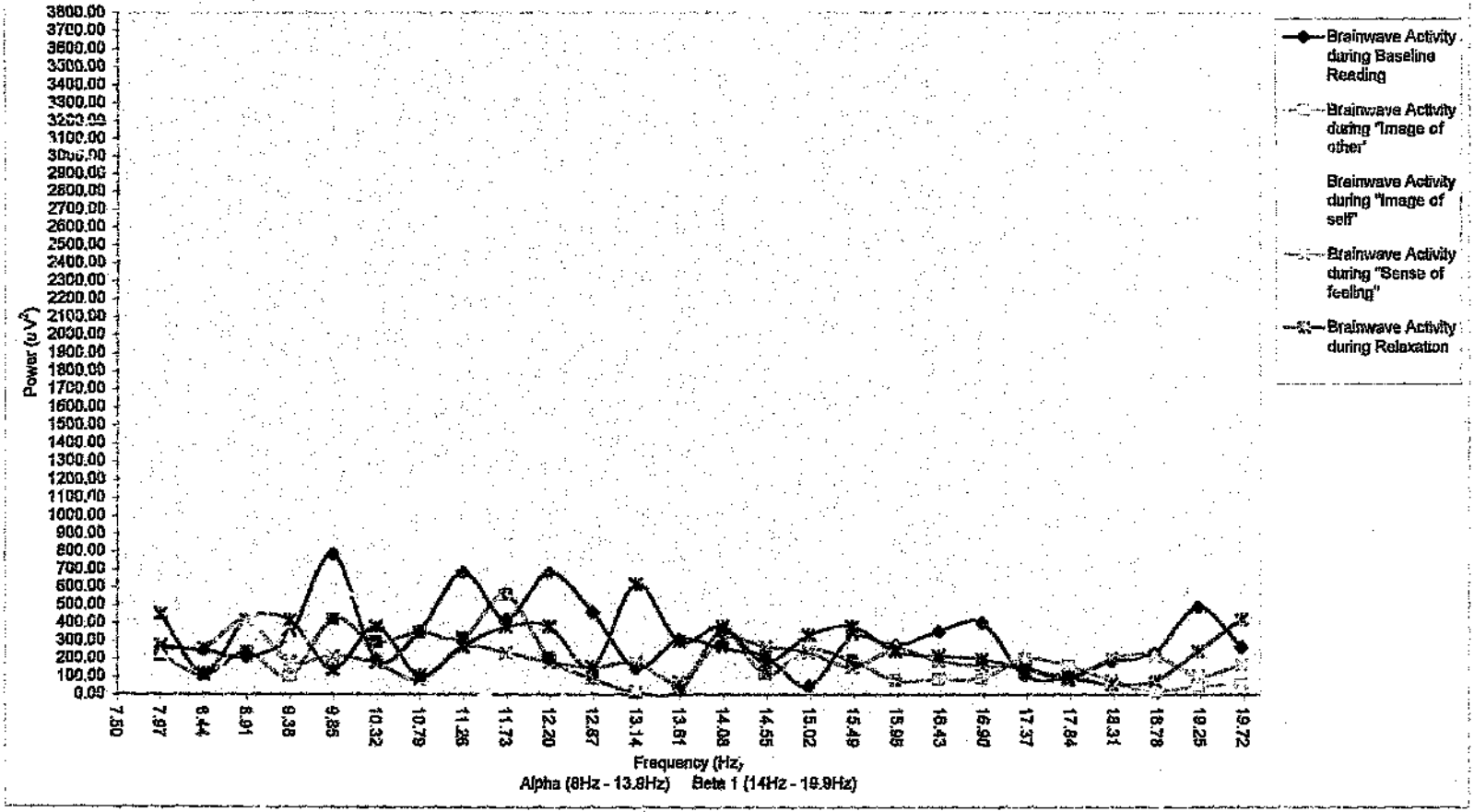



Subject 8 : Brainwave Activity
Power (uV²)
3800.00
3700.00
3600.00
3500.00
3400.00
3300.00
3200.00
3100.00
3000.00
2900.00
2800.00
2700.00
2600.00
2500.00
2400.00
2300.00
2200.00
2100.00
2000.00
1900.00
1800.00
1700.00
1600.00
1500.00
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
7.50
7.97
8.44
8.91
9.38
9.85
10.32
10.79
11.26
11.73
12.20
12.67
13.14
13.61
14.08
14.55
15.02
15.49
15.96
16.43
16.90
17.37
17.84
18.31
18.78
19.25
19.72
Frequency (Hz)
Alpha (8Hz - 13.9Hz)
Beta 1 (14Hz - 19.9Hz)
Brainwave Activity during Relaxation
Brainwave Activity during "Image of self"

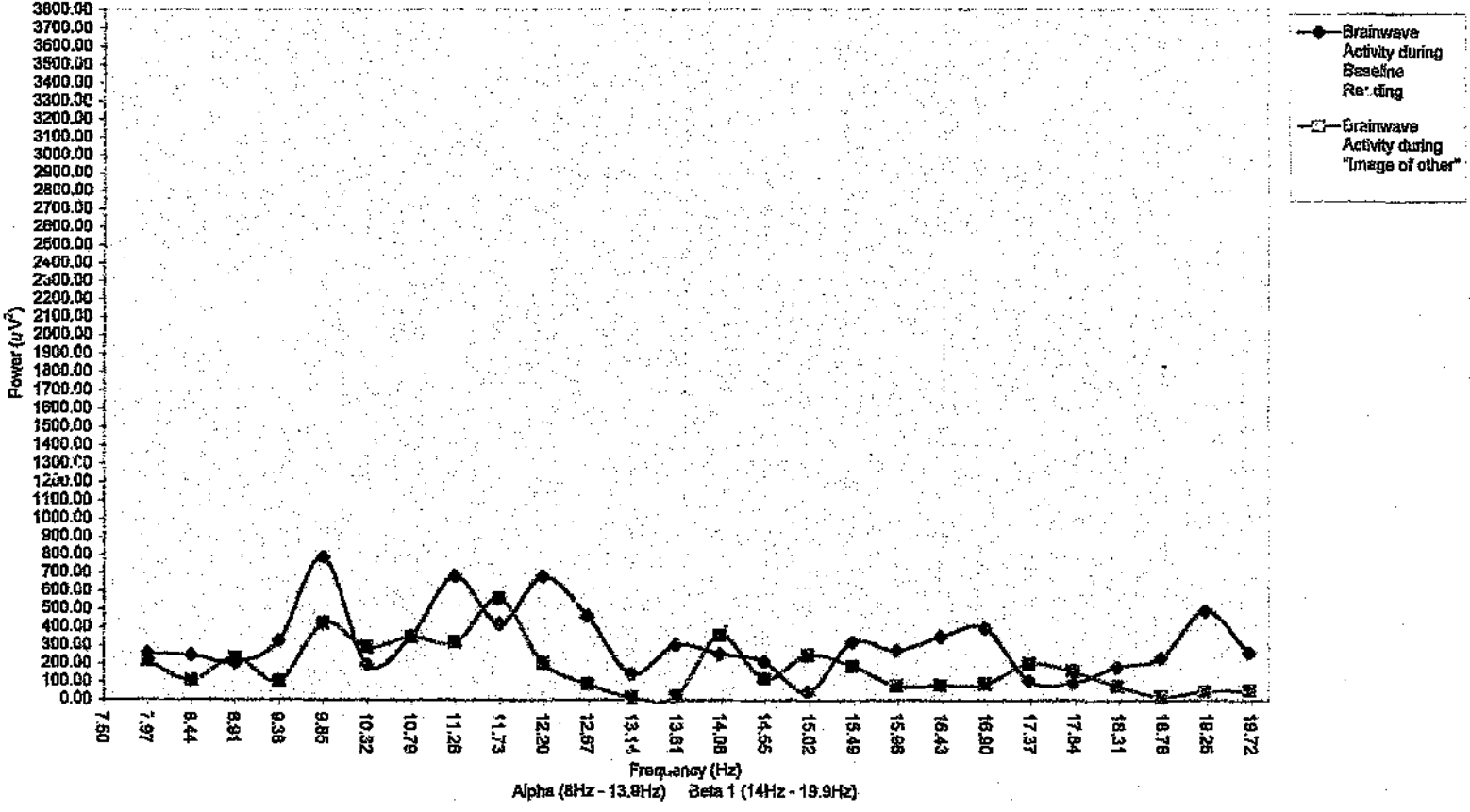
Subject 8 :Brainwave Activity



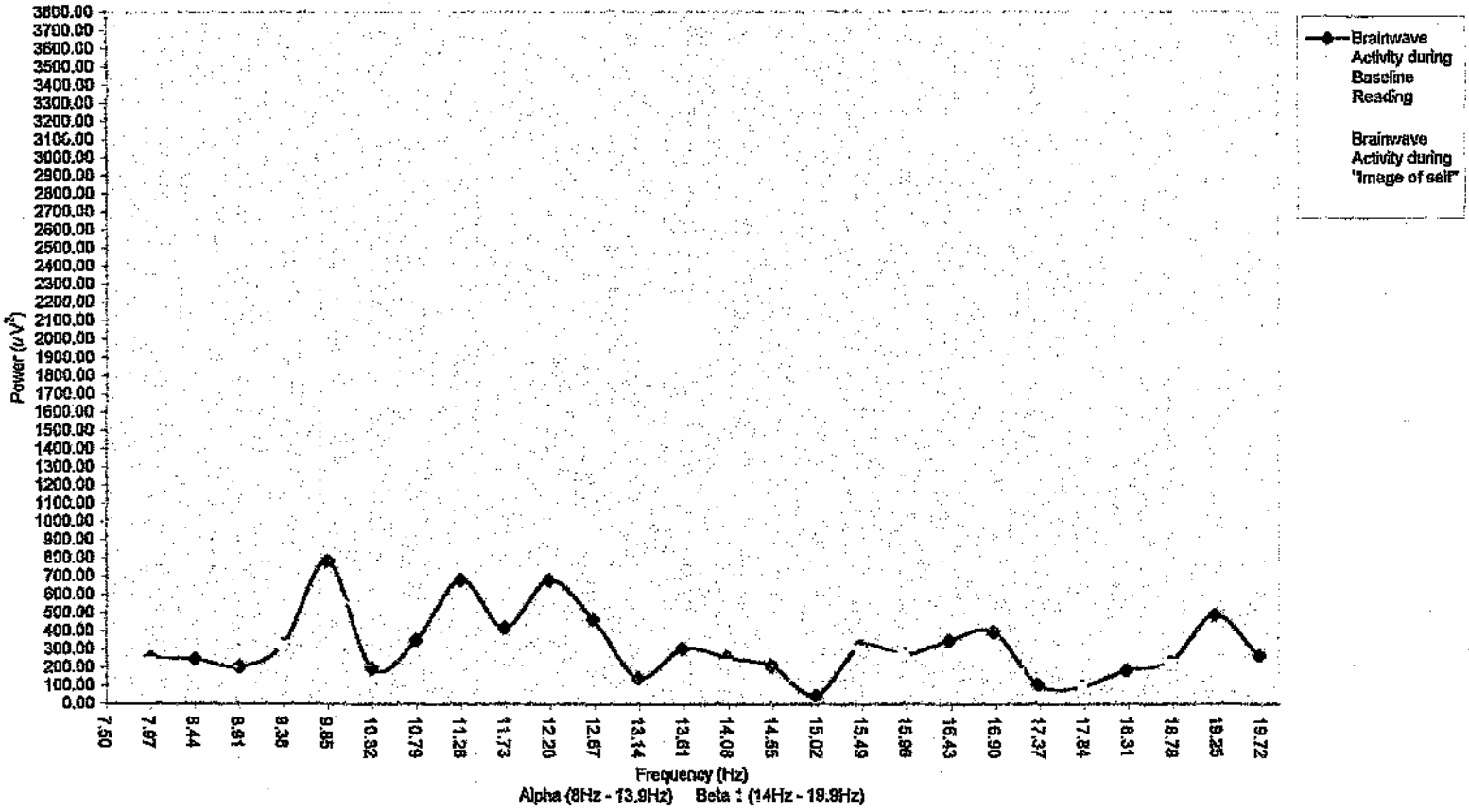
Subject 9 : Brainwave Activity



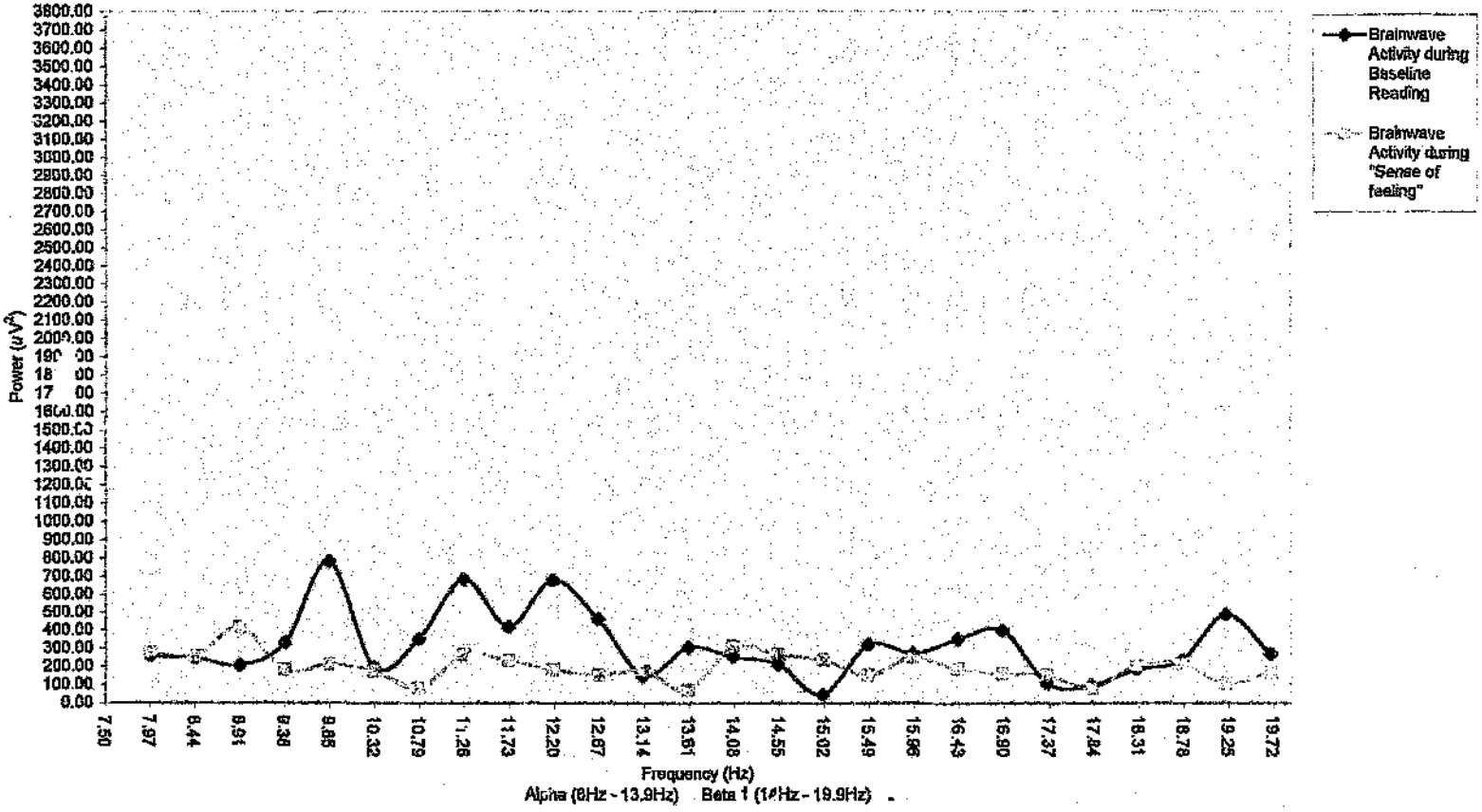
Subject 9 : Brainwave Activity



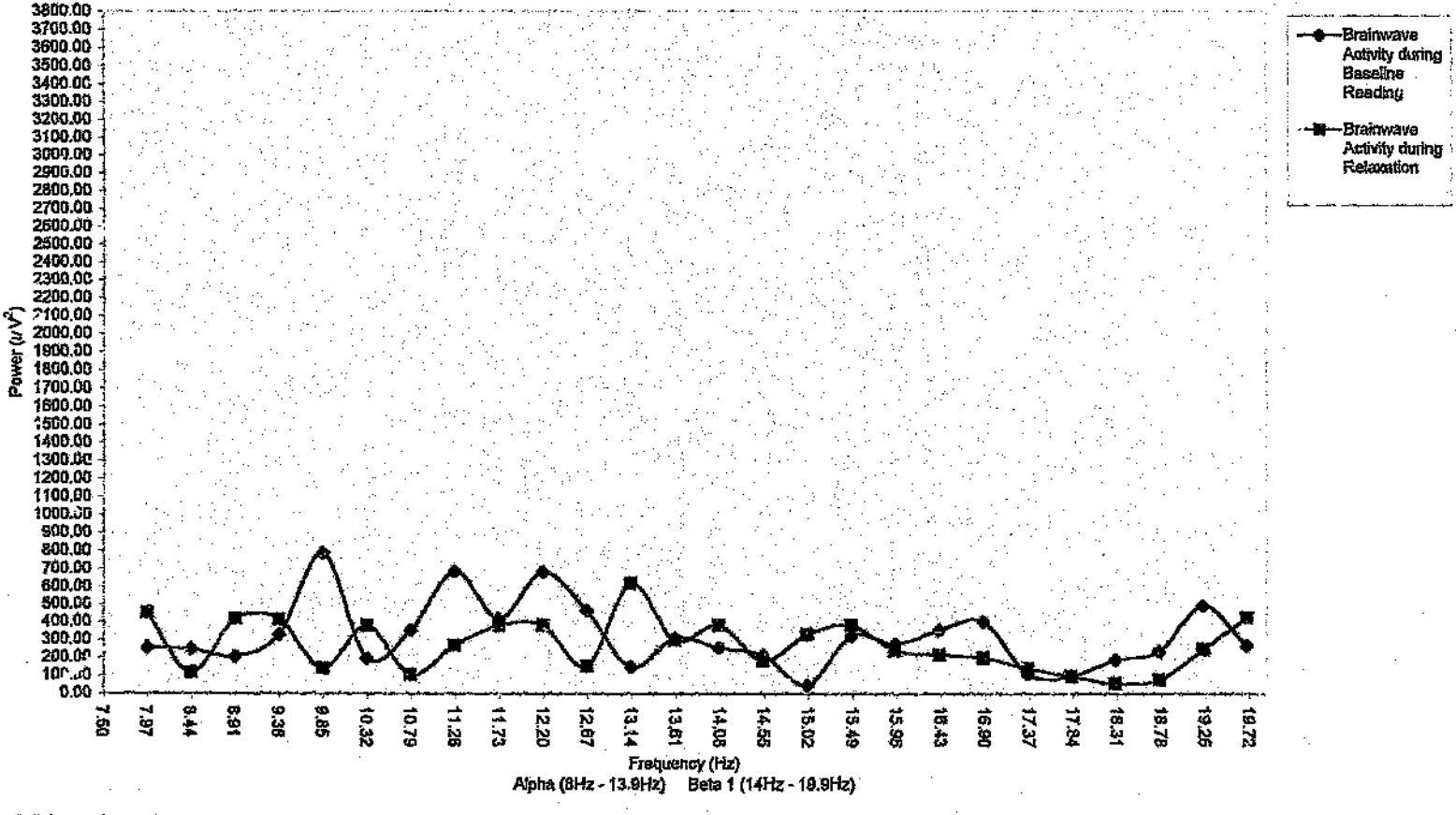
Subject 9 : Brainwave Activity



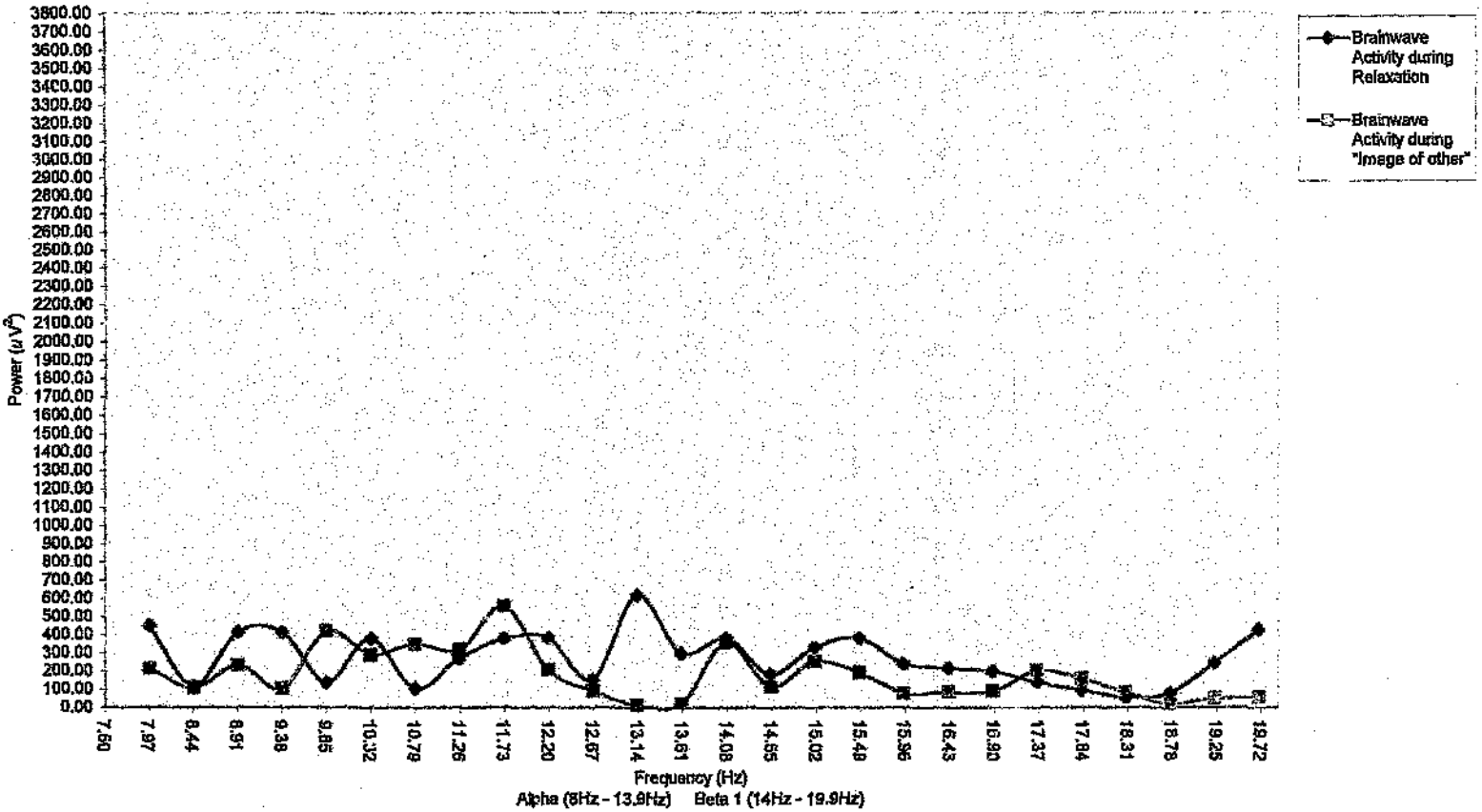
Subject 9 : Brainwave Activity



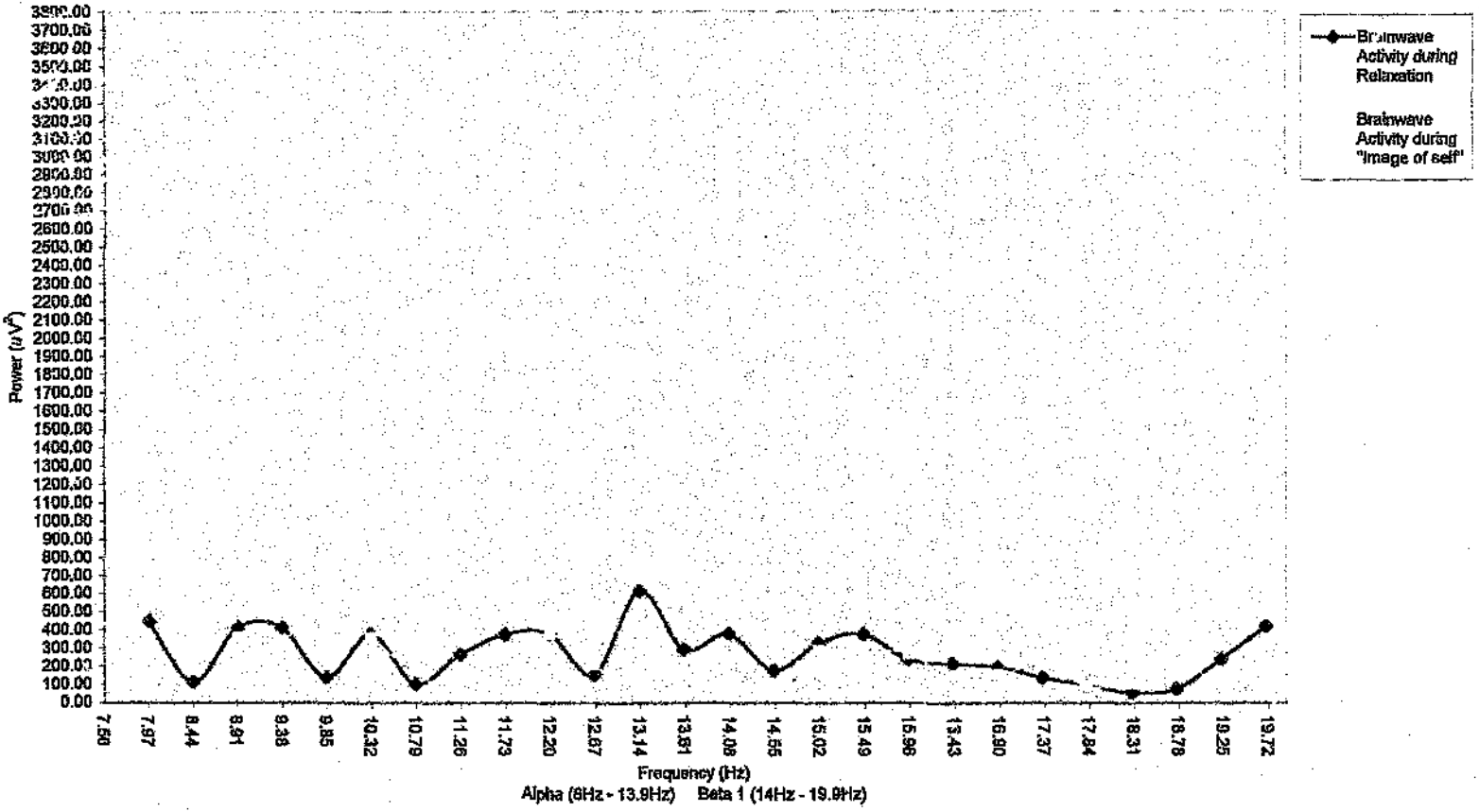
Subject 9 : Brainwave Activity



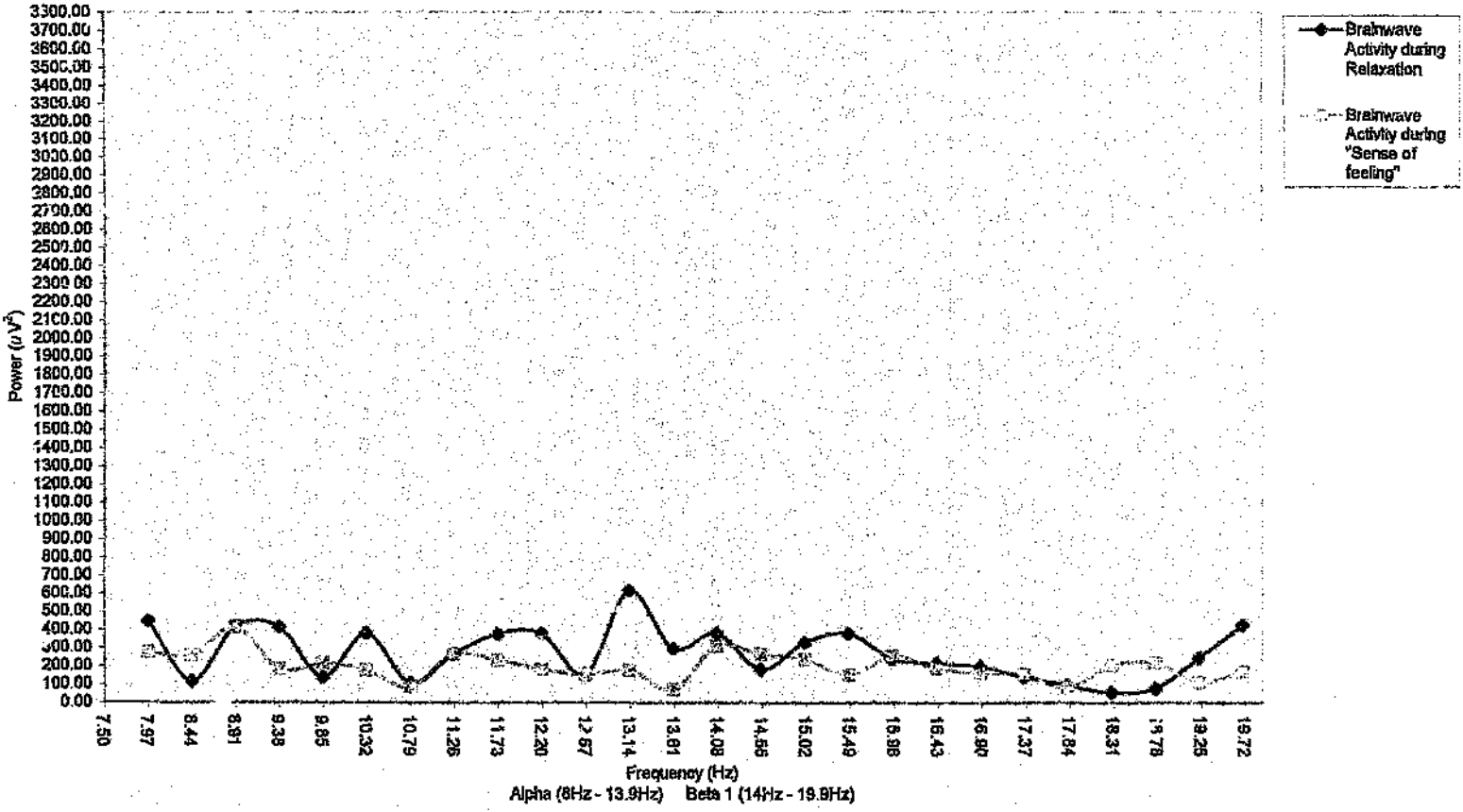
Subject 9 : Brainwave Activity



Subject 9 : Brainwave Activity



Subject 9 : Brainwave Activity



Author: Behrmann, Mandy.
Name of thesis: Imagery rehearsal ability, relaxation and brainwave activity - implications for imagery intervention programmes in sport psychology.

PUBLISHER:
University of the Witwatersrand, Johannesburg
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