Eysenck's contribution to the study of intelligence was significant but overshadowed by his studies of personality. His model of intelligence serves a useful purpose of delineating different meanings of the term in contemporary psychology. However, his most important work has been the exploration of the biological correlates of intelligence. His work on genius and creativity is an interesting attempt at synthesis of different strands of his research but, at this stage, its future impact on the field cannot be anticipated.

Although Hans Eysenck has made many contributions to the study of human intelligence in the course of almost 60 years, his most significant work was carried out during the last three decades of his life. Thus, Gibson's (1981) biography of Eysenck does not contain a separate section on intelligence. Conversely, the most recent edition of his autobiography (Eysenck, 1997) contains a chapter entitled "Intelligence and personality: the fight for a new paradigm".

It is convenient to classify his contributions into two main areas: a.) Basic research involving biological correlates of intelligence; and b.) Debates about the role of heredity and environment in intelligence. In this paper I shall briefly summarize his contributions and, at the end, I'll make a few comments about Eysenck as a man that will be based on several meetings with him over the past twenty years.
The impact of Eysenck's work is often compared to that of Raymond Cattell. Both have left their mark on the study of personality and less so in the area of abilities and intelligence. However, while it may be that Cattell will be remembered largely for his ideas about cognitive functioning, in particular for his theory of fluid and crystallized intelligence, Eysenck's contribution to intelligence is likely to be overshadowed by his work on personality.

The Theory of Intelligence

My first exposure to Eysenck's (early) theoretical views on intelligence was through an article of his that appeared in the 1960s. At the time, Guilford's Structure of Intellect model was rather popular and Eysenck pointed out that he had similar ideas some ten years earlier. Just like Guilford's, his theory was presented in the form of a cube but, unlike Guilford's, there were no little cubes corresponding to the primary abilities. Two dimensions of the cube are quite similar between the models: content (verbal, numeric, and spatial) and mental processes (reasoning, memory, and perception). These correspond to Guilford's categories of "content" and "operations". The third dimension in Guilford's Structure of Intellect model was "products". In Eysenck's system, the third dimension was "quality" which refers to the nature of test administration - the distinction between speeded and "power" tests.

This structural theory, like Guilford's, represented a good way to organize different items and tests of human abilities. However, as pointed out by Stankov (1973), empirical tests of Guilford's theory found little support for its major dimensions and it is likely that Eysenck's theory would have experienced the same fate. This lack of success was of little importance to Eysenck's position. His training was firmly grounded in British psychological tradition, particularly in the work of Spearman and Burt, and the Thurstonian ideas that guided Guilford's work on his model were not particularly important to him.

From among his many other ideas that can be classified as "theories of intelligence", the most important is the model Eysenck first proposed in the early 1980s (see Eysenck, 1982). It is probably fair to say that this model is not a proper theory but rather a way to understand the reason for disagreements among people interested in the definition and role of intelligence. According to Eysenck, the disagreements often arise from the fact that intelligence means different things to different people.

The most basic understanding concerns biological intelligence that depends on genetic potential and is expressed through biological and biochemical effects. Biological intelligence can be measured using the electroencephalogram (EEG), averaged evoked potential (AEP), contingent negative variation (CNV), galvanic skin response (GSR), reaction time (RT), and other similar methods.
Psychometric intelligence that is measured by tests that provide an IQ score is a related yet distinct concept. Whilst this intelligence has been associated with biological intelligence, it is also dependent on cultural factors, family conditions during the development, socio-economic status, education, and the like. Its association with biological intelligence is apparent through the fact that heredity, according to Eysenck, accounts for about 70% of the total variance. Its dependence on the effects of environment is reflected in the fact that 30% of total variance is accounted for by non-genetic influences. It is necessary to mention, however, that one of the best known contemporary behavioral geneticists, Robert Plomin (1990), estimates the heritability of intelligence to be around 50%. As far as I am aware, until the end of his life Eysenck maintained his 70% : 30% claim.

Finally, there exists social intelligence which corresponds to Robert Sternberg's "practical intelligence". This refers to the application of intelligence in everyday social life and at work. This type of intelligence is dependent on psychometric intelligence and also on a large number of additional factors. For example, even if a person has high IQ but is an alcoholic, mentally or physically ill, has poor education, is neurotic or has low motivation and drive, it is unlikely that he or she will achieve much in life.
This model, of course, is plausible and corresponds to the intuition of those working in the area of intelligence. It can certainly help in delineating the field for the purpose of discourse and, as far as I am aware, nobody has argued against its usefulness. However, this is not the type of theory that invites people to test its feasibility. Most of Eysenck's work has, however, been at the interface between biological and psychometric intelligence.

**Biological Correlates of Intelligence**

At the end of the 1970s several experimental psychologists turned their attention to cognitive processes that are activated by typical tests of intelligence. The work of R. Sternberg's became known as the "cognitive components" approach and that of Earl Hunt the "cognitive correlates" approach. Sternberg, in effect, tried to break down the problem solving process into its constituent cognitive processes. Hunt, on the other hand, gave a test of intelligence and a well-understood experimental task with the aim of correlating IQ scores with parameters that may be derived from the task. Some contemporary psychologists see these two approaches as being reductionistic. I do not accept that classification since the experimental tasks used by cognitive psychologists reside on the same conceptual level as items on tests of intelligence. Most of Eysenck's empirical work was, however, reductionistic - his interest was in linking IQ to its biological substrates. He used all the measures of biological intelligence listed in Figure 1. The bulk of his work, however, was on mental speed and EEG.

*Mental Speed.* Eysenck's (1967) paper on mental speed proved to be quite influential and timely. In that paper he argued that mental speed is of central importance in our discussions about intelligence and that the time had come to examine Galton's hypothesis about the close link between mental speed and intelligence. That article was written in a typically clear language and it was, in effect, a popularization of the ideas which Eysenck developed in collaboration with his colleague and friend Furneaux. A very interesting paper by Furneaux was published in a book edited by Eysenck (1960) and an equally important work by a student of Eysenck's, P. O. White, appeared in another book (Eysenck, 1973). All these papers assume that there are three components of intelligence: speed and two aspects of personality that are labeled as persistence (tendency to invest an effort when it becomes clear that the solution is not easy) and error checking (tendency to check the answer to an item prior to registering it). Unfortunately, the quite interesting and detailed mathematical statements related to these ideas did not generate a continuation of work in this area. Nevertheless, the suggestion to use mental speed in research on intelligence fell on a fertile ground.
In the second half of the 1960s, a re-vitalized cognitive psychology began to employ measures of reaction time in studies of thinking. Its usefulness was demonstrated in Saul Sternberg's studies of memory search. This era was also close to the advent of microcomputers, whose presence at a latter stage facilitated precise measurements of timed performance.

Whilst Eysenck appears to have been only marginally interested in the new developments in experimental cognitive psychology and in the study of cognitive models and theories, his plea to examine Galton's ideas was taken seriously by others. The most important was the work of Arthur Jensen. In many studies over the past twenty years, Jensen has shown that simple and choice reaction time correlates about .20 to .30 with measures of intelligence. The size of correlation coefficients depends, among other things, on parameters (i.e., the type of measure employed) since several different speed scores can be derived from any reaction time task. Another measure of mental speed that shows correlation with intelligence is the inspection time - the shortest time period needed for the detection of difference between two stimuli (e.g., two visually presented lines that are 2cm and 3cm long). Several groups of British and Australian psychologists, but excluding Jensen, were active in studying inspection time and meta-analyses of many published studies indicate that inspection time correlates between .30 and .40 with intelligence.

At the beginning of this research program on the role of mental speed in intelligence Eysenck was of the opinion that more intelligent people are simply faster in their thinking and in information transmission and processing. Jensen still subscribes to the same notion, although with a slight twist: mental speed is important because of the role of working memory in thinking. Since the information in working memory fades quickly, people with higher intelligence and greater mental speed can perform more operations in a limited amount of time than those with slower speed of processing.

Towards the end of his life Eysenck modified his account of the relationship between mental speed and intelligence. This change was brought about by the finding of notable correlations between intelligence test scores and measures of variability in reaction time. Variability refers to the fact that over the many trials needed for the effective reaction time measurement, some people show considerable stability from trial to trial. Some, however, show a considerable variability. In general, intelligent people tend to show relatively small variability in comparison to less intelligent individuals. Eysenck was of the opinion that less intelligent people tend to transmit information less efficiently since there is a greater probability of error occurring at the level of synapses. He believed that his original proposal about the role of speed and this relatively new idea regarding the probability of synaptic errors were compatible and jointly provide a satisfactory account of the relationship between intelligence and various measures of speed.

I am of the opinion that mental speed is not the basic process of intelligence and the reasons for my view have been published in Serbian (Stankov & Roberts, 1996). A difficulty with Eysenck's view derives from the finding of high correlation between measures of mental speed and measures of variability of speed. This calls
for a single mechanism rather than two distinct mechanisms (i.e., speed and probability of synaptic error) as an account of the observed phenomena. Nevertheless, I agree that mental speed is an important aspect of intelligence and Hans Eysenck played the role of initiator and active contributor to this area. My paper with Roberts was also published in *Personality and Individual Differences* in 1997, a journal edited by Eysenck. In my experience, some journal editors have difficulties publishing material that is even slightly critical of their own position. Given everything Eysenck stood for all his life, his acceptance did not come as a great surprise to me. Since he had to fight many times against the prevailing view, I would have been surprised if he acted otherwise in relationship to a paper that challenged his own position.

_Electroencephalography and intelligence_. Towards the end of the 1960s, Eysenck became interested in using a better (i.e., more direct) measure of biological intelligence - the EEG. Two methods were employed in his work. In the first method, the EEG was recorded while the person was in a resting position. Significant but relatively low correlations (comparable to those reported with reaction time) were obtained between intelligence and parameters of the EEG recording. In the second method, the person was again resting but a light (or a tone) was presented at certain time intervals. The light evokes a change in the EEG records and these records are averaged over many trials to obtain the "average evoked potential" or AEP. Different measures can be obtained from the AEP and in studies by Eysenck and his collaborators these measures are correlated with intelligence test scores. Eysenck and his two students, the husband and wife Hendrickson, developed a new measure of AEP that reflects the complexity of the signal. This refers to the amount of small departures from the smooth AEP recording. It is measured using a string as the tool and the longer the string, the more complex is the signal. According to Eysenck, the differences in complexity of the AEP recordings are, like reaction times, related to the transmission of signals over the synapses within the central nervous system.

When papers reporting on the Hendricksons' findings appeared in press in the early 1980s, the published correlation coefficients were so high (above .70 and .80) that many felt skeptical about the results. In an article that defended this research against criticism, Eysenck listed a large number of technical requirements and controls that need to be taken into account in studies of AEP. These control conditions appear so restrictive that it became clear that replication will be rather difficult to achieve. As far as I am aware, no other group or laboratory has reported similar correlations. In his autobiography (Eysenck, 1997) the results of a study with children are mentioned and he cites correlations between .30 and .40. These values appear more realistic than those reported by the Hendricksons.

Many of Eysenck's collaborators have employed the EEG and, more recently, other sophisticated methods (e.g., PET) in research. His tireless efforts to improve the measurement of biological correlates of intelligence have led to a better understanding of the causes of individual differences.
**Vitamins and intelligence.** At the beginning of the 1990s, Eysenck was one of the chief investigators on a project that studied the relationship between the amount of vitamin and mineral intake and intelligence in children. This work led to a considerable debate and it is possible that I should mention it in the next section. According to the model in Figure 1, nutritional types of intervention belong to "social intelligence". However, the link with "biological intelligence" is also apparent. In these experiments, children in several school districts in California were given vitamins and minerals in quantities recommended by the medical profession. There were three experimental groups and a control (placebo) group. One experimental group (100% group) was given a full recommended dosage, and the other two groups were given either half of the recommended amount (50% group), or twice that amount (200% group). In the outcome, all four groups showed an increase in IQ but only one experimental group - the 100% group - showed significantly better performance than the control group. The results attracted a lot of media attention. A well-publicized television program appeared on air at the completion of the study and a pharmaceutical company was getting ready with an advertising campaign for the pill containing the 100% dosage of vitamins and minerals. However, to the surprise of most people involved, immediately after the show, the British Medical Research Council (MRC) issued a statement that supported the findings of two other studies carried out by different investigators, and reported no significant effects. Upon closer scrutiny, Eysenck found out that the quality of these other studies was poor. However, the damaging action of the MRC statement on the work of Eysenck's team proved effective and the study had relatively little impact.

After reading the articles based on that study, it appeared to me that the effects of mineral and vitamin supplementation were rather small and statistically significant only because of the large samples involved. I felt that further research was needed to establish the psychological significance of the results. Nevertheless, why should we doubt the possibility of improving IQ performance in this way? It is to be expected that health and general well-being may have a role to play in our cognitive activities. Not everybody accepted the MRC's verdict. For example, the authors of "The Bell Curve", Herrnstein and Murray, point out that one of the reliable ways to increase IQ is through nutritional means and they base their conclusions on the work of Eysenck's group. "The Bell Curve" also reviews studies that examine the role of educational interventions in the improvement of IQ. The conclusions reached by Herrnstein and Murray on the effectiveness of such interventions are gloomy. As far as I am aware, Eysenck was in agreement with their position. I have always been puzzled by this stance since my own examination of the literature leads me to conclude that educational interventions cause either the same or, quite frequently, stronger effects than those achieved through improved nutrition and mineral/vitamin supplementation (see Stankov, 1986). How is it possible to judge the same magnitude of an effect as psychologically significant when achieved through one medium (e.g., nutrition) and play it down when achieved through some other means (e.g., education)?
Since Eysenck believed that the heritability of intelligence is high, he could not stand on the side while others debated the nature/nurture issue. Two somewhat related polemics engaged him deeply. The first debate was related to the work of Arthur Jensen and the second was prompted by a post mortem attack on the work of Sir Cyril Burt.

In 1969 Jensen published a paper entitled "How much can we boost IQ and scholastic achievement?" in which he pointed out high heritability of intelligence and the lack of success of educational projects started under J. F. Kennedy's administration. These projects were designed to improve the conditions of blacks and other disadvantaged groups in American society. Although this was not the main point of the paper, Jensen stressed that it was plausible to assume that the consistently reported difference of 15 IQ points between blacks and whites is due to genetic influences. The reaction to this article was comparable to that accorded "The Bell Curve" twenty-five years later. Eysenck entered the debate with his book "Race, intelligence and education" (Eysenck, 1971). This book was an attempt to explain the main issues in a simple language and it was filled with a lot of interesting facts on the matter of race and IQ. Nevertheless, the book was also exposed to attack. One of the main reasons for the attack stemmed from a relatively minor point in the book. Namely, Eysenck speculated that one of the reasons for the existence of racial differences in intelligence in the United States of America derives from the possibility that those blacks who were enslaved in Africa had lower intelligence than those who managed to escape that fate. This was especially irritating to the civil rights movement, which was in the ascendancy in the US at that time. Both Jensen and Eysenck were attacked not only verbally and in the press but also physically. The fact that they maintained their dignity and defended their beliefs and judgments under such pressures is a testament to their civil bravery and is also an example that should be heeded by the scientific community.

The second debate was related to the first since one of the central issues was that of heritability and, in particular, the data that were collected by Cyril Burt. A couple of years after the death of this influential British psychologist, an American psychologist Leon Kamin, noticed that two papers of Burt's on identical twins that appeared in the 1950s reported the same values of correlation coefficients despite the fact the second paper allegedly included some additional pairs of twins. This is a very unlikely outcome - additional participants normally change the value of correlation coefficients. Furthermore, it proved difficult to identify two of Burt's collaborators - they seemed to have disappeared without a trace. Since Eysenck was a student of Burt it was expected that he would enter the debate and perhaps shed some light on what might have happened. Although I believe that the relationship between the two was tense at times, Eysenck initially came to Burt's defence. However, he did accept a later suggestion from Hearnshaw's that it is possible that Burt might have become a bit careless after his retirement and that errors might have occurred
in his work. It is interesting that two books on Cyril Burt's contributions appeared recently and both shed a somewhat more positive light on Burt's life and achievements than previous reports. In this debate Eysenck pointed out that the main findings on the heritability of intelligence remain unchanged even if one were to remove Burt's data from consideration (Eysenck & Kamin, 1981). A large number of studies on heritability that were published subsequently provided strong support for this position. In the course of these debates Eysenck was called a racist and a fascist. These were insults to a person who had emigrated from Germany because of disagreements with Nazi policies!

Another area of Eysenck's activity was his attempt to write popular, not scholarly, books on the measurement of intelligence. He published two books for people who are interested in assessing their own intelligence (Eysenck, 1962; 1966) and a book on how to assess the intelligence of their children (Eysenck & Evans, 1995). These works can be found in bookshops in all English-speaking countries.

In his last book related to intelligence, Eysenck attempted to make a synthesis of the several areas of psychology that he had been actively involved in. This took form of a book on genius which, close to the time of his death, he saw as one of his best works. In this book Eysenck starts with the assumption that a genius has high intelligence, that he/she is prepared to work hard, and that he/she has strong motivation and appropriate conditions for development. However, since there are many people who possess these pre-conditions, what is the difference between a genius and an ordinary mortal?

A genius is a person who is judged by others working in the same field to be exceptionally creative. This creativity can be measured, to an extent, with tests of divergent thinking. According to Eysenck, however, geniuses, as well as less creative people, often have psychopathological personality traits. He came to the conclusion that our understanding of a genius could be improved by taking into account personality structure and, in particular, the trait of psychoticism. This is a personality trait that predisposes a person towards psychosis in the presence of stress. Low psychoticism is linked to rigidity while high psychoticism indicates a pathological personality which, like schizophrenia, is characterized by uncontrolled associations and speech. A middling amount of psychoticism, i.e., controlled psychoticism, is indicative of high creativity and originality. Both schizophrenics and creative people tend to generate unusual, remote and original associations. This assumed link with schizophrenia led Eysenck to postulate that dopamin activity may be the core of creativity since it affects schizophrenic behavior. The presence of dopamine, of course, is related to genetic factors that affect personality. Eysenck's model of creativity and genius is depicted in Figure 2.
Psychoticism and creativity are also linked to the construct of latent inhibition. This refers to an aspect of Pavlov's conditioned reflex. If a stimulus is presented many times to an organism and it is not paired with an unconditioned reflex, it becomes associated with the "nothing-is-happening" situation. If we start pairing the same stimulus with an unconditioned reflex, people exhibiting low psychoticism require a lot of trials in order to establish a conditioned response. Such a limitation does not exist in people who exhibit high psychoticism; the establishment of a conditioned response tends to be quick in those who obtain high psychoticism scores. All these conditions - genetic determinants, high dopamine activity, psychoticism, and the lack of latent inhibition - are present in people we call geniuses.

Eysenck's theory of creativity and genius is interesting and many aspects of this theory are open to empirical checks although I am not aware of any empirical studies of his theory at this stage. A critique of Eysenck's views on the relationship between psychopathology and genius points to the fact that this link is not very strong - the majority of Nobel laureates, for example, do not display psychopathological symptoms. It appears that the majority of highly creative people tend to be exceptionally mentally healthy.
My Contacts

I have met Hans Eysenck several times in my life but the most memorable were the first and the last meetings. The first meeting took place in Sydney in 1977, when Eysenck and Jensen were invited to give talks at several Universities in Australia. Jensen discussed the relationship between intelligence and learning while Eysenck focused on two topics: intelligence and behavior therapy. Their first stopover was in Melbourne and from media reports it became clear that demonstrations protesting their positions were both relatively large and well-organized. Their next stopover was Sydney where Eysenck was supposed to give two talks. At the first talk people present at the lecture theatre were abusive using many derogatory terms. A water bomb hit the professor who was to introduce Eysenck to the audience. The talk was therefore cancelled. Security arrangements for the second talk were increased but almost nothing of his talk could be heard due to the noise produced by demonstrators at the door. It was quite pleasing to see Eysenck keep his composure and behave in a dignified way in the face of such disruptive behavior. For his second talk I organized a group of postgraduate students and tutors with the intention of defending him against physical attacks. This allowed me to exchange a few words with him and I was impressed by his calm in face of physical threats and surprised by his pronounced introversion. When the news of Eysenck's death reached us, one of the lecturers at Sydney University showed a film depicting that 1977 event. This brought back memories of the unreasonableness of crowd's behavior and the calmness of Eysenck's reactions.

I want to use this opportunity to mention an event that is linked to Eysenck but, in fact, tells more about the behavior of the media in our society. I am sure that he must have had similar experiences and I hope that he has forgiven my falling into "the journalist's trap". During one of his visits to Australia in 1980s, the Australian Broadcasting Commission television service was planning to interview him and the format of the show required the airing of a "portrait" of the guest. Without much success, a journalist spent a lot of time trying to find somebody who would say that Eysenck was a racist. Everybody interviewed for the program was asked the same question: "Do you think that Eysenck is a racist". My own answer was as follows: "No, he is not a racist. However, some of the findings he talks about have not been exposed to sufficient scrutiny and replication and under these circumstances, if the findings can be used by the racists, it would be best not to publicize them too much since such an action may lead to social upheaval. For this reason, I can imagine that some people may be prepared to say 'Yes, he is a racist". When the program was shown later on that evening, only the last sentence, out of context, was transmitted. My effort to retrieve the original tapes
was unsuccessful - the Australian Broadcasting Commission representative told me that the original tapes were destroyed after the cuts for the program were completed. I still feel bad about the whole episode.

I saw Eysenck for the last time at the meeting of the International Society for the Study of Individual Differences (ISSID) in Aarhus, Denmark in summer of 1997. Surgical removal of a brain tumor had taken place and the hair on the back of his head had not yet grown. He was sitting in a wheelchair listening to the talks, many of which were inspired by his own work. The impression he left on me was that of a strong person, even in adversity. That is how he will remain in my memory. Although his contribution to the study of intelligence may not be as influential as his work on personality, he has done much more in intelligence than many other ordinary mortals.

References

Eysenck on Intelligence: Biological Correlates and Polemics


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Hans Ajzenk o inteligenciji: Biološki korelati i polemike

LAZAR STANKOV

Ajzenkov doprinos proučavanju inteligencije bio je značajan, ali u senci njegovog proučavanja ličnosti. Njegov model inteligencije je koristan u razgranjanju različitih značenja ovog termina u savremenoj psihologiji. Ipak, najznačajniji je njegov rad u istraživanju bioloških korelata inteligencije. Rad u oblasti genijalnosti i kreativnosti predstavlja interesantan pokušaj sinteze različitih oblasti njegovog istraživanja ali, u ovom trenutku, njegov budući uticaj u oblasti inteligencije ne može se predvideti.

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Ханс Айценк об интеллекте: Биологические корреляты и споры

ЛАЗАР СТАНКОВ

Вклад Айценка в исследование интеллекта был значительным, хотя остался в тени его исследований личности. Его модель интеллекта в современной психологии применяется в разграничении различных значений этого термина. Однако, самая значительная его работа - это исследование биологических коррелятов интеллекта. Изучение гениальности и творческого воображения
представляют собой интересную попытку синтеза различных областей исследований Айзенка, но, в настоящее время, его влияние на будущие исследования в области интеллекта нельзя предвидеть.