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In memoriam of Marvin Zuckerman: His impact on Spanish Psychology

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Abstract

Background: The work of recently deceased Marvin Zuckerman is well-known in Psychology. Zuckerman is mainly known around the world for describing the nature of the Sensation Seeking personality trait (with a strong biological basis related to physiology, endocrinology, brain biochemistry and genetics), and its practical usefulness in explaining many human behaviors, especially high-risk behaviors. **Method:** The article refers to biographical aspects of Zuckerman's career, and presents and presents an outline of results produced in Spain within the Zuckerman framework. **Results:** We summarize studies conducted in our context with the Sensation Seeking Scale, form V (SSS-V), the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ), the new Zuckerman-Kuhlman-Aluja Personality Questionnaire (ZKA-PQ) and its short form (ZKA-PQ/SF) about psychometric and biological aspects of Zuckerman's theory. **Conclusions:** Results support the good psychometric properties of the Zuckerman instruments, the transcultural viability of his personality model, and their multiple biological correlates (gonadal hormones, genetic polymorphisms, and electrophysiological variables such as the startle reflex and frontal spectroscopy [fNIR]). The whole picture demonstrates the great usefulness of Zuckerman's theoretical framework in personality psychology research.

Keywords: Zuckerman's psychobiological personality model, Zuckerman's alternative five-factor model, Gray's personality model, Eysenck's personality model.

Resumen

En recuerdo de Marvin Zuckerman: su impacto en la psicología española. **Antecedentes:** Marvin Zuckerman, recientemente fallecido, ha sido un investigador muy conocido en Psicología. De hecho, Zuckerman es principalmente reconocido por el rasgo de Búsqueda de Sensaciones (con una base biológica relacionada con la fisiología, endocrinología, bioquímica cerebral y la genética), y su gran relevancia práctica para la comprensión de numerosas conductas humanas, especialmente conductas de riesgo. **Método:** en el artículo se hace referencia a aspectos biográficos de la trayectoria de Zuckerman y se expone una síntesis de resultados obtenidos por nuestro grupo en España a partir de las propuestas teóricas de Marvin Zuckerman. **Resultados:** se resumen los trabajos psicométricos y biológicos realizados con los instrumentos de evaluación generados a partir del modelo de Zuckerman: Sensation Seeking Scale forma V (SSS-V), Zuckerman-Kuhlman Personality Questionnaire (ZKPQ), el nuevo Zuckerman-Kuhlman-Aluja Personality Questionnaire (ZKA-PQ) y su forma reducida (ZKA-PQ/SF). **Conclusiones:** los resultados de estos trabajos muestran las buenas propiedades psicométricas de los instrumentos de Zuckerman, así como la validez transcultural de su modelo, y sus múltiples correlatos biológicos (hormonas gonadales, polimorfismos genéticos, variables electrofisiológicas como el startle reflex y espectroscopia frontal [fNIR]). Se demuestra la gran utilidad del modelo teórico de Marvin Zuckerman para el desarrollo de la investigación en psicología de la personalidad.

Palabras clave: modelo psicobiológico de personalidad de Zuckerman, modelo alternativo de cinco factores de Zuckerman, modelo de personalidad de Gray, modelo de personalidad de Eysenck.

On November 8th, 2018, Professor Marvin Zuckerman died at the age of 90 (1928-2018). He suffered a heart attack while going to vote in the American elections, went into coma and passed away a few days later. Recent tributes to his memory can be consulted on the web pages of the University of Delaware[1] (where he was emeritus professor), and the International Society for the Study of Individual differences[2] (of which Zuckerman was founder and president). Additionally, a summary of his career as a personality researcher can be found on the Internet[3].

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Zuckerman's contribution to psychology in general, and personality and differential psychology in particular, has been extraordinary. In his ResearcherID there are 241 publications, with 10,471 citations, and an h index of 48. In recent years, he has received an average of more than 300 citations per year[3]. He is mainly known worldwide in the field of psychology for his psychobiological model of personality, mainly focused on the mono-trait called "Sensation Seeking", with a strong psychobiological basis and especially useful in the study and prediction of risky behaviors (Zuckerman, 1994). The author himself has published seven books in which he describes his own contributions and those of others investigating within the Zuckerman framework.

After a long professional life, Zuckerman retired aged 74 at the University of Delaware, where he then became professor emeritus until his death. Two years after his retirement, he published an autobiographical article in the *Journal of Personality Assessment* (Zuckerman, 2004), in which he talked about aspects of his

family, social and professional life. From his reading, Zuckerman developed a great and active interest in psychological science. Initially, he combined his interest in psychoanalytic theory and projective tests with an interest in science, logical positivism and physiology. In his autobiography, he commented jokingly that his clinical psychology students said that he had a multiple personality: Dr. Jekyll and Mr. Hyde. Unlike Eysenck, who hated psychoanalysis, Zuckerman always had a soft spot for Freud's theory, at least in its philosophical essence. However, he soon recognized the lack of scientific basis and therapeutic utility of psychoanalysis and focused exclusively on scientific research.

The first contributions of Zuckerman in the field of psychological research date back to the late 60s with the development of a trait-state anxiety test (Zuckerman, 1951, 1960), which was later extended to three factors (anxiety, depression, hostility), the Multiple Affect Adjective Check List (Zuckerman & Lubin, 1965). Later on, he began his experimental research on sensory deprivation. In this research, volunteers were placed in dark and soundproof rooms with tactile and movement restrictions, as well as visual and auditory restrictions. He studied the reactions of anxiety, panic, hallucinations, and complaints of cognitive inefficiency, boredom and restlessness (Zuckerman, Albright, Marks, & Miller, 1962).

It was at this time that he became interested in the Sensation Seeking personality trait. He was interested in personality traits that could predict sensory deprivation responses. Sensory deprivation has been called a "walk-in inkblot," an ambiguous situation in which personality might shape responses. Sensory deprivation was a situation that was below the so-called "Optimal Level of Stimulation" (OLS), a construct developed by Wilhelm Wundt (see revision by Zuckerman, 1994). Note that individuals differed in their optimal level of stimulation. It was believed that OLS was regulated by the reticular activation system in the brain. In order to study the relationship between sensory deprivation and OLS, Zuckerman, together with other colleagues, developed the first Sensation Seeking Scale (Zuckerman, Kolin, Price, & Zoob, 1964). This Scale eventually evolved into version V with four subscales called Thrill and Adventure Seeking, Experience Seeking, Disinhibition, and Boredom Susceptibility (Zuckerman, 1971). The SSS-V was the psychometric measure that generated most psychobiological research within the framework of Zuckerman's theory (Zuckerman, 1994; Zuckerman & Aluja, 2014).

In 1976, Zuckerman took a sabbatical year at the Institute of Psychiatry in London with Hans Jürgen Eysenck. Eysenck had published a seminal book 10 years earlier, in which the biological basis of his personality model was formally proposed (Eysenck, 1967). He had already linked extraversion with the optimal level of activation and with the ascending reticular system. For Eysenck, the Sensation Seeking was a sub-trait of Extraversion. Zuckerman had the opportunity to work with Eysenck and his wife Sibyl with the SSS-V and also participate in a major genetic study with the twin database of *Mausdley Twin Banck* (Fulker, Eysenck, & Zuckerman, 1980), which concluded with the demonstration of a strong heritability of the Sensation Seeking trait.

Later, Zuckerman became interested in the psychological bases of Sensation Seeking from Neary's studies on the orientation reflex and the skin conductance. In his autobiographical article (2004), Zuckerman talked about how he, Siegel and Murtaugh studied the relationship between Sensation Seeking and the cortical visual potentials evoked. Some of these studies are described in Zuckerman (1991). In the 1980s, Zuckerman began to study the connection between Sensation Seeking (SS) and gonadal hormones (Daitzman & Zuckerman, 1980). In these studies, testosterone had been linked to the disinhibition scale of the SSS-V. Not long previously, Murphy et al. (1977), had found a negative relationship between the MAO B and the SS. The results of the relationship between MAO and SS were confirmed with other similar studies and with comparable results (Zuckerman, 1994).

Another researcher who had a great influence on Zuckerman was Gray, with whom he took a sabbatical in Oxford in 1983. Gray was a neuroscientist who worked with animals and had established the biological basis of motivational systems such as sensitivity to punishment and reward (Gray, 1982, 1987). The motivational mechanisms in turn affect the basic personality traits: anxiety, impulsivity (approach), and aggression (fight-flight). The training undergone with Gray motivated Zuckerman to write his book *Psychobiology of Personality* (Zuckerman, 1991).

Zuckerman's contributions have aroused great interest in researchers in psychology from around the world, Spain included. I personally began to investigate using his model of the Sensations Seeking trait in the 80s, when working on my doctoral dissertation on sexual hormones and Sensation Seeking in delinquents and non-delinquents (Aluja, 1989, 1991). Later, our research group became particularly interested in his Alternative Five Factor Model personality model (AFFM). In fact, our work group have devoted the last 18 years to researching within this inspiring framework.

We started our research working on the psychometric aspects of the model. In this sense, and as will be described below, we carried out different studies and adaptations to two different languages, Spanish and Catalan, of the Sensation Seeking Scale (SSS, form V mainly), the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ) and, in recent years, the development of a new instrument for the AFFM called Zuckerman-Kuhlman-Aluja Personality Questionnaire (ZKA-PQ). With Zuckerman's help, the Zuckerman-Kuhlman-Aluja Personality Questionnaire (ZKA-PQ) was designed to measure 20 facets and five domains (Aluja, Kuhlman & Zuckerman, 2010). This questionnaire also has a short version (Aluja, Lucas, Blanch, García, & García, 2018), and an as yet unpublished version for children and adolescents. As a result of these adaptations, we also investigated the relationships between AFFM and Sensation Seeking and several outcomes such as personality disorders, emotional intelligence and others.

As I mentioned above, I arrived at Zuckerman's model with a psychobiological study. This approach would continue in this last decade analyzing the biological bases of the Zuckerman model from the perspective of endocrinology (gonadal hormones), molecular genetics and electrophysiology (startle reflex and functional near infrared spectroscopy). In memory of Marvin Zuckerman, we will summarize the research conducted by our workgroup, inspired by an intense personal and professional relationship with Zuckerman during the last 18 years of his life.

Psychometric studies of the SSS-V and the ZKPQ

The Sensation Seeking (SSS-V) was validated in Spanish by Pérez and Torrubia (1986), who were pioneers in the study of the factorial-biological personality models in Spain (Eysenck, Gray, & Zuckerman). Both worked at the Autonomous University of Barcelona together with professors Lluis García and Adolf Tobeña in Barcelona. In the 1980s, Eysenck's studies generated

great interest and a good deal of research in Catalonia, resulting in what was popularly known among Catalan researchers as the *Barcelona Eysenck School*. Pérez (1984) investigated Eysenck's theory of criminality in delinquents, whereas Torrubia (1985) focused on Gray's theory of personality. We studied the psychometric properties of the original version of the SSS-V in a sample of Spanish university students (Aluja, García, & García, 2004). As previous studies had suggested, the exploratory factor structure indicated that several items loaded on a different factor or presented loadings lower than .30. A revision of Sensation Seeking scales can be found in Zuckerman and Aluja (2014).

At the end of the eighties, Zuckerman and colleagues conducted a series of factor analyses of several personality and temperamental questionnaires (Zuckerman, Kuhlman, & Camac, 1988). As a result of these preliminary results, Zuckerman formally proposed a new personality model in the seminal paper by Zuckerman, Kuhlman, Joireman, Teta, and Kraft (1993). This model proposes five basic dimensions of personality: Neuroticism-Anxiety, Sociability, Hostility-Aggression, Activity and Impulsive Sensation Seeking. This new model was also composed of five factors like the Five-Factor Model (FFM; Neuroticism, Extroversion, Openness to Experience, Agreeableness, and Conscientiousness), but it was somewhat in disagreement with the FFM, and so Zuckerman's personality model was called the Alternative Five Factor Model.

From his psychobiological standpoint, Zuckerman sought to build his personality model on the the foundations of biological evidence and temperamental dimensions. Hence, Zuckerman did not include the Openness to Experience (or Culture) dimension. He also considered a factor combining Impulsivity and Sensation Seeking. This factor retained the temperamental aspects of unsocialized impulsivity better than the Conscientiousness factor from the FFM, which could not be studied in animals. From the same standpoint, Zuckerman included a Hostility-Aggression dimension which had emerged from the Aggression studies conducted both in humans and animals, instead of the Agreeableness dimension from the FFM. Note that the non-inclusion of a dimension of Aggression in the FFM had been criticized (Bouchard, 2015). Zuckerman also introduced the classical temperamental dimension of Activity already mentioned in the famous longitudinal study of New York by Thomas and Chess (1957). Finally, the AFFM included a dimension of Sociability instead of the most general trait of Extroversion, and a Neuroticism-Anxiety scale. In a seminal article published in 1993, Zuckerman et al. proposed a questionnaire of 89 personality items with a dichotomous answer format to measure these five temperamental dimensions plus an Infrequency scale (10 items): the ZKPQ.

As we have commented above, our first studies about Zuckerman's personality model explored the psychometric properties of the ZKPQ. Specifically, relationships with other personality inventories (NEO-PI-R and EPQ [Eysenck`s Personality Questionnaire]) were analyzed within the framework of the same structural models proposed by Zuckerman et al. (1993). Extraversion and Neuroticism were quite similar across all three models (AFFM, FFM and Eysenck's). With a three-factor solution, the different measures of personality could be grouped into Neuroticism, Extraversion and Psychoticism factors. In this model, Openness to Experience from NEO-PI-R, and Sociability and Activity of the ZKPQ were clearly located on the Extraversion factor, while Conscientiousness and Agreeableness loaded on the Psychoticism factor, together with the Impulsive Sensation Seeking and Aggressiveness-Hostility scales of the ZKPQ. The four-factor structure suggests that Psychoticism was split into two factors. The first one was formed of Conscientiousness, Impulsive Sensation Seeking and Psychoticism, and the other of Agreeableness and Aggression-Hostility. The five-factor model seemed to be similar to the four-factor one, except for Openness markers, which formed an independent factor (Aluja, García & García, 2002; Aluja et al., 2004). Later on, we collaborated in the validation of the French version of the ZKPQ (Rossier, Verardi, Massoudi, & Aluja, 2008).

Shortened versions of the ZKPQ

After these studies about the convergent and divergent validity of Zuckerman's model, we then set out to develop the first short version of the ZKPQ. Finally, by means of a complex item analysis system, a short 69-item version was obtained. After some Exploratory (EFA) and Confirmatory Factor Analyses (CFA) conducted in a large sample of university students, it was found that a 69-item model showed better fit, similar reliability coefficients, and slightly better construct and convergent validity than the original 89-item version (Aluja, García, & García, 2003a). This procedure (or a similar one) was used in other studies to improve the goodness-of-fit indices and remove unnecessary items (Aluja, Blanch, & García, 2005; Aluja, Rolland, García, & Rossier, 2007), and to develop short versions of the Sensitivity to Punishment and Sensitivity to Reward scales from Gray's model (SPSRQ-20, Aluja & Blanch, 2011a) or the EPQ (Aluja, García, & García, 2003b),

The second short version of the ZKPQ was the result of joint analyses of four samples with different languages: English (United States), French (Switzerland), German (Germany), and Spanish (Spain) (Aluja et al., 2006). Using several criteria derived from EFA and CFA item analysis, 10 items per scale were selected. This short version (named ZKPQ-50-CC) presented psychometric properties strongly similar to the original version and a factor structure equivalent in the four countries. We concluded that the ZKPQ-50-CC presented high cross-language replicability, and could be a useful questionnaire for personality research in different settings and languages (Aluja et al., 2006; Aluja, Rossier, & Zuckerman, 2007).

Development of the ZKA-PQ

My relationship with Marvin Zuckerman began with the study to develop the ZKPQ-50-CC. After we had completed this paper, I wrote to him to point out that the ZKPQ had not been developed according to the current standards of personality questionnaires. I told him that the questionnaires should have a factorial structure based on facets, not items, and that if not, it would be obsolete. In addition, the dichotomous answer format was no longer used. I gave him the examples of NEO-PI-R from Costa and McCrae, and TCI-R from Cloninger's model.

Zuckerman replied that re-working the ZKPQ was a huge task, and that he was already retired. I then proposed that I could do this work with his help. Zuckerman was excited about the project. Together with Luis, Óscar and Àngel Blanch (newly incorporated), we applied for a grant from the Spanish "National Research Plan" from 2008 to 2010 to develop the new questionnaire.

The first thing we did was to design five theoretical facets for each ZKPQ construct (25 facets) and then write 20 items per facet.

Some of the facets did not work well or did not load properly on their factor. Some were rewritten and others were deleted. Several samples were used to calibrate 20 facets (4 per factor), and finally we used only 10 items per facet. If a facet obtained secondary loads in a factor different from its own, it was necessary to identify each item responsible for the problem, change it and repeat the analysis. I was in close touch with Zuckerman throughout the entire process. The items were written both in Spanish and English.

After this hard process, during which Marvin and I sent each other hundreds of emails, the final structure of the new questionnaire was eventually composed of 5 factors, 20 facets, and 200 items. It should be remarked that this new questionnaire presented very few secondary loads, and that the average reliability of the facets was .75 or higher. Note also that only 16 items were taken from the old ZKPQ. The structure was replicated in a Spanish validation sample, and also in an American sample obtained by Mike Kuhlman. The questionnaire was finally published (Aluja et al., 2010) with the name of Zuckerman-Kuhlman-Aluja Personality Questionnaire (ZKA-PQ), including my name by express wish of Zuckerman. This new instrument included five factors were: Neuroticism, Sensation Seeking, Extraversion, Activity and Aggressiveness (Aluja et al., 2010). We later proposed an inconsistency index for discarding subjects with low reliable responses (Aluja, Blanch, Martí-Guiu, & Blanco, 2017).

The ZKA-PQ short form (ZKPQ/SF)

After realizing that the ZKA-PQ could be too long to be used in clinical, other applied settings or Internet studies, we decided to develop a short version (ZKA-PQ/SF). This brief version has only 80 items (four items per facet), in contrast with the 200 items (10 items per facet) of the long version (Aluja et al., 2018). The ZKA-PQ/SF has a robust five-factor structure, highly similar to the long questionnaire (average factor congruence of 0.98). The alpha reliability coefficients of four-item facets ranged between 0.64 and 0.86 and test-retest coefficients were between .80 and .84. Controlling for item overlap, correlations between long and short forms ranged between 0.65 and 0.80. It can thus be concluded that the ZKA-PQ/SF is adequate and useful for research purposes in those cases where the long version is inappropriate. As a final remark, note that, in comparison with the shorts versions of the NEO-PI-R (NEO-FFI or NEO-FFI-R), the ZKA-PQ/SF retains the 20 facets with generally good reliabilities per facet (Aluja, García, Rossier & García, 2005; Aluja et al., 2018). The Spanish ZKPQ-50-CC, the ZKA-PQ and the ZKA-PQ/SF are available with the scoring keys and norms for researchers[4].

Cross-cultural studies with the ZKPQ/ZKA-PQ

The first cross-cultural study was conducted with the ZKPQ in a sample of 9,152 subjects from six countries: China, Germany, Italy, Spain, Switzerland, and the United States (Rossier et al., 2007). The internal consistencies for all countries were generally similar to those found for the normative American sample. Factor analyses showed that the normative American structure was replicated in every culture for all factors, with just a few exceptions.

The second study was already carried out with the ZKA-PQ. It included a total of 15,048 participants from 23 cultures (Rossier et al., 2016; see novel back-translation system by Blanch & Aluja, 2016). The ZKA-PQ structure was highly replicable with total congruence coefficients ranging from .94 to .99. Measurement invariance across cultures was assessed using multi-group confirmatory factor analyses at three levels. The results showed that the underlying structure of the ZKA-PQ replicates well across cultures (configural and metric invariance was observed), suggesting that this questionnaire can be used in a wide range of cultures, and that the Zuckerman Alternative Five Factor Model might be as universal as the FFM or Eysenck`s model.

A similar study has recently been published with the reduced version (ZKA-PQ/SF). The results showed that the 5-factor structure with 20 facets replicated well across 18 cultures and 13 languages (from Africa, America, Asia and Europe) with a total congruence coefficient of .97. As with the long form, a series of CFA to assess measurement invariance across cultures resulted in adequate CFIs and TLIs for configural and metric invariance. However, factors did not show scalar invariance. The average percentage of the variance explained based on the adjusted R^2 was 2.9%, 1.7% and 5.1% for age, sex and cultures respectively. Finally, multidimensional scaling suggested that geographically or culturally close cultures share mean profile similarities (Aluja et al., 2019).

The ZKPQ/ZKA-PQ in the personality space

Several studies analyzed the relationships of the ZKPQ with Eysenck's, Gray's, Cloninger's, and FFM personality models (Aluja et al., 2002, 2004; Zuckerman et al., 1993; Aluja & Blanch, 2011a). Results demonstrate that the Neuroticism-Anxiety and the Sociability scales of the ZKPQ were grouped together with Neuroticism and Extraversion of the EPQ, respectively. The Psychoticism scale of the EPQ was related to the Impulsive Sensation Seeking and the Aggression–Hostility scales of the ZKPQ. In Aluja and Blanch (2011a), the Sensitivity to Reward scale correlated with Impulsive Sensation Seeking (ZKPQ) and Impulsiveness from Eysenck I^7, total Impulsivity of BIS-10 and with Venturesomeness (I^7). Sensitivity to Punishment correlated with Neuroticism–Anxiety (ZKPQ) and with Empathy (I^7) (Aluja & Blanch, 2007; Aluja & Blanch, 2011a).

The relationships between the ZKPQ-50-CC, the TCI-R, and the NEO-FFI were analyzed by Aluja and Blanch (2011b). Factorial analysis shows strong relationships among the three questionnaires. The first factor comprised NEO-Agreeableness, TCI-Cooperativeness and ZKPQ-Aggressiveness-Hostility. The second factor was composed of NEO-Neuroticism, ZKA-Neuroticism-Anxiety, TCI-Harm Avoidance and TCI-Self-directiveness. The third factor comprised ZKA-Sociability, NEO-Extraversion, TCI-Reward Dependence, ZKA-Impulsive Sensation Seeking and TCI-Novelty Seeking. The fourth factor comprised TCI-Persistence, ZKA-Activity, and NEO-Contentiousness, whereas the fifth factor comprised NEO-Openness and TCI-Self-Transcendence.

It should be remarked that further studies using the ZKA-PQ replicated the relationships with the Eysenck, Gray, Cloninger, and FFM models obtained with the old ZKPQ (Aluja et al., 2013; García, Aluja, García, Escorial, & Blanch, 2012; García, Escorial, García, Blanch, & Aluja, 2012).

ZKA-Aggressiveness had a negative and strong relationship with NEO-Agreeableness, ZKA-Activity was positively related with NEO-Conscientiousness rather than NEO-Extraversion,

and ZKA-Sensation Seeking presented a more diverse pattern, although some reported relationships (negative with NEO Conscientiousness, positive with Extroversion, and positive with Openness to Experience) that were in agreement with previous evidence using the old ZKPQ and the NEO-PI-R (García, Aluja, García, & Cuevas, 2005; García et al., 2012).

The ZKPQ/ZKA-PQ and psychopathology

After the psychometric studies, we shifted our focus to the relationships between Zuckerman's traits and psychopathological constructs, with special attention to personality disorders (PDs). In this line, some papers analyzed the relationships between the ZKPQ and PDs measured through the Millon Clinical Multiaxial Inventory III (MCMI-III). Thus, Aluja, García, Cuevas, and García (2007a) reported a good predictive power, similar to the FFM. It should be remarked that Zuckerman's model also helped to increase specificity and discriminate between PDs. For instance, the Histrionic scale was related to Sociability and Impulsive Sensation Seeking in Zuckerman's model, not only with Extraversion as usually happens in the FFM.

In a further paper designed to compare the NEO-FFI-R with the ZKPQ-50-CC prediction in a Spanish non-clinical sample (Aluja, García, Cuevas, & García, 2007b), each instrument explained around 30% of the MCMI-III scales variance, with no sharp differences between them. Using the 10 personality scales from both instruments conjointly raised the personality disorders accounted variance to 38%, suggesting that Zuckerman's model might add some explanatory power beyond the FFM (Aluja et al., 2007b). Note that results support the usefulness of short versions in predicting personality disorders.

This research line was taken up again when the ZKA-PQ was published. As was the case with the ZKPQ, the ZKA-PQ proved to be a good predictor of PDs measured through the MCMI-III in healthy subjects (Aluja, Blanch, García, García, & Escorial, 2012). ZKA-PQ Neuroticism correlated with most PD scales. ZKA-PQ Aggressiveness and Sensation Seeking correlated with the Antisocial PD scale, and ZKA-PQ Extraversion correlated with several scales such as Avoidant and Histrionic PDs. Similarly, to the NEO-PI-R (Aluja et al, 2007a), when using the ZKA-PQ facets the predictive capacity improves, although the main advantage is that the availability of more information also improves the descriptive capacity of PDs from personality (Abad, Sorrel, García, & Aluja, 2018; Aluja et al., 2012).

The ZKA-PQ dimensions also accounted for between 35% and 61% of the variance of another psychopathological instrument (the Dimensional Assessment of Personality Pathology-Basic Questionnaire; Livesley, & Jackson, 2009), whereas ZKA-PQ facets accounted for between 54% and 63% of the variance. Local regression graphical analysis (LOESS) showed ZKA-PQ Neuroticism and Aggressiveness were the dimensions most related with Emotional Dysregulation, ZKA-PQ Sensation Seeking and Aggressiveness with Dissocial Behavior, Neuroticism and Extraversion (negative) with Social Avoidance, and Activity and Sensation Seeking (negative) with Compulsiveness (Aluja, Blanch, & Balada, 2013).

This research line is still open given the changes in the theory and measurement of the Personality Disorders included in the DSM-V (American Psychiatric Association, 2013). From this standpoint, a study has been conducted to compare the ZKA-PQ with NEO-PI-R, and the Cloninger's model in the prediction of the Personality Inventory for DSM-5 (PID-5; Krueger, Derrigen, Markon, Watson, & Skodol, 2012). Dimensions or facets from the three models predict about 60% of the variance for Detachment, 50% for Negative Affectivity, Antagonism, and Disinhibition, and 40% for Psychoticism. There was a highly congruent pattern of relationships across personality models (García, Cuevas, Lucas, and Aluja, *submitted for publication*). As expected, facets of the three instruments outperform dimensions, but the differences were not large, except for Detachment and Antagonism domains. On the other hand, it should be highlighted once again that other personality models may complement the prediction of the FFM, and help to understand the origins, development and biological, cognitive and practical correlates of personality disorders as conceptualized from PID-5 (García et al., *submitted for publication)*. As a final point in regard to this topic, several papers are currently in preparation to investigate the relationships between ZKA-PQ and ZKA-PQ/SF, and the Personality Inventory for ICD-11 (PiCD; Oltmanns & Widiger, 2018) and other psychopathological measures.

ZKA-PQ, emotional intelligence and alcohol consumption

Our research efforts in regard to Zuckerman´s model have also focused on other phenomena. First of all, we have investigated the relationships between Emotional Intelligence (EI) measured by the Trait Emotional Intelligence Questionnaire (TEIQue; Petrides, 2009), and ZKA-PQ (Blanco, García, & Aluja, 2016). The results showed that the ZKA-PQ predicts 66% (using facets) and 64% (using traits) of the variance of the TEIQue. High scores on EI correlated negatively with Neuroticism (r = -.66) and Aggressiveness (r = -.27); and positively with Extraversion (r = .62). Oblique factorial analyses demonstrated that TEIQue scales were located basically on the Neuroticism and Extraversion factors. These findings suggest that EI is a not a distinct construct of personality, and it cannot be isolated in the ZKA-PQ personality space. In the same paper (Blanco et al., 2016), we studied the relationship among Personality, EI, General Intelligence (GI) and Social Position Index (SPI). The SPI and GI did not load on any personality factor.

Zuckerman and colleagues have extensively analysed the relationships between personality traits, especially Impulsive-Sensation Seeking, and drug intake (Zuckerman & Kuhlman, 2000). In a recent paper, Aluja, Lucas, Blanch, and Blanco (2019) found that Impulsive/disinhibited personality variables had a stronger and direct effect on drinking problems, alcohol consumption, and pattern of drinking behaviour, which supports previous findings within Zuckerman's theoretical framework.

Sensation Seeking, personality trait and hormones

The initial studies of the workgroup analyzing the biological correlates of Zuckerman's model focused on the role played by sex hormones. They aimed to test Zuckerman's biological theory about the causes of differences in personality traits (Zuckerman, 1991; 1994; 2005) with special attention to Sensation Seeking. Aluja and Torrubia (2004) investigated the relationship between sex hormones and aggressiveness, hostility and Sensation Seeking in 30 healthy males. Using a standardized technique of radioimmunoassay, we obtained blood values of Luteinizing Hormone, Follicle-Stimulating Hormone, 17ß-estradiol, Total

Testosterone, Sex Hormone Binding Globulin and the Free Androgen Index. Spearman and Pearson correlations between Sensation Seeking and Testosterone were positive and significant after controlling for age. Considerably higher correlations were obtained after controlling for Luteinizing Hormone and Sex Hormone Binding Globulin. A group of subjects with high scores in a factor made up of Experience Seeking, Disinhibition and Boredom Susceptibility obtained significantly higher scores on Total Testosterone and Free Androgen Index. Subjects with high scores in a factor made up of Assault, Indirect Aggression and Verbal Aggression obtained significantly higher scores in Sex Hormone Binding Globulin and Total Testosterone.

Later, the relationships between Sensation Seeking, curiosity about sex, and total and free testosterone were investigated in inmates (Aluja & García, 2005). It was observed that higher values of Sex Hormone Binding Globulin produced an increment in Total Testosterone, but not in free testosterone. Positive relationships between total testosterone and the Disinhibition scale of the Sensation Seeking Scale were replicated, although they were affected by Sex Hormone Binding Globulin. Significant relationships between total and free testosterone and curiosity about sex were also found. In spite of the role of Sex Hormone Binding Globulin, subjects who were disinhibited and curious about sex presented higher concentrations of total and free testosterone.

In recent years, the relationship among Testosterone, Free Testosterone, Bioavailable Testosterone and personality were also studied (Aluja, García, García, & Blanco, 2016). Based on the findings of previous studies, the possible effects of age and other hormones, such as Luteinizing Hormone, Follicle-Stimulating Hormone, Sex Hormone Binding Globulin and Albumin were controlled. Main results show that there was a weak association among three measures of testosterone with Novelty Seeking (NS from TCI), Sociability and, to a lesser extent, with Impulsive Sensation Seeking. It should be remarked that all the studies commented on supported Zuckerman's biological theory for the Sensation-Seeking trait (Daitzman & Zuckerman, 1980; Zuckerman, 1994).

The ZKPQ/ZKA-PQ and genetics

From the mid-90s, a considerable research effort has been addressed at examining the molecular genetic basis of personality traits. Our research team started to investigate this topic in the middle of the first decade of the present century. The first papers focused on the genetic basis of Impulsive-disinhibited personality. Aluja, García, Blanch, Lorenzo, and Fibla (2009) found that higher scores in Impulsive Sensation Seeking and Aggression-Hostility dimensions were associated with carrying one or two copies of the 5-HTTPLR S allele (S/S homozygous and S/L heterozygous), and carrying two copies of the 5-HTTVNTR 12 allele (12/12 homozygous) serotonin polymorphisms. The 5-HTTPLR has related with Antisocial Personality disorder in the same sample (García, Aluja, Fibla, Cuevas, & García, 2010). Another study suggested an association between impulsive-disinhibited personality traits (using the ZKPQ and other measures) and the androgen receptor CAG and GGN repeat polymorphisms in both inmates and control samples (Aluja, García, Blanch, & Fibla, 2011). This paper was the logical next step given the relevant role played by hormonal factors in Zuckerman's psychobiological model.

Continuing with this idea, Aluja et al., (2015) designed a study with two aims: a) to analyze the interactions between testosterone levels and CAG repeat length polymorphism as a modulator of androgen receptor (AR) sensitivity with regard to impulsiveness traits, and b) to evaluate the contribution of other biological variables such as Luteinizing Hormone, Follicle-Stimulating Hormone, Sex Hormone Binding Globulin and Albumin in the relationship between testosterone levels and AR CAG length polymorphism with impulsiveness. To reach both aims, a sample of 105 healthy males was analyzed resulting in three groups of subjects according to CAG repeat lengths. Impulsiveness was measured through the Barratt's Impulsiveness Personality Scale. A series of ANOVAS and linear regression models predicting impulsiveness scales were conducted. Results showed that subjects with short or medium CAG repeat length tended to show higher impulsiveness phenotypes compared to long CAG repeat. The interaction between Free Testosterone and CAG, and between Sex Hormone Binding Globulin and CAG accounted for differences in impulsiveness (R^2 = .22 and R^2 = .18, respectively). This pattern was especially observed for the short CAG repeat group and Motor Impulsiveness.

Further research about a quantitative trait *locus* analysis of candidate copy-number variants (CNVs) was conducted across the impulsive-disinhibited pool test (including the Impulsive Sensation Seeking and Aggression-Hostility scales of the ZKPQ). The analysis was extended to the full series, showing that the presence/absence of the 30.1 Kb region within *SIRPB1* intron 1 was correlated with the levels of Impulsivity and Sensation-Seeking in a copy-number dependent manner (Laplana et al., 2014). A common copy-number variant within the *SIRPB1* gene was recently associated with impulsive behavior, in human out-of-Africa migration (Royo et al., 2018).

Focusing on the whole of Zuckerman's psychobiological personality model (Zuckerman, 2005), a series of genetic association hypotheses between some polymorphisms of serotonin, testosterone, dopamine, MAO-A, and COMT, and three temperamental factors (Impulsive Sensation Seeking, Neuroticism, and Sociability) were tested by García, Aluja, García and Cuevas (2016). It was concluded that Zuckerman's psychobiological model provides the necessary theoretical framework to explore the complex paths from genetics to behavior.

Using more advanced genetic techniques, a recent study using the ZKA-PQ evaluated the overall contribution of 153 tagged single-nucleotide polymorphisms (tagSNPs) from 20 candidate-genes to predict Neuroticism and Sensation Seeking. The four tagSNPs related to GABBR2, GNAS-AS1, DRD4 and FKBP5 candidate genes explained 13.8% of the Neuroticism variance, and the four tagSNPs related to AR, SLC6A3, DRD2 and DRD4 explained 14.5% of the Sensation Seeking variance. GABAergic, dopaminergic glutamatergic and glucocorticoid receptors were associated with Neuroticism, whereas serotonin carrier, dopaminergic and androgenetic receptors were associated with Sensation Seeking. These findings account for 24.87% and 29.78% of the heritable variance in base of the 4 tagSNPs for each personality variable (Aluja, Balada, Blanco, Fibla, & Blanch, 2019).

ZKA-PQ and electrophysiology

Blanch, Balada and Aluja (2014) analyzed the relationship of individual differences in personality with habituation in the

Acoustic Startle Response. Data from nine trials in Acoustic Startle Response to white noise bursts and a personality questionnaire based on the Alternative Five Factor Model personality approach were modelled with a Latent Growth Curve including intercept and slope habituation growth factors. There was a negative correlation between the intercept and slope, indicating that individuals with higher initial Acoustic Startle Response levels also had a more pronounced and faster decrease in the Acoustic Startle Response. Contrary to expectations, Extraversion and Sensation Seeking did not relate to habituation in Acoustic Startle Response. Neuroticism and Aggressiveness related asymmetrically to the habituation rate in Acoustic Startle Response. Higher levels of Neuroticism were related to faster habituation, whereas higher levels of Aggressiveness were related to slower habituation.

In another study, we explored the prefrontal cortex response to emotional salient stimuli in subjects with high scores in Neuroticism (and low in Sensation Seeking) or high scores in Sensation Seeking (and low in Neuroticism) personality traits (Balada, Lucas, Blanch, Blanco & Aluja, 2019). Ten pleasant and ten unpleasant pictures from the International Affective Picture System were presented to all subjects. The Neuroticism group showed significant effects for valence at the lateral prefrontal cortex in both brain hemispheres. They showed higher Oxygenation for pleasant pictures, more significantly in the left than in the right hemisphere. The highest differences were registered in ventral optodes. In contrast, the Sensation Seeking group did not show significant differences in hemodynamic variables such as depending on the valence of the pictures. These data suggest a differential functioning of the lateral prefrontal cortex, mainly the left ventrolateral cortex, in the Neuroticism group to pleasant and unpleasant visual stimuli. We hypothesize that if the lateral prefrontal activity is low, it could be the result of an over-activation of the amygdala in response to unpleasant pictures in subjects with Neuroticism or negative emotionality. These activation patterns could be related to vulnerability to emotional disorders.

Conclusions

Zuckerman began his professional career as a clinical psychologist in the fifties when psychoanalysis was a dominant paradigm in psychology. However, both his curious nature and his critical and nonconformist spirit quickly guided him to scientific research. He became interested in psychopathology, a discipline in which he published several books and articles (Zuckerman, 1999, 2011) although his most relevant contribution was the development of his theory on personality and the Sensation Seeking trait from his initial research on sensory deprivation.

The Sensation Seeking personality theory is a heuristic and attractive framework that has been used by a multitude of researchers and applied to very different areas of psychology. In this sense, other researchers have incorporated this personality trait in their models, a notable example being Cloninger, whose model includes a scale of very similar content called Novelty Seeking (Zuckerman & Cloninger, 1996; García et al., 2012). The author of reference of the Sensation Seeking trait, however, will always be Zuckerman. In Spain, we have contributed with a body of evidence, summarized in the previous sections, which helps understand the biological nature of Sensation Seeking, including brain biochemistry, endocrinology or electrophysiology and, finally, genetics. However, much remains to be investigated, and we are sure that psychobiological research within this personality model will continue.

In the new ZKA-PQ, the SS mono-trait has been integrated into an alternative five-factor model, along with Neuroticism, Extraversion (Socialization is now a facet of Extraversion), Activity and Aggressiveness. This model has demonstrated its validity, reliability and cross-cultural generality, similarly to the Five Factor Model or the PEN model of Eysenck (Rossier et al., 2016). This new five-factor personality model of Zuckerman was presented as an alternative to the dominant FFM. In our opinion, the Zuckerman model may help to resolve some inconsistencies of the FFM, such as those depicted by Eysenck (1991, 1992a, 1992b), increase our prediction of some constructs as personality disorders or risk behaviors and, especially, guide us to a better understanding of the psychobiological basis of personality.

One of Eysenck's criticisms of the FFM refers to the Openness to Experience factor. Although O is correlated with Extraversion and Sensation Seeking personality traits (Aluja, García, & García, 2003c; García et al., 2005) and has a place in the personality space (Aluja et al., 2002; 2004), this dimension has never had a high predictive capacity for personality disorders (Aluja, Cuevas, García, & García, 2007; Aluja, et al., 2007b) or other phenomena. Hence, we believe it is much more relevant and useful to measure Sensation Seeking as a basic personality dimension than Openness to Experience. This is one reason why we prefer the Zuckerman model to the FFM.

Another main reason for taking Zuckerman's model as a framework of reference was the solid psychobiological model depicted by Marvin in recent decades. Any interested researcher could take a look at the psychobiological schema on page 270 of his book about psychobiology of personality (Zuckerman, 2005). This schema represents the hypothesized causal paths from neurotransmitters (Dopamine, Serotonin, Norepinephrine and Gamma-Aminobutyric acid, enzymes (such as MAO-B), and metabolites (such as Dopamine Beta Hydroxylase) and gonadal hormones to three temperamental basic traits: Impulsive Sensation Seeking, Neuroticism-Anxiety and Sociability. It is a modern, practical and useful theoretical model, and has been the inspiration for all of our psychobiological research.

Summing up, we believe that Zuckerman has made an immense contribution to the development of personality psychology, and to the growth of our knowledge about the biological basis of personality traits. His theory is framed, along with Eysenck's and Gray's, in the so-called biological-factorial models tradition. These models begin with a biological causal approach to personality, rather than the purely descriptive or taxonomic approach of the Five Factor Model. Indeed, the evolution of psychological science in personality provides more and more evidence for the need to adopt a biological approach like Eysenck, Gray or Zuckerman. Even the Big Five model began to relate personality to the brain (De Young et al., 2009). In future, personality research will undoubtedly continue along the biological course chartered by Zuckerman and his contemporaries (Eysenck, Gray, and others).

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Notes

1 https://www.udel.edu/udaily/2018/november/in-memoriam-marvin-zuckerman/
2 https://issidorg.com/whats-new-at-issid/in-memoriam-marvin-zuckerman-1928-2018
3 https://en.wikipedia.org/wiki/Marvin_Zuckerman
4 http://www.researcherid.com/rid/C-6544-2011 (last access: 15/01/2019)
5 http://web.udl.es/usuaris/e7806312/Cuestionarios_Zuckerman.zip
6 http://web.udl.es/usuaris/e7806312/foto_grupo.jpg

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