

EXCEPTIONAL EXPERIENCES REPORTED BY SCIENTISTS AND ENGINEERS



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Context: Throughout history people have reported exceptional experiences that appear to transcend the everyday boundaries of space and time, such as perceiving someone's thoughts from a distance. Because such experiences are associated with superstition, and some violate currently accepted materialist conventions, one might assume that scientists and engineers would be much less likely to report instances of these experiences than the general population.

Objectives: To evaluate 1) the prevalence of exceptional human experiences (EHEs), 2) the level of paranormal belief, 3) the relationship between them, and 4) potential predictors of EHEs in three groups.

Participants: Potential volunteers were randomly selected to receive invitations for an anonymous survey.

Main Measures: Data were collected on 25 different types of EHEs, demographics, religious or spiritual affiliations, paranormal beliefs, mental health, and personality traits. Group differences were analyzed with chi-square tests and analysis of variance, and predictors were evaluated with a general linear model.

Results: 94.0% of the general population ($n=283$), 93.2% of scientists and engineers ($n=175$), and 99.3% of enthusiasts ($n=441$) endorsed at least one EHE ($X^2(2) = 21.1$, $p < 0.0005$). Paranormal belief was highest in EHE enthusiasts, followed by scientists and the general population ($F(2,769) = 116.2$, $p < 0.0005$). Belief was positively correlated with experience ($r = 0.61$, $p < 0.0005$). An exploratory general linear model showed that variables such as mental health, personality, impact and family history predict the endorsement and frequency of EHEs. This study indicates that EHEs occur frequently in both the general population and in scientists and engineers.

Keywords: Scientists, Engineers, Exceptional human experiences

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INTRODUCTION

Throughout recorded history, people have reported experiences of receiving information unconstrained by conventional notions of space and time. These experiences reside on a spectrum from intuition, gut feelings, or hunches to forms of extra-sensory perception (ESP), such as *telepathy* for supposed mind-to-mind communication, and *clairvoyance* or *precognition* for perceptions that seem to transcend space or time, respectively. For ease of exposition, we will call these “exceptional human experiences” (EHEs). Some studies have demonstrated positive benefits of EHEs¹ and theories explaining their potential evolutionary advantage have been developed.²

Belief in EHE is widespread worldwide.^{3–16} “Paranormal beliefs pertain to phenomena that have not been empirically attested to the satisfaction of the scientific establishment.”¹⁷ Over the last 40 years, in various populations and using different survey techniques, the prevalence of people reporting

EHEs range from a low of 10% among Scottish citizens¹⁸ to a high of 81% among Icelandic women.^{10,19} A survey of 300 university students and 700 townspeople in Charlottesville, Virginia found that 38% reported EHEs;²⁰ among 503 adults in Winnipeg, Canada, the percentage was 65.7%,²¹ among 1922 Chinese, Japanese, African-American and Caucasian-American college students, 31–47%;²² among 18,607 adults from 13 European countries and the US, 21–54%,²³ among 4,096 British adults, 37%;²⁴ among an unspecified number of adults in the United States, 31–67%²⁵ and most recently among 1207 American adults, 74.7%.²⁶

The relationship between *beliefs* in EHEs, actual *experiences* of EHEs, and laboratory performance is not clear. Some studies show a positive correlation between beliefs and reported experiences.^{27,28} For example, one study found that exposure to television programs that regularly depict paranormal phenomena was positively correlated with belief, but only for respondents who had personal EHEs.²⁹ However, the relationship between belief and EHEs is often confounded by the fact that many belief measures intermix items of belief and experience and then misconstrue these scores as belief only.^{17,30} A meta-analysis of 122 “sheep-goat” experiments conducted over seven decades examined the role of high belief (sheep) versus low belief (goats)

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in forced-choice ESP task performance and found that belief and performance were tightly coupled.^{31,32} Belief and performance on other laboratory tasks have not shown such a clear relationship.³³ In general, the effects of belief on performance are mixed and further research is needed to evaluate moderators and/or mediators.³⁴

Various other predictors such as psychopathology, gender, and personality have also been associated with EHEs. Clinical descriptions of schizotypy and Dissociative Identity Disorder include symptoms that could be considered an EHE in a normally functioning person.³⁵ People with EHEs compared to controls often have higher dissociative symptoms, although they do not reach pathological levels.^{36–40} Psychoticism has shown a marginally significant negative relationship with some laboratory tasks.⁴¹ Other studies show that belief scores correlate with proneness to schizophrenia, but schizotypy does not explain a majority of the variance in paranormal belief nor do symptoms reach clinically pathological levels.¹⁷ Gender may also play a role in EHEs. Women reported EHEs in greater numbers than men, specifically precognition, extrasensory perception, mystical experiences, telepathy and after-death communication²⁴ and in general, women have stronger belief than men for some EHEs,¹⁷ though not in all studies.⁴² Women are more likely to engage with different types of EHEs, such as consulting a horoscope, visiting a psychic or having had a prophetic dream.⁴³ Interestingly, one study evaluated gender roles of masculinity and femininity in addition to gender and found that while gender was not related to belief, masculinity was associated positively with both belief and experience.²⁸ Extraversion^{44,45} and openness^{33,46} show positive correlations to performance on various tasks while neuroticism has mixed results.^{34,41} Studies on personality factors and EHE belief have also been mixed^{34,47} with some finding positive correlations with extraversion⁴⁸ and neuroticism^{49,50} and others not finding any correlations.^{45,48,50}

Almost no studies have explored the role of occupational culture or scientific worldview in reported prevalence of EHEs. Opinions in the scientific community about EHEs are usually skeptical, often passionately so.^{51,52} A tempered view is rarer in the scientific community but does exist. A recent paper argued that “researchers should consider adopting a liberal criterion for entertaining anomalous cognition while maintaining a very strict criterion for the outright endorsement of its existence.”⁵³ Other scientists are open to the rigorous study of EHEs such as the Parapsychological Association within the American Association for the Advancement of Science, Division of Perceptual Studies at the University of Virginia School of Medicine, and a call for an open, informed study of all aspects of consciousness including EHEs endorsed by over 100 scientists and major university worldwide.⁵⁴

Few surveys have evaluated belief or prevalence of reported EHE among scientists and engineers. One of the few that addressed this question was a 1991 poll of National Academy of Sciences members. Only four percent of respondents believed in ESP (although 10% thought it was worth investigating).⁵⁵ Another study indicated that science students have weaker belief in EHEs as compared to non-science students.¹⁷ One might expect that these survey results are due to the analytic and rational thinking styles required by these professions; however, rational thinking preference does not seem to have a clear relationship with either EHE belief or reported experiences.^{34,56,57} On the other

hand, many studies have found that people with experiential-intuitive thinking style preference tend to have more EHEs and to attribute them to paranormal phenomena.^{34, 58} In addition to thinking style preferences, biases against such topics exist. For example, many college psychology textbooks uncritically dismiss EHE topics.⁵⁹ The fact that EHEs are not considered empirically attested to the satisfaction of the majority of the scientific establishment,¹⁷ plus long-standing academic taboos that restrict open discussion about these experiences,⁶⁰ and lack of research funding,⁶¹ likely conspire to discourage scientists and engineers from publicly expressing their beliefs about or describing personal EHEs.

The aim of this study was to evaluate the prevalence of EHEs among three categories of adults in the United States, and to investigate factors such as occupation, paranormal belief, mental health, and personality that might predict subjective EHE reports. Individuals in the three groups were randomly selected to receive an invitation to an anonymous survey. Those who decided to participate were self-selected. The first group was drawn from scientists and engineers, who we hypothesized would have the lowest belief and reported prevalence of EHEs. The second sample was from among members of the Institute of Noetic Sciences (IONS), who we hypothesized would have the highest belief and reported prevalence (we refer to this group as *enthusiasts*). The third sample was drawn from the general population, whose belief and experiences we hypothesized would likely be between the other two groups. We further hypothesized that higher levels of belief in EHEs would be correlated with higher reports of EHEs. Finally, we conducted exploratory analyses to assess the effects of potential predictors.

MATERIALS AND METHODS

Study participants were randomly sampled from three US email lists. The general population and science/engineering lists were obtained from the National Data Group (Omaha, NE), which maintains email contact information from various opt-in sources and routinely verifies that the emails are valid and active. The general population list consisted of 124,903 randomly selected adults, normally distributed in age and gender, and with racial and socioeconomic distributions reflecting the general population. The “science/engineering” list (thereafter noted as “scientist” for brevity) consisted of 124,210 randomly selected adults engaged in science or engineering occupations. Occupation categories listed by the National Data Group that were used to generate the initial email sample included Analyst, Chemical Analyst, Chemist, Chief Analyst (as it relates to a scientific laboratory), Computer/Systems Analyst, Engineer, Engineer/Aerospace, Engineer/Chemical, Engineer/Civil, Engineer/Electrical/Electronic, Engineer/Field, Engineer/Industrial, Engineer/Mechanical, Geologist, Lab Director, Physicist, Professor, Scientific Examiner, Scientist, and Statistician/Actuary. The enthusiasts list consisted of 4,989 adults randomly selected from a larger email list provided by IONS. The latter group was under-sampled because we anticipated a higher response rate from this list. Inclusion criteria in all cases were ≥ 18 years old, understanding and agreeing to the informed consent language, and completing the prevalence and frequency items on the survey.

Recruitment

All individuals were invited to participate via an email administered through SurveyMonkey (surveymonkey.com), which allows for HIPAA compliant data collection and provides detailed tracking of invitations and survey completion. The email subject was “Unique Human Experiences: How Common Are They?” The email text described how we obtained their email address, and the sentence, “Will you help us discover how common certain human experiences are? Please click *begin* to complete a 15-minute survey that will help us answer this question.” The study was approved by the IONS Institutional Review Board (approval number 03-14-17-102). Volunteers checked a box acknowledging that they had read the informed consent and understood the risks and benefits of participating in the study.

Measures

Measures taken in the survey included EHE prevalence and characteristics, potential predictors of EHEs, and demographics. Descriptions of the measures and the rationale for their use in this study are as follows:

Prevalence of EHEs: main outcome

The main focus of this study was to assess the prevalence of EHEs. Respondents were asked to report on whether they had experienced any of 25 EHEs (see Table 2 for the 25 items). Percentages were calculated by taking the number of participants endorsing each item and dividing by the total number of participants who responded. Endorsement of at least one EHE was defined as an occurrence.

The list of EHEs was formed from peer-reviewed and popular literature that was then evaluated by a panel of experts in the field of EHEs. Three items were introduced by Andrew Greeley in 1975 and have been included in other prevalence studies:^{23,62,63} one item each on mental communication, seeing at a distance, and contact with the dead. Some item definitions overlapped because there is no systematic nomenclature within the field. Terms such as paranormal, psychic, psi, extrasensory perception, etc., were not used in these questions to reduce the risk of bias. We tested the internal consistency of this 25-item EHE scale with the data collected in this study and found it to be reliable (Cronbach's $\alpha = 0.90$). We hypothesized *a priori* that the prevalence for at least one EHE item would be greatest for the enthusiasts, followed by the general population, and lastly by the scientists.

EHE characteristics

To characterize the EHEs in our study population, the total number of EHEs endorsed out of 25 was calculated as well as a total EHE score that incorporated both endorsement and frequency. The total EHE score was created by summing the endorsement binary variables (i.e. experienced item = 1, no experience = 0) combined with the frequency scores (Seldom – 1; Sometimes – 2, Often – 3, Nearly Always – 4) for each item. This sum results in a maximum possible score of 125 (25 items + 4 maximum frequency score for each item), which is then divided by 125 for ease of interpretation, providing a range 0-1). We hypothesized *a priori* that the number of EHEs

endorsed and the total EHE score would be greatest for the enthusiasts, followed by the general population, and lastly by the scientists.

In order to more fully understand EHEs and their characteristics, respondents who endorsed at least one EHE were asked if the experience happened in the last 30 days (binary variable), when they first had that experience (categorical), if they told anyone about it (binary), and if they were aware of any family members having had similar experiences (categorical). They were also asked “What impact have these experiences had on your life?” They responded by moving a slider anchored by “Very Negative” corresponding to a value of 0 on the left to “Very Positive” corresponding to a value of 100 on the right. These variables were collected as exploratory measures to further understand the characteristics of EHEs and thus, no *a priori* hypotheses were generated. They were also used as potential predictors of the total EHE score in the exploratory GLM analysis.

Potential predictors of EHEs

Paranormal belief, mental health, and personality were measured in the study and as potential predictors of the total EHE score in our exploratory GLM analysis.

Paranormal belief

An 18-item scale that included the Anomalous Experiences Inventory paranormal belief subscale,⁶⁴ three items from the Sheep–Goat Scale,⁶⁵ and three investigator-developed items on mind-body and energy healing, connection with sources from other dimensions of reality, and retrocausation. Respondents chose True (2 points), Uncertain (1 point), or False (0 points) regarding whether they believed in (without necessarily having experienced) each of the phenomena listed (points summed for total score; range 0–36). We tested the reliability of the 18-item scale using data collected in this study and found it to be reliable (Cronbach's $\alpha = 0.94$). We hypothesized *a priori* that the enthusiasts would have the highest paranormal belief followed by the general population, and then the scientists. We also hypothesized that paranormal belief would be positively correlated with the total EHE score.

Mental Health

Dissociation and psychotic symptoms as well as current use of psychotropic medications were measured to explore whether participants who reported EHEs might be suffering from psychopathology that could explain their experiences. Many EHEs are similar to symptoms present in psychiatric disorders, such as auditory or visual hallucinations or communication with non-physical entities. We assessed self-reported symptoms of dissociation and psychotic symptomology as compared to clinical cut-offs, and also if perception of EHEs were related to pathology. There were no *a priori* hypotheses generated for these mental health variables and they were used as potential predictors in our exploratory GLM analysis.

Dissociative symptoms were measured with the Dissociation Experiences Scale Taxon (DES-T). The DES-T is an eight-item scale where respondents indicate how frequently they experience each dissociative symptom in their daily life (e.g., 0%, 10%, . . . 100%) (Cronbach's $\alpha = 0.78$).⁶⁶ The DES-T score is the mean of the eight items.

Psychotic symptoms were measured with the Community Assessment of Psychic Experiences - Positive Scale (CAPE-P15). The CAPE-P15 is a self-report instrument that measures current frequency of positive psychotic-like experiences (Cronbach's $\alpha = 0.79$).⁶⁷ Each item uses a 4-point Likert scale from 0, 'never', through 'sometimes' and 'often', to 3, 'nearly always.' If participants endorsed a psychotic-like experience (at least 'sometimes'), they were also asked how distressed they were about the experience using a 4-point Likert scale from 0, 'not distressed', through 'a bit distressed' and 'quite distressed', to 3, 'very distressed', which produces a total score of 0–6.

Personality was measured with the Big Five Inventory-10 (BFI-10), which is a ten-item scale measuring extraversion, agreeableness, conscientiousness, neuroticism, and openness and retains BFI-10 scales' significant levels of reliability and validity compared to the longer 44-item version.⁶⁸ Each item is rated on a 5-point Likert scale ranging from "disagree strongly" to "agree strongly." Items within each category were averaged to derive category scores. There were no *a priori* hypotheses generated for personality.

Demographic variables

Demographics (age, gender, relationship status, annual household income, childhood and current religious/spiritual affiliations and importance) were collected to characterize the population of the study and determine equivalence of the groups. Group differences on these variables were evaluated and addressed through statistical means; namely, these variables were included in our general linear model (GLM) to account for any group differences. Science and engineering sub-categories (Physical, Life, Applied, Social sciences) were allocated to each respondent in that group based on their profession. There were no *a priori* hypotheses proposed for these demographic variables and they were used as covariates in our exploratory GLM analysis.

Sample size

The sample size required for statistical power was calculated with an estimated low-end prevalence of 10%¹⁸ and precision of 5% as recommended by Naing et al. for prevalence studies.⁶⁹ Assuming a confidence interval of 95% where the area of a normal distribution is within 1.96 standard deviations of the mean, the sample size required was at least 138 in each group.

Statistical analysis

General methods

For continuous variables, means and standard deviations were calculated by group, and group differences evaluated with analysis of variance. For binary and categorical variables, percentages by group were calculated and group differences evaluated with Pearson's chi-square test.

Correction for multiple comparisons

A conservative approach was taken to correct for multiple comparisons. All group comparisons and correlations for *a priori* and exploratory analyses were counted resulting in 58 items to be included in a Bonferroni correction (demographics – 8; mental health – 3; EHEs individual and prevalence items – 28; EHE characteristics and predictors – 11; correlations of total EHE score with impact and belief – 8). A Bonferroni multiple comparison correction was applied to α values designating $p = 0.00085$ as the cutoff for a significant result. An α value less than 0.05 was considered significant for exploratory/posthoc pairwise comparisons between groups.

Missing data

Missing values were present because participants were allowed to skip questions or quit the survey at any point. Analysis of missing values indicated that they were not systematic and were missing completely at random. Participants with missing values were not included in the GLM.

GLM analysis

An exploratory GLM used the following predictors to see what proportion of the variance was explained out of the total EHE score: group, personality, paranormal belief, dissociation score, psychotic score, family history of similar experiences, age of onset, impact of EHEs, and childhood and current religious/spiritual affiliations and importance.^{70, 71} These predictors were retained in the GLM if they were associated with $p \leq 0.05$.

The model retained the following variables regardless of their p -value because the groups had an unbalanced number of respondents and significant differences on these variables: gender, age, race, relationship status, education, and income. Retaining the demographic variables as covariates in the model factored out their contribution, thus addressing the argument that any total EHE score group difference might have been due to demographic variable group differences. We also examined interactions between group and all other independent variables to further control for specific group idiosyncrasies.

RESULTS

The results below are grouped by: (1) demographic variables characterizing the study population; (2) prevalence of EHEs; (3) EHE characteristics; and (4) potential predictors.

Demographic variables characterizing the study population

Twelve hundred and sixteen people started the survey and 899 completed it (Fig. 1).

Table 1 summarizes the demographic variables of the survey respondents. They were mostly older adults, Caucasian, female, well-educated, married, higher income, and were raised Christian but now identify themselves as Spiritual but not Religious. The average level of education for scientists was similar to the enthusiasts, both of which were higher than the general population. The scientists had a higher annual income and percentage in a

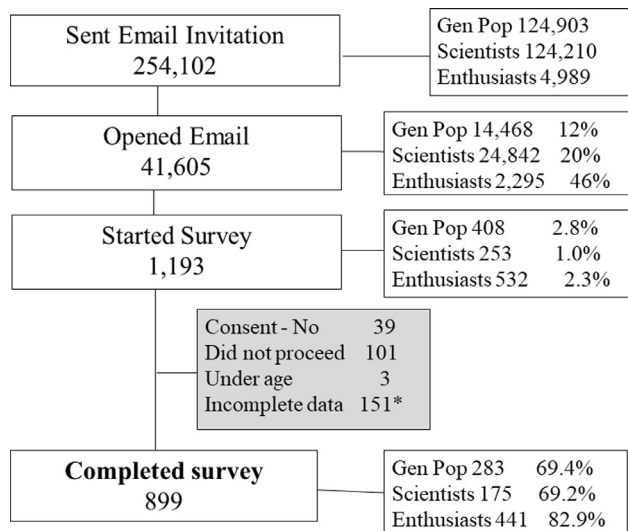


Fig. 1. Recruitment diagram. 899 participants completed the survey. 151* respondents (63 general population, 39 scientists, and 49 enthusiasts) began entering data into the survey but stopped before answering the EHE questions. There were no differences between these dropouts and those that completed the survey on variables listed in Table 1 except for gender (18% men vs. 11% women; $\chi^2 = 7.7$, $p = 0.005$).

relationship, were older, and included more men. The percentage distribution by science category was: 56.3% applied sciences (e.g. engineering, medicine, computer science, etc.); 5.2% life sciences (e.g. biology, zoology, botany); 20.1% physical sciences (e.g. physics, chemistry, geoscience); and 18.4% social sciences (e.g. psychology, education, business). In descending order of

the number of participants, these disciplines were represented: Medicine, Computer Science, Engineering, Education, Psychology, Chemistry, Aerospace, Environmental, Biology, Business, Physics, Biogenetics, Biogeography, Botany, Meteorology, Oceanography, Philosophy, and Physiology. The three groups had similar childhood religious/spiritual affiliations. For current religion/spirituality, the enthusiasts had a higher selection of “Spiritual but not Religious,” whereas the other two groups on average specified Christianity. The importance of childhood religion/spirituality reported by participants was not different between groups ($\chi^2(10) = 18.7$, $p = 0.04$) but the importance of current religion/spirituality was greater in the enthusiasts compared to the scientists and general population ($\chi^2(8) = 82.0$, $p < 0.0005$). Demographic variables were included in the GLM to take into account group differences and factor out their contribution (see Methods).

Prevalence of EHEs: main outcome

The enthusiasts had the highest percentage of respondents endorsing at least one experience. Post-hoc comparisons revealed that the scientists’ prevalence was lower than the enthusiasts but not different than the general population. The percent of respondents endorsing at least one EHE and the 25 EHEs individually, as well as statistics for comparisons across groups, are reported in Table 2.

The most endorsed EHEs were “Felt another person’s emotions” and “Just known something to be true or having a clear sensation or feeling of knowing something that you would otherwise have no way of knowing.” Eighteen of the 25 EHEs showed significant differences between groups with the enthusiasts having the highest percentages on all items as compared to the other two groups.

Table 1. Participant demographics by group

Factor	Level	General Population	Scientists	Enthusiasts	Statistics
Age, mean (SD)		55 (11)	62 (10)	56 (14)	$F(2,899) = 21.7$, $p < 0.0005^*$
Race	White/Caucasian	86.7%	86.3%	89.9%	$\chi^2(8) = 29.9$, $p < 0.0005^*$
	Asian/Pacific Islander	1.1%	2.9%	3.4%	
	Hispanic	5.2%	0.6%	4.6%	
	Black/African American	5.9%	6.9%	1.4%	
	Native American	1.1%	3.4%	0.7%	
Gender	Female	62.1%	40.3%	68.1%	$\chi^2(2) = 40.9$, $p < 0.0005^*$
Mean years of education (SD)		16 (3)	18 (2)	18 (3)	$F(2,899) = 61.4$, $p < 0.0005^*$
Income	\$0–49,999	23.3%	15.3%	36.7%	$\chi^2(4) = 38.0$, $p < 0.0005^*$
	\$50,000–99,999	38.2%	51.1%	34.7%	
	\$100,000 & up	38.5%	33.5%	28.6%	
Relationship status		65.7%	75.0%	47.8%	$\chi^2(2) = 46.5$, $p < 0.0005^*$
Childhood spirituality	Atheist	0.4%	1.2%	2.9%	$\chi^2(6) = 14.3$, $p < 0.03$
	Christian	91.2%	84.1%	84.4%	
	Spiritual but not religious	2.2%	2.4%	4.1%	
	Other	6.2%	12.4%	8.7%	
Current spirituality	Atheist	5.6%	4.2%	1.6%	$\chi^2(6) = 206.2$, $p < 0.0005^*$
	Christian	60.7%	55.2%	15.5%	
	Spiritual but not religious	24.0%	24.8%	66.1%	
	Other	9.7%	15.8%	16.7%	

Note: * = significant at Bonferroni corrected $\alpha = 0.00085$. Number of participants: General Population–283, Scientists–175, Enthusiasts – 441.

Table 2. Self-report endorsement of EHE by group, sorted by combined prevalence largest to smallest

Question Asked in Survey	General Population	Scientists	Enthusiasts	Pearson $\chi^2(2)$ or $F(2,897)$, <i>P</i> -value	All Groups
Endorsed \geq one experience	94.0% ^c	93.2% ^a	99.3% ^{a,c}	21.1, <0.0005*	96.4%
Mean number of experiences endorsed	7.7 (5.2) ^c	8.7 (5.6) ^a	13.1 (5.8) ^{a,c}	92.0, <0.0005*	10.5 (6.2)
Total EHE score (0–1.0)	.18 (.14) ^c	.21 (.16) ^a	.32 (.17) ^{a,c}	83.3, <0.0005*	.25 (.17)
7. Felt another person's emotions?	65.8% ^c	70.9% ^a	88.6% ^{a,c}	58.0, <0.0005*	78.0%
6. Just known something to be true or had a clear sensation or feeling of knowing something that you would otherwise have no way of knowing?	69.6% ^c	67.0% ^a	87.4% ^{a,c}	46.4, <0.0005*	77.8%
16. Known you were dreaming during your dream or been able to control your dreams?	61.5% ^c	63.6% ^a	78.7% ^{a,c}	29.1, <0.0005*	70.3%
25. Felt as though you were in touch with someone when they were far away from you? ^g	52.7% ^c	59.2% ^a	79.9% ^{a,c}	64.1, <0.0005*	67.2%
14. Received important information through your dreams?	43.1% ^{b,c}	59.4% ^{a,b}	73.9% ^{a,c}	69.1, <0.0005*	61.3%
10. Seen something in your mind's eye about an object, person, location, or physical event?	46.6% ^{b,c}	59.7% ^{a,b}	67.4% ^{a,c}	30.6, <0.0005*	59.3%
19. Known something about the future that you had no normal way to know?	47.3% ^c	48.0% ^a	69.2% ^{a,c}	42.9, <0.0005*	58.1%
12. Felt as though you were really in touch with someone who died? ^g	41.3% ^c	39.1% ^a	66.2% ^{a,c}	59.7, <0.0005*	53.1%
9. Smelled something that could not be explained by your physical surroundings?	48.2% ^c	44.6% ^a	59.3% ^{a,c}	14.6, 0.001	53.0%
1. Felt like you could hear, feel or communicate with animals beyond your normal five senses?	34.3% ^c	37.1% ^a	66.3% ^{a,c}	86.1, <0.0005*	50.5%
5. Heard something in your "inner ear" from or about an object, person, location, or physical event?	26.6% ^c	29.7% ^a	61.0% ^{a,c}	100.9, <0.0005*	44.1%
23. Been able to see a place, person or thing when you are not physically viewing it?	35.8% ^c	42.3%	50.2% ^c	14.8, 0.001	44.1%
2. Experienced your awareness traveling outside of your body?	20.2% ^c	27.0% ^a	60.4% ^{a,c}	131.3, <0.0005*	41.3%
24. Known information about past events or an individual's past experiences without any possible way of you knowing it?	35.2% ^c	43.4% ^a	41.8% ^{a,c}	36.0, <0.0005*	40.0%
8. Tasted something that was not physically present in your mouth?	28.3%	31.6%	49.0%	4.1, 0.13	39.1%
3. Seen colors or energy fields around people, places or things?	21.0% ^c	21.8% ^a	52.2% ^{a,c}	91.7, <0.0005*	36.4%
17. Felt like you knew how a tree or flower was feeling, or heard them speaking?	12.9% ^c	18.9% ^a	52.7% ^{a,c}	143.0, <0.0005*	33.6%
20. Received information about an object by touching it?	18.5% ^b	26.4% ^{a,b}	41.5% ^a	44.2, <0.0005*	31.3%
13. Received information about the land or earth without any traditional way of knowing the information?	15.4% ^c	20.0% ^a	42.4% ^{a,c}	69.4, <0.0005*	29.5%
18. Healed another person's illness with or without intending it?	11.4% ^c	15.0% ^a	32.9% ^{a,c}	51.8, <0.0005*	22.6%
	8.8% ^c	10.9% ^a	30.0% ^{a,c}	59.3, 0.002	19.6%

Table 2 (continued)

Question Asked in Survey	General Population	Scientists	Enthusiasts	Pearson $\chi^2(2)$ or $F(2,897)$, <i>P</i> -value	All Groups
21. Had a non-physical source from a different level or dimension of reality use your body as an instrument for communication?					
4. Had the experience of your hand writing information that your conscious mind was not aware of?	6.7% ^c	11.4% ^a	30.0% ^{a,c}	68.5, <0.0005*	19.0%
11. Seen events that happened at a great distance as they were happening? ^g	12.1% ^c	15.5%	21.2% ^c	10.2, 0.006	17.2%
15. Caused your body to float in the air for any period of time using only your mind?	7.8% ^c	10.9%	16.2% ^c	11.6, 0.003	12.5%
22. Created fire using only your concentration or will?	1.1%	0.0%	0.9%	1.8, 0.42	0.8%

Notes: * = significant at Bonferroni corrected $\alpha = 0.00085$. Number of participants: General Population – 283, Scientists – 175, Enthusiasts – 441. ^e = Greeley items. Post-hoc comparisons between ^ascientists and enthusiasts, ^bscientists and general population, ^cgeneral population and enthusiasts significantly different $p < 0.05$.

Post-hoc analyses revealed that group differences were driven mostly by differences between the enthusiasts and the other two groups. The scientists had higher values than the general population on 21 of the 25 items, three of which were significantly higher (“Received information about an object by touching it,” “Received important information through your dreams,” and “Seen something in your mind’s eye about an object, person, location, or physical event”). Also, there were no significant differences on any of the 25 items within the scientists between the science categories of Physical, Life, Applied, Social sciences (All $\chi^2 > 4.9$ and p ’s > 18).

“Felt another person’s emotions,” “Just known something to be true or having a clear sensation or feeling of knowing something that you would otherwise have no way of knowing,” and “Known you were dreaming during your dream or been able to control your dreams?” were in the top five endorsed EHEs for all three groups. “Felt as though you were in touch with someone when they were far away from you?” was in the top five endorsed for the general population and enthusiasts but not for the scientists. “Smelling something that could not be accounted for by physical surroundings” was in the top five endorsed for the

general population but not the others. “Receiving important information through your dreams” was in the top five endorsed by scientists and enthusiasts but not the general population. Finally, “Seen something in your mind’s eye about an object, person, location, or physical event” was in the top five endorsed for scientists but not for the other two groups.

EHE characteristics

The percentages, means and standard deviations, and statistics for the EHE characteristics are listed in Table 3. The enthusiasts had the greatest number of EHEs endorsed and total

EHE score. Post-hoc comparisons of these two measures revealed that the general population and scientists were significantly lower than the enthusiasts but were statistically the same in comparison to each other.

The same pattern with higher values for enthusiasts and similar lower values for the general population and scientists was found for “Happened in the last 30 days,” family members with similar experiences, told other people about their experiences, and personal impact of EHEs. The age EHE experiences began

Table 3. EHE characteristics

Factor	General Population	Scientists	Enthusiasts	Statistics
Happened last 30 days	39.6% ^c	41.6% ^a	66.9% ^{a,c}	$\chi^2(2) = 59.1, p < 0.0005^*$
Age started	Always - 15 yrs	51.2%	62.4%	$\chi^2(4) = 9.4, p = 0.05$
	16–45 yrs	38.0%	28.7%	
	46 yrs & older	9.8%	8.9%	
Family history	Yes	31.2% ^c	41.6% ^a	$\chi^2(4) = 142.3, p < 0.0005^*$
	No	14.0%	46.0%	
	Unknown	54.8%	12.4%	
Told anyone	70.0% ^c	69.6% ^a	88.9% ^{a,c}	$\chi^2(2) = 46.7, p < 0.0005^*$
Impact (0–100; 100 = very positive)	62.7 (17.7) ^c	64.9 (16.8) ^a	79.1(18.2) ^{a,c}	$F(2,833) = 80.2, p < 0.0005^*$

Note: * = significant at Bonferroni corrected $\alpha = 0.00085$. Number of participants: General Population – 283, Scientists – 175, Enthusiasts – 441. Post-hoc comparisons between ^ascientist and enthusiasts, ^bscientist and general population, ^cgeneral population and enthusiasts significantly different $p < 0.05$.

Table 4. Potential predictors

Factor	General Population	Scientists	Enthusiasts	Statistics
Paranormal belief	22.7 (8.8) ^c	23.0 (8.9)	30.8 (5.5) ^c	$F(2,769) = 116.2, p < 0.0005^*$
Dissociation experience scale	6.3 (10.7)	4.2 (6.3)	8.1 (11.8)	$F(2,772) = 6.6, p = 0.0014$
Psychotic symptoms total	6.2 (7.7)	5.6 (6.6)	6.4 (6.9)	$F(2,741) = 0.67, p = 0.51$
On Psychoactive medications	10.5%	11.9%	9.8%	$\chi^2(2) = 0.50, p = 0.78$
Personality				
Extraversion	3.2 (1.1)	3.2 (1.0)	3.1 (1.0)	$F(2,920) = .13, p = 0.88$
Agreeableness	2.4 (0.8)	2.3 (0.8)	2.2 (0.9)	$F(2,885) = 4.2, p = 0.02$
Conscientiousness	4.1 (0.9)	4.2 (0.7)	4.0 (0.8)	$F(2,889) = 4.1, p = 0.02$
Neuroticism	2.6 (1.1)	2.4 (1.0)	2.5 (1.0)	$F(2,890) = 1.9, p = 0.14$
Openness	3.6 (0.9) ^{b,c}	3.9 (0.9) ^{a,b}	4.1 (0.9) ^{a,c}	$F(2,889) = 31.0, p < 0.0005^*$

Notes: * = significant at Bonferroni corrected $\alpha = 0.00085$. Number of participants: General Population – 283, Scientists – 175, Enthusiasts – 441. Mean (standard deviation).

was the same across groups. Means, standard deviations, percentages endorsed and statistics for EHE characteristic variables are presented in Table 3.

Potential Predictors: paranormal belief, mental health, and personality

Paranormal belief was highest for the enthusiasts, followed by the general population and scientists who had similar values. Dissociation experiences, psychotic symptoms, and psychotropic medication use were statistically the same across all three groups. The Openness personality trait was different between groups (enthusiasts > scientists > general population), while Extraversion, Agreeableness, Conscientiousness and Neuroticism personality traits were not. The means and standard deviations or percentages endorsed, along with statistics evaluating group differences on potential predictors are listed in Table 4.

Relationship of Paranormal belief and impact with total EHE score

There was a positive Pearson correlation between the total EHE score and paranormal belief score $r = 0.61$ ($p < 0.0005$; $r^2 = 37.2\%$ of the variance explained) as we had hypothesized. The correlation was highest for the general population $r = 0.64$ ($p < 0.0005$; $r^2 = 41.0\%$) followed by scientists $r = 0.58$ ($p < 0.0005$; $r^2 = 33.6\%$) and then the enthusiasts $r = 0.47$ ($p < 0.0005$; $r^2 = 22.1\%$). These correlations differed ($z = 3.24$, $p = 0.0012$) between the general population and enthusiasts, but other group comparisons did not (i.e. scientists with general population or scientists with enthusiasts).

There was a positive Pearson correlation between the total EHE score and positive impact on the person's life $r = 0.46$ ($p < 0.0005$; $r^2 = 21.2\%$ variance explained). This correlation was highest for the scientists $r = 0.50$ ($p < 0.0005$; $r^2 = 24.6\%$) followed by enthusiasts $r = 0.35$ ($p < 0.0005$; $r^2 = 12.3\%$) and then the general population $r = 0.31$ ($p < 0.0005$; $r^2 = 9.9\%$). The scientists' correlations of EHE score and personal impact were different than the general population ($z = -2.36$, $p = 0.018$) and enthusiasts ($z = -2.36$, $p = 0.04$).

GLM Analysis

Table 5 shows the GLM statistics for total EHE score including the beta coefficient, t -value, significance, and 95% confidence interval for each variable in the model (covariate and predictors). The GLM predicted 55.7% of the variability of the total EHE

score ($F(21, 648) = 37.41$, $p < 0.0005$). Significant covariates included gender (female > male); age (older > younger); and relationship status (in relationship > no relationship). Significant predictors for the total EHE score were group assignment (general population < scientists < enthusiasts), higher paranormal belief; dissociation experiences; psychotic symptoms; and openness; lower neuroticism; positive impact on one's life; family members with similar experiences; and younger age when experiences started. None of the group interaction terms were retained in the model because they failed to reach significance, did not improve model diagnostics, and further decreased the power of the analysis. This also demonstrated that the group differences were not dependent on one of the other independent variables (i.e. gender, age, etc.). The GLM analysis also showed that the total EHE score group difference was not accounted for by demographic variable group differences, such as gender or age. The total EHE score group difference seems to be directly related to group membership.

DISCUSSION

In summary, this study found that prevalence of EHEs in all three groups were high with enthusiasts having the highest prevalence followed by scientists and the general population. The impact of EHEs on the respondents was positive. Paranormal belief was highest for the enthusiasts, followed by the general population and scientists who had similar values. Group assignment, higher paranormal belief; dissociation experiences; psychotic symptoms; and openness; lower neuroticism; positive impact on one's life; family members with similar experiences; and younger age when experiences started predicted the endorsement and frequency of EHEs after adjusting for demographic covariates.

Prevalence of EHEs: main outcome

All three groups reported a high prevalence of at least one EHE (94.0% general population, 93.2% scientists, 99.3% enthusiasts). Some of these high percentages are undoubtedly due to the question about "feeling another's emotions," which could be interpreted as conventional forms of empathy, or to the question about "having an innate knowing about something," which could be considered the definition of "intuition,"⁷²⁻⁷⁴ or to the question about "lucid dreaming." However, when these top three most common experiences were eliminated, the prevalence for endorsing at least one other EHE remained surprisingly high

Table 5. Summary of general linear model for total score.

Total EHE Score	Coefficient	Std Error	<i>t</i>	Sig	[95% CI]	
<i>Covariates</i>						
Gender	0.034	0.010	3.550	<0.0005	0.015	0.053
Age	0.002	0.000	4.340	<0.0005	0.001	0.002
Race-Asian/Pacific Islander	-0.010	0.031	-0.310	0.754	-0.071	0.051
Hispanic	-0.013	0.022	-0.600	0.549	-0.056	0.030
Black/African American	0.006	0.025	0.260	0.799	-0.042	0.054
Native American	0.067	0.036	1.870	0.062	-0.003	0.138
Relationship status	0.020	0.010	1.980	0.048	0.000	0.040
Education	-0.001	0.002	-0.400	0.692	-0.004	0.003
Income \$50,000-99,999	-0.019	0.013	-1.510	0.131	-0.044	0.006
\$100,000 & up	-0.022	0.012	-1.840	0.066	-0.045	0.001
<i>Predictors</i>						
Group	0.017	0.006	2.800	0.005	0.005	0.029
Paranormal beliefs	0.006	0.001	8.190	<0.0005	0.005	0.008
Dissociation experiences	0.004	0.000	8.150	<0.0005	0.003	0.005
Psychotic symptoms	0.004	0.001	5.300	<0.0005	0.003	0.006
Impact on one's life	0.001	0.000	4.280	<0.0005	0.001	0.002
Family history yes	0.046	0.013	3.470	0.001	0.020	0.071
Unknown	0.002	0.013	0.180	0.855	-0.023	0.028
Neuroticism	-0.014	0.004	-3.260	0.001	-0.023	-0.006
Openness	0.019	0.005	3.770	<0.0005	0.009	0.030
Age started 16-45 yrs old	-0.030	0.010	-2.980	0.003	-0.049	-0.010
46 and older	-0.051	0.017	-3.050	0.002	-0.085	-0.018
_cons	-0.213	0.045	-4.690	0.000	-0.302	-0.124

Notes: Reference categories: Race – Caucasian; Income - \$0–50,000; Family history – no family history; Age started - Always - 15 yrs old. Std error – standard error; Sig – *p*-value significance, CI – confidence interval.

(89.3% general population, 89.5% scientists, and 97.8% enthusiasts group). To take this one step further, information from dreams and “seen something in your mind’s eye about an object, person, location, or physical event,” which could be perceived as imagination, were also removed resulting in similar results (87.4% general population, 87.1% scientists, and 97.1% enthusiasts).

The enthusiasts had the highest prevalence and paranormal beliefs, as expected. We also hypothesized that the scientists would have the lowest prevalence and beliefs, but in fact they were essentially the same as the general population. There were also no EHE differences within the scientists based on science subcategory or specific discipline. Only “seen something in your mind’s eye about an object, person, location, or physical event”, “received important information through your dreams”, and “received information about an object by touching it” had significant post-hoc differences between the scientists and general population, with the scientists having higher prevalence than the general population. When comparing the top five EHEs, “felt as though you were in touch with someone when they were far away from you” was not present for the scientists but information from dreams was, perhaps reflecting the lack of plausibility from the current scientific paradigm for mind-to-mind communication but precedence of creative insights coming from dreams in well-respected scientists who made ground-breaking discoveries (i.e. Kukele and atomic structure of benzene).

These prevalence and belief results suggest that scientists and engineers have more EHEs and higher paranormal belief than is

commonly assumed. It may also be the case that these individuals represented a self-selected group that were more favorably inclined toward the survey content. However, the purpose of the survey was masked in the invitation, and terms within the survey were defined as “unique human experiences” and purposefully did not include terms like paranormal, psi, psychic, etc. Only 39 (25.9%) scientists who began the survey did not complete the experience items, compared to 63 (41.7%) participants from the general population and 49 (32.5%) enthusiasts. Thus, the scientists had the lowest percentage dropouts, lowering the possibility of self-selection bias. Also, respondents may have been retired scientists or engineers allowing them more time to respond to an online survey. Age was a significant covariate in the GLM with older people having slightly higher total EHE scores.

We were able to compare our prevalence results to other studies that used the Greeley questions (i.e., “Felt as though you were in touch with someone when they were far away from you”, “Seen events that happened at a great distance as they were happening”, “Felt as though you were really in touch with someone who died”).²⁵ For example, Haraldsson et al. conducted a large study in 13 European countries and the US using these questions (*N* = 18,607),²³ and they reported separate values for the US population. Our prevalence for “in touch with someone far away” was similar to those studies, our “seeing at a distance” responses were somewhat lower, and our “contact with the dead” responses were somewhat higher compared to the Haraldsson et al. US sample (Fig. 2). The Pew Research Center conducted a study (*N* = 2003) finding that 29% of US adults

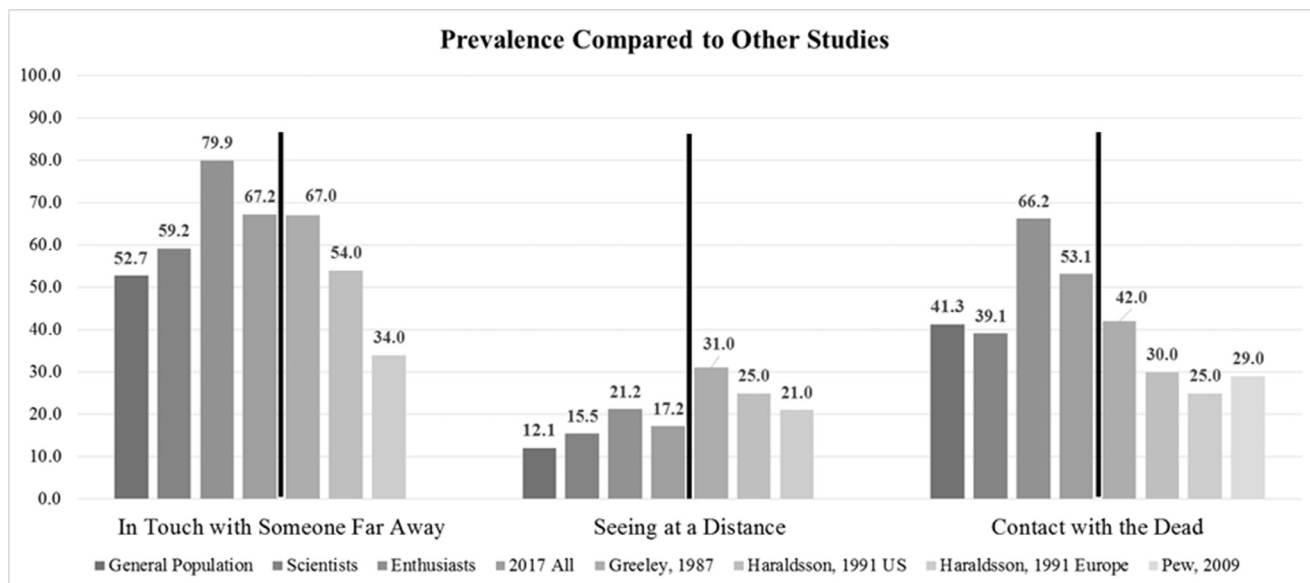


Fig. 2. Prevalence of Greeley items in the present survey as compared to previous surveys.

surveyed reported some perceived contact with the dead,⁶³ which was lower than our 53.1%.

The surveyed EHEs, which involve purported ways of knowing that transcend conventional boundaries of space and time, are experienced on a spectrum. On one side of the spectrum are two common, well-studied experiences that do not challenge existing paradigms: empathy⁷⁵ and intuition.⁷⁶ On the other side are experiences like sensing the future which have a growing body of supportive experimental evidence.^{77,78} Studies comparing “normal” human empathy, which is thought to incorporate conscious and nonconscious sensory cues, in contrast to exceptional empathetic connections that reportedly reach beyond the ordinary senses, would be useful in furthering our understanding of the relationship between anomalous and ordinary forms of information reception.

EHE characteristics

Scientists’ degree of sharing their EHEs with others was similar to the general population, which is surprising considering the skepticism expressed about these experiences within academia.⁷⁹ Perhaps the most important result of this study was the positive impact that these experiences had on the respondents’ lives. The total EHE score explained 21.2% of the variance of the positive impact score and was significantly correlated with it, demonstrating that as the frequency and number of different EHEs increased, so did the reported positive impact. These positive impact ratings may be useful in helping to discriminate between healthy and pathological responses to various EHEs.^{80, 81} The positive ratings are consistent with other studies that have shown that extraordinary or mystical experiences can have a lasting positive impact on people’s lives.^{1, 82, 83}

Most respondents (40.3%) reported that they were aware of family members who had shared similar experiences. Also, family history predicted EHE endorsement. There are anecdotal

reports that EHEs, like many psychological and physical traits, run in families.⁸⁴ There is also some field case study evidence supporting what may be a genetic factor underlying these beliefs and experiences.^{18, 85}

Potential predictors: paranormal belief, psychopathology, and personality

Higher paranormal belief scores were correlated with higher total EHE scores, as evidenced through a simple correlation, where the total EHE score explained 37.2% of the variance of belief, and also by the GLM. The correlation between total EHE scores was highest for the general population followed by the scientists and then the enthusiasts, reflecting that belief in EHEs is more important for the general population and scientists for them to endorse having an EHE, whereas the enthusiasts’ experiences were not as dependent on their belief in them.

Medication use across groups was similar and reflect a national age-adjusted average of 11.1% taking psychotropic medications.⁸⁶ Psychotic and dissociative symptoms were also similar across groups. Values were lower than clinical cutoffs for dissociation as described by Waller et al.⁸⁷ and lower than other populations studied such as healthy university students for psychotic symptoms.⁸⁸ Higher dissociation experiences and psychotic symptoms predicted higher EHE scores (although the mean values were below clinical cutoff for pathology). This could be interpreted as indicating that EHEs are in part due to psychiatric difficulties, but it could also be attributed to content overlap in items from the dissociation and psychotic symptom scales with EHEs. For example, item 8 on the dissociation scale is “Some people sometimes find that they hear voices inside their head which tell them to do things or comment on things that they are doing.” This overlaps with the EHE construct of “clairaudience” or “heard something in your “inner ear” from or about an object, person, location, or physical event.”

The enthusiasts scored higher on the personality dimension of openness, followed closely by the scientists. Increased openness predicted higher total EHEs in our GLM. This makes sense considering that a certain level of openness must exist for someone to acknowledge EHEs. Interestingly, while neuroticism was not different between groups, lower neuroticism predicted higher EHE scores. Individuals who score high on neuroticism are more likely than average to experience negative emotions like anxiety, worry, and fear, and to respond worse to stressors. Thus, it is possible that less concern with personal distress might allow for greater capacity to turn one's attention toward more existential experiences, or that high distress might interfere with openness to EHEs. It is also possible that EHEs could be related to shifts in personality. Personality traits can be modulated such as reduced neuroticism from meditation training⁸⁹ and increased openness from psilocybin.⁹⁰ Other studies on neuroticism, belief, and experiences are inconclusive and thus, our results contribute data for future meta-analyses evaluating neuroticism as a predictor of EHEs.

Demographic variables

Many of the demographic covariates we evaluated were different across groups and these differences were accounted for in our GLM. Racial background for our general population group mirrored national averages,⁹¹ but the scientists had fewer Hispanic respondents and a greater percentage of Black/African Americans and Native Americans. Historically, science and engineering professions in the US have been dominated by Caucasian men, so the greater diversity of race in our sample is notable.⁹² Race was not a significant covariate in the total EHE score.

Gender was also different across groups with the scientists having more men, reflecting historical trends in gender inequality. While women have reached parity with men in educational attainment in STEM professions, their employment still lags behind.⁹³ Our GLM showed gender as a borderline significant covariate, with women having higher total EHEs than men. This result aligns with Castro et al.'s study showing women reporting EHEs in greater numbers than men.²⁴

Relationship status was also different across groups with fewer enthusiasts being in a relationship. In the GLM, being in relationship and older was more predictive of a higher EHE score. Educational levels were significantly different across groups, with the enthusiasts and scientists having on average 2 years more education; education was a significant covariate in our GLM with lower education being more predictive of a higher EHE score.

Similarly, current religious and spiritual affiliation was different across groups with Christianity being the most endorsed religious affiliation, similar to the US general population. The shift to "Spiritual but not Religious," as most respondents' current endorsed religious/spiritual affiliation, has also been observed in large surveys on religion in the US.⁹⁴ Religious and spiritual affiliation and importance were not significant predictors of EHE and were removed from the GLM. This is interesting because one might expect religion/spiritual affiliation to influence EHEs. Some traditions such as esoteric Christian practices or Spiritualism may endorse some EHEs, but many traditional Christian

sects teach that such experiences are heretical or even demonic, and thus they may not be reported.⁹⁵

A number of limitations to the study should be considered when interpreting these results. We exceeded the sample size required by our power calculations, but the response rate for the study was lower than we would have preferred. Only 2.9% of the people who opened the email invitation started the survey, and of those 65% completed the survey. Like all prevalence studies, capturing a truly random sample of the target population is always a challenge because of self-selection at the collection level (e.g. people not answering their telephones, completing mailed surveys, or opening email invitations). The demographic results we obtained matched our expectations for the three target populations, but our results might be distorted by self-selection bias with people having a greater affinity or sympathy for these notions being more likely to complete the survey. This could have inflated the results despite the use of neutral language and the randomly selected samples who received the invitation.

The three groups also consisted of a different number of individuals. A balanced group distribution is not an assumption for chi-square analysis, but it is for the simple ANOVA used to analyze the continuous variables. Fortunately, the GLM analysis assessed the interaction between the different variables, factoring out their independent contributions in the different groups, and it confirmed the results found with the ANOVA. Therefore, the GLM was able to compensate for the fact that the groups were not balanced by number or by covariates. Finally, the survey was self-reported, which although anonymous still introduces potential bias in the validity of the responses.

In conclusion, our study suggests that various types of exceptional human experiences are highly prevalent not only among enthusiasts, but also among the general population, and scientists and engineers. Even experiences that could be termed "psychic" are reported by scientists and engineers to a surprisingly large degree, especially in light of academic bias against the existence and investigation of such experiences. Building upon the results of this study, future studies could focus on further classification of EHE types and who experiences them, qualitative research on scientists' primary reports of EHEs, and evaluating the impact of such experiences on people's lives, as well as factors that influence that impact.

It is possible that the experiences people report are the products of imagination, rather than verifiable experiences of extraordinary perception. It is also possible that these experiences point to unconventional sources of information that deserve further exploration. For scientists and engineers in particular, whose work relies on creative problem solving and generation of innovative ideas, it may be useful to entertain the broader notions of perception that could complement conventional methods of achieving insight.

Acknowledgments

This work was supported by the Ray Benton Foundation and the Federico and Elvia Faggini Foundation. We would also like to thank Amira Sagher and Fraser Fontane for their help with the project.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.explore.2018.05.002.

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