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Genetics of psychic ability - A pilot case-control exome sequencing study

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ABSTRACT

Introduction: It is commonly believed that psychic ability, like many mental and physical traits, runs in families. This suggests the presence of a genetic component. If such a component were found, it would constitute a biological marker of psychic ability and inform environmental or pharmacologic means of enhancing or suppressing this ability.
Methods: A case-control study design was used to evaluate differences between psychic cases and non-psychic controls. Over 3,000 candidates globally were screened through two online surveys to locate people who claimed they and other family members were psychic. Measures of relevance to the claimed abilities (e.g., absorption, empathy, schizotypy) were collected and based on those responses, individuals with indications of psychotic or delusional tendencies were excluded from further consideration. Eligible candidates were then interviewed and completed additional screening tests. Thirteen individuals were selected as the final "psychic cases," and ten age-, sex-, and ethnicity-matched individuals with no claims of psychic ability were selected as controls. DNA from the saliva of these 23 participants was subjected to whole-exome sequencing. Two independent bioinformatics analyses were blindly applied to the sequenced data, one focusing exclusively on protein-coding sequences and another that also included some adjacent noncoding sequences.
Results: Sequencing data were obtained for all samples, except for one in the control group that did not pass the quality controls and was not included in further analyses. After unblinding the datasets, none of the protein-coding sequences (i.e., exons) showed any variation that discriminated between cases and controls. However, a difference was observed in the intron (i.e., non-protein-coding region) adjacent to an exon in the TNRC18 gene (Trinucleotide Repeat-Containing Gene 18 Protein) on chromosome 7. This variation, an alteration of GG to GA, was found in 7 of 9 controls and was absent from all psychic cases.
Discussion: The most conservative interpretation of these results is that they result from random population sampling. However, when the results are considered in relation to other lines of evidence, the results are more provocative. Further research is justified to replicate and extend these findings.

Introduction

Many cognitive and perceptual abilities are associated with genetic factors.[1] An open question is whether or not extraordinary "psychic" abilities such as mind-to-mind communication (in the vernacular, *telepathy*),[2] knowledge of future events before they occur (*precognition*),[3] and perception of hidden or remote events (*clairvoyance*)[2,4–6] might also be associated with genetic factors. Evidence for the reality of such extraordinary abilities has been offered by multiple meta-analyses of experiments conducted over the past century, which demonstrate independent repeatability and robust statistical significance. These abilities are also more common than some might realize, possibly because of taboos that prevent people from openly discussing them. For example, a recent study found that over 85% of 899 respondents, including 175 scientists and engineers, had personally experienced at least one psychic phenomenon.[7]

Anecdotal evidence suggests that extraordinary manifestations of these abilities run in families. Few formal studies have evaluated the genetics of psychic abilities. Telepathy studies with identical and non-identical twins have found mixed evidence for greater concordance among identical versus non-identical twins on telepathy task performance.[8,9] Other case studies of families with data on up to four generations have been conducted.[10–14] The pattern of familial

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transmission in "second sight" has also been examined. This capacity is defined as "a special psychic ability believed to be a natural faculty of mind, regarded as an inborn gift by some and an affliction by others. . .Second sight implies that there are two forms of sight. One is normal sight and the other is the ability to have prophetic visions which occur spontaneously and are rarely directed at will."[14(p389)] Second sight is considered hereditary within the Scottish tradition.[15(p129)] A formal pedigree analysis of second sight found an autosomal dominant pattern of inheritance.[16] Other studies have evaluated the relationships between psychic abilities and the temporal lobe.[11,17–19] However, to our knowledge, no similar investigations have been conducted using modern genetics techniques.

The objective of this exploratory case-control study was to evaluate the possible relationships between genetics and psychic ability by examining differences in DNA samples from psychics compared to age-, sex-, and ethnically-matched non-psychic controls. Due to previously noted anecdotal evidence and pedigree study, we hypothesized that some genetic differences between the cases and controls would be found, but candidate genes were not predicted because of this study's exploratory nature.

Methods

Participants

Participants recruited for this study were high-functioning psychics and controls. All participants were English-speaking adults (>18 years old) and in good general health (as noted through self-report). Exclusions included being unable to understand English, having a chronic or acute health condition that precluded participation (as determined by the principal investigator), taking psychoactive medications, having a score greater than 21 on the Dissociative Experiences Scale-Taxon[20] and/or endorsing persecutory ideation or bizarre experiences (items 3, 4, 7, 10, or 12 on the CAPE-P15 (Community Assessment of Psychic Experiences-Positive scale).[21] Candidate cases were vetted for their psychic claims. Matched controls were required not to claim any psychic abilities or be aware of any family members who claimed such skills.

Study procedures

Candidates were recruited from members of the Institute of Noetic Sciences (~75,000), our associated social networks (~5000,000), and through personal contacts and recommendations worldwide. All study activities were approved by the Institute of Noetic Sciences Institutional Review Board (IRB# WAHH_2016_01).

Candidates completed two online surveys developed for this project on the HIPAA-compliant site, SurveyMonkey.com. The first survey began with consenting procedures and then collected demographics and health information, reported psychic skills of participants and family members, and exclusion questions (medications, dissociative symptoms,[20] psychotic symptoms[22]). Participants who passed the eligibility criteria were invited to complete a second survey. The second survey collected information on paranormal beliefs,[23,24] New Age beliefs,[25] depression and anxiety symptoms,[26] personality characteristics,[27] absorption,[28] empathy,[29] and sensory processing sensitivity.[30]

Participants who completed the second survey and consented to the remaining study activities then completed three online tasks designed to evaluate psychic abilities. The psychic performance tasks were located at the website www.GotPsi.org, which was designed and hosted by the Institute of Noetic Sciences. Participants were asked to complete 25 Card Test trials, 5 Long Remote Viewing trials, and 25 Location Task trials. These tasks evaluated variations of precognitive ability because the computer randomly selected the targets after the participant made their response.

Candidate psychic cases were further vetted with an additional Remote Viewing Task (RV Task #2) where psychic candidates were asked to "Please use psychic skills in whatever way works for you to (a) Tell me the color of the table I'm using for this experiment, and (b) Describe the object that is on the center of the table." The final step in the psychic case vetting was a structured telephone interview. The study staff reviewed the survey and task data and responses from the telephone interview. The final psychic cases were based on study staff consensus primarily based on participant accuracy and responses to a telephone interview. Selection of controls involved matching age, sex, and ethnicity to the psychic cases (see Supplemental Materials for details on the questionnaires, tasks, and the vetting interview).

The cases and controls were then sent saliva collection kits by mail (Oragene•DISCOVER OGR-500, DNA Genotek, Ontario, Canada). Saliva samples were collected, returned to the Institute of Noetic Sciences, and then forwarded to ORT Braude College in Karmiel, Israel on dry ice for processing, where the DNA was extracted (see Supplemental Materials for details).

Statistical analyses of nongenomic data

Variables are described with means and standard deviations for continuous variables and the number of people in each level for categorical variables. The non-parametric Wilcoxon rank-sum test was used to evaluate differences between cases and controls for continuous variables. A chi-square test was used to evaluate differences between cases and controls for categorical variables. Correction for multiple comparisons was performed using the False Discovery Rate algorithm at the $p = 0.05$ level.[31]

Genetic analyses

Two independent analyses were applied to the DNA data by separate parties, blinded to each other's results. The first analysis, conducted at ORT Braude College blindly compared potential variations in DNA sequences between the psychic and control cases and did not exclude intronic regions adjacent to exomes. The second analysis compared the 13 psychic samples to a large-scale public sequencing database and excluded consideration of intronic regions. The analysis was performed by an independent bioinformatics company (Strand Life Sciences, Bangalore, India). Significant variant analysis of the 13 psychic samples versus 125,748 controls from the Genome Aggregation Database (gnomAD; https://gnomad.broadinstitute.org/) was performed to find variants that are rare in the general population and controls in our study but are enriched in the psychic cases (see Supplemental materials for details of the genetic analysis).

Results

The flow of recruitment for the psychic cases is shown in Fig. 1. The selection process found that 0.4% of candidates apparently had psychic talent and were sufficiently motivated to participate in this study.

To age-, sex-, and ethnicity-match the psychic cases, controls were recruited after the psychic cases were selected. All of the psychic cases were female, Caucasian, and over the age of 37. To find suitable controls, from January through April 2017, a total of 628 people completed the same questionnaires as the psychic candidates. Twenty-two candidates were selected and sent the invitation to complete the same tasks the candidate psychics took. Of these candidates, 11 completed those tasks and agreed to proceed with the study. They were then sent saliva sample kits, of which ten were returned. The final participants for this case-control study included 13 psychic cases and ten controls.

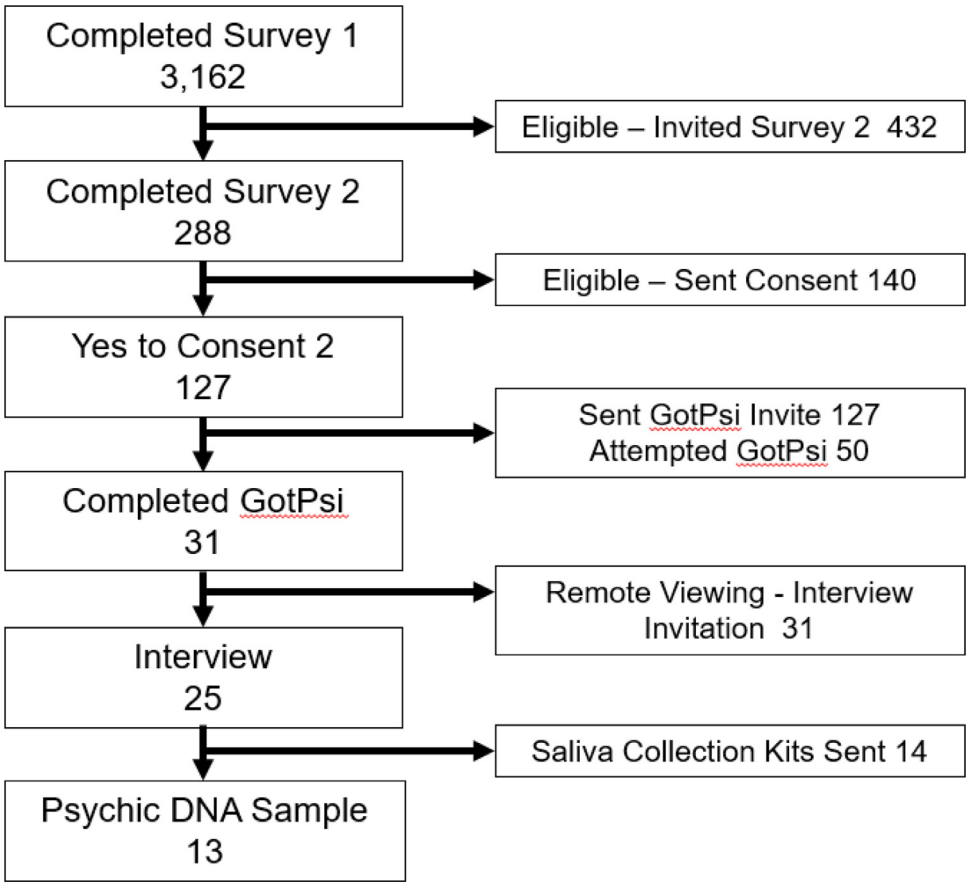

Fig. 1. Recruitment Flow for Psychic Cases.

Participant characteristics

Participant characteristics, mental health and personality scores are listed in Table 1. None were statistically different between groups after correction for multiple comparisons.

Psi-Related questionnaires and tasks

The psychic cases reported various ages when their abilities began, with "0–10 years old" being the most commonly reported answer (n = 9). The psychic cases endorsed the following abilities in descending order (number of psychic cases in parentheses after each ability): claircognizance (psychic "knowing," n = 13), clairempathy (psychic "feeling," 13), emotional healing (13), precognition, premonition and precognitive dreams (12), animal communication (11), clairvoyance (11), mediumship (11), telepathy (11), astral projection (10), aura reading (10), clairaudience (10), clairsentience (10), lucid dreaming (10), channeling (8), clairalience (8), nature empath (8), remote viewing (8), physical healing (7), retrocognition (7), psychometry (6), geomancy (5), psychokinesis (4), automatic writing (3), levitation (1), and psychic surgery (1). Clairgustance and pyrokinesis were not endorsed. On average, cases endorsed 9.5 ± 8.9 abilities.

Twelve cases listed relatives with similar abilities. Biological mother, father, and siblings were listed, as were grandfather, grandmother, aunt(s), uncle(s), and first cousin on the mother's side. "Other" was also listed as a familial category with no additional information collected. No relatives on the father's side were endorsed besides the biological father. Eighty-four percent of the familial abilities noted were shared by the cases. The psychic cases' scores on paranormal beliefs, New Age beliefs, high sensitivity, and absorption were significantly higher than controls (Table 2).

The cases' performance was better than controls on most tasks, although this difference only reached statistical significance on the Remote Viewing test (Table 3).

Through the vetting process, 31 psychic candidates were invited to complete an additional remote viewing task, of which 25 responded. The remote viewing answers were scored by table color and object shape, color, and category (score range 0–4). One person received a score of 3, five people received a 2, five people a score of 1, and 15 people received a score of 0. Finally, these same 25 candidates completed a one-on-one structured phone interview with a research assistant, which took place between January 10 and 18, 2017.

Comparison of psychic cases to control DNA data

DNA data were obtained for 13 psychic samples and ten control samples. One control sample did not pass a quality control test and was not included in the analysis. The Samtools analysis comparing the psychic cases with the controls found no significant differences when probing protein-coding sequences. However, probing intronic DNA adjacent to coding regions in exomes did find one non-coding region with a variation from the wild-type DNA sequence in 7 of the 9 control samples that was identical in all case samples and matched the sequence most commonly found in humans (i.e., wild-type). The variant was a modification from GG to GA in the intron region of the TNRC18 gene (Trinucleotide Repeat-Containing Gene 18 Protein) on chromosome 7 (rs117910193 position 5,401,412).

Comparison of psychic cases to a large-scale public sequencing database

No significant results were found when comparing psychic samples with general population samples obtained from a large-scale

Table 1
Participant characteristics.

Measure	Cases (n = 13)Mean (SD) or n	Controls (n = 10)Mean (SD) or n	Z or $X2$	p-value
Age	55.4 (12.1)	59.1 (13.1)	−0.67	0.49
Country				
United States	10	9	1.69	0.64
Canada	1	1		
United Kingdom	1	0		
France	1	0		
Education	17.0 (2.7)	17.8 (2.4)	−0.78	0.44
Income			0.30	0.86
0-$75,000	6	6		
$76,000−$150,000	4	3		
>$150,000	2	1		
In Relationship	6	7	1.31	0.25
Childhood Spiritual Affiliation			2.20	0.53
Christian	10	8		
Jewish	1	0		
Spiritual but not religious	1	2		
None	1	0		
Current Spiritual Affiliation			7.81	0.17
Christian	0	1		
Jewish	2	0		
Spiritual but not religious	8	7		
Buddhist	0	1		
Agnostic	0	1		
Other	3	1		
Mental Health				
Dissociative Symptoms	6.3 (5.1)	2.3 (5.2)	2.90	0.004
Psychotic symptoms	0.2 (0.1)	0.1 (0.2)	2.54	0.01
Depression	1.0 (0.9)	0.7 (0.7)	0.74	0.46
Anxiety	0.6 (0.9)	0.2 (0.4)	1.15	0.25
Personality				
Extraversion	3.92 (1.89)	2.85 (2.08)	1.58	0.13
Agreeableness	2.38 (0.98)	2.3 (0.98)	0.19	0.85
Conscientiousness	5.35 (1.43)	6.78 (0.36)	−2.72	0.007
Neuroticism	2.62 (1.37)	1.95 (1.19)	1.26	0.21
Openness	6.31 (0.78)	5.15 (1.25)	2.45	0.014

Notes: The p-values listed above are unadjusted. None of these comparisons remained significant at the p = 0.05 level after correction for multiple comparisons.[31] z = statistic for Wilcoxon rank-sum non-parametric test; X^2 = statistic for chi-square test for categorical variables.

Table 2
Psi-related questionnaires for psychic cases and controls.

Measure	Cases (n = 13)	Controls (n = 10)	z	p-value
Paranormal Beliefs				
Paranormal Belief Scale	4.3 (0.8)	3.7 (1)	1.41	0.16
Australian Sheep-Goat	31.2 (3.8)	10 (4.9)	4.04	0.0001*
New Age Beliefs	4.9 (0.6)	3.5 (1.4)	2.48	0.013*
Absorption	26 (4.6)	8.4 (4.6)	3.98	0.0001*
Empathy	51.2 (7.5)	45.4 (7.7)	2.15	0.03*
Sensory Processing Sensitivity	5.2 (0.8)	3.3 (0.8)	3.16	0.002*

Notes: The p-values listed above are unadjusted. Those marked with * are significant at the 0.05 level after correction for multiple comparisons. z = statistic for Wilcoxon non-parametric test.

Table 3
Online Psi Tasks for psychic cases and controls.

Measure	Cases (n = 13)	Controls (n = 10)	z	p-value
Card Task	0.20 (0.1)	0.19 (0.1)	0.44	0.66
Remote Viewing	56.4 (9.7)	46.5 (15.7)	2.05	0.04
Location Task	−0.005 (0.2)	−0.133 (0.2)	1.80	0.07

Notes: The p-values listed above are unadjusted. None of the p-values remained significant after correction for multiple comparisons. z = statistic for Wilcoxon signed-rank non-parametric test; In the online psi tests, higher scores indicated better performance in the Card task and Remote Viewing task, and lower scores were better for the Location task.

Table 4
Results of weighted least-squares regression (Type 1 Sum of Squares). .

Parameter	Type 1 SS	Df	B	Mean Square	F	p
Christianity YBP	92.99	1	−0.057	92.99	4.89	0.046
Log-transformed BSI	111.36	1	0.612	111.36	5.86	0.031
Interaction YBP*lnBSI	0.077	1	0.027	0.08	0.044	0.950
Error	247.16	13		19.01		
Total	451.58	16				

Notes: Duration of contact with Christianity (scaled as years before present [YBP] which was natural log transformed due to potential non-normality), biological state index (BSI), and the interaction between the two are regressed hierarchically against the population/country level percent variant alleles (expressed as a percentage of the whole allele population). Percentage of Christians is used as the weighting term. N = 16 countries. Model: Type 1 SS = 204.422, df = 3, Mean square = 68.141, F = 3.584, Adjusted R^2 = 0.326, p = 0.044.

public sequencing database. This analysis followed standard practice and excluded consideration of intronic regions.

Discussion

Vetting procedures

The process of recruiting and identifying the candidate psychics was designed with multiple steps to only include those who were motivated, psychologically well-grounded, and claimed psychic traits that many observed in their family members. Persons making frivolous claims or those with delusional or psychotic tendencies were filtered through this process. Given the limitations in resources and our

global search process, our multi-step procedure could not be said to have conclusively established psychic ability in each candidate. However, it did provide confidence that as a group, the selected cases matched the required personality and subjective reports of psychic ability and showed enhanced performance on actual psi tasks.

The psychics' performance was better than controls on most psychic tasks, although these differences did not reach statistical significance after correction for multiple comparisons. The lack of significance was likely due to the small number of participants. That is, the performance tests were not powered to detect differences. Despite these constraints, these tasks were useful in discriminating among the specific talents we were interested in between our cases and controls.

Despite positive self-report of psychic abilities, many candidate psychics reported that the online tasks did not adequately capture their particular set of skills. This is a known limitation in devising scientific tests of psychic abilities. We nevertheless encouraged the candidates to do the best they could, not only to gather performance data but also to provide a way to assess their motivation to participate in the study. Future selection studies would benefit from a broader range of vetting tasks administered in the laboratory and online. Such tasks would ideally be selected to be more aligned with each candidate's specific claims. However, developing a validated suite of such tests would not be a trivial undertaking, nor would it be inexpensive to administer. Vetting could also include real-world examples of their abilities (e.g., evidential information from client readings).

Recruiting controls and matching cases

The process of finding matched non-psychic controls proved to be more challenging than anticipated. It was surprisingly difficult to find women who did not claim any psychic ability in themselves or their family members. Nevertheless, we could match cases and controls on age, sex, ethnicity, and other important demographic, mental health, and personality indices. While there were undoubtedly other variables that we did not assess that may have played a role in genetic differences, the measures we did assess were successfully matched.

Participants' skills and characteristics

The most commonly endorsed skills were claircognizance (the ability to understand or know something without any direct evidence or reasoning process), clairempathy (the ability to feel emotions of another person or non-physical entity), and emotional healing. As a group, this set of skills falls into a class that might be labeled "exceptional empathy." Few existing experimental tasks have attempted to measure such claimed abilities objectively. Perhaps the closest category is experiments that measure unconscious physiological reactions in one person to the distant intentions of another person, referred to in the vernacular as the "feeling of being stared at."[32–34]

Due to the study's exploratory nature, no selection was attempted for specific types of claimed psychic abilities. It seems unlikely that the same genetic component or networks generate all psychic abilities, so our small sample's heterogeneity may have precluded the observation of more robust genetic differences. Future studies could include comparisons between specific types of psychic abilities.

In general, people who claim psychic experiences tend to score higher on empathy scales than controls,[35,36] and we observed the same trend in this study. We also observed increased sensory processing sensitivity levels in our cases, as reported in previous studies.[12,13,37] Sensory processing refers to sensitivity to stimuli, deep processing of information, and higher degrees of emotional and physiological reactivity[30] that some believe may have served some evolutionary benefit for humans.[38] Others suppose the opposite because hypersensitivity of the nervous system can lead to immune system disorders,[39] which in the long term could be detrimental to survival.

The psychic cases scored significantly higher than the controls on paranormal beliefs. This is also expected, as multiple studies have reported that people who have paranormal experiences consistently score higher on paranormal beliefs.[7,40,41] Likewise, trait absorption was higher in the psychic cases, again as reported in other studies.[12,37,40] Absorption refers to the inclination to have the totality of one's attention absorbed in a task or stimulus and has also been associated with psychic abilities.[28,40]

Cross-Cultural sociogenetic analysis

The variant of interest identified in this pilot study is located in the intronic region adjacent to the TNRC18 gene. Due to its proximity, it might be involved in regulating that gene's expression. TNRC18 is highly expressed throughout the body, including in the brain. Gene ontology annotations indicate that the gene product has multiple functions, including chromatin binding and transcription regulatory region sequence-specific DNA binding.

The variant is generally quite common in the populations sampled by the 1000 genomes (www.1000 genomes.org) and genome aggregation consortium (https://gnomad.broadinstitute.org/variant/7−5401412-G-A?d). The common wild-type allele, found in all of our psychic cases, is present in >90% of the individuals comprising these populations. The alternate allele found in the controls is relatively rarer. It was found to be present in approximately 10% of the European/Ashkenazi Jewish population. Thus, this finding may simply be an artifact of the small cohort size. On the other hand, if validated, these preliminary data would be highly provocative. Indeed, evaluating cross-population variability in the wild-type to alternate allele ratios may determine the presence of cross-cultural sociogenetic factors that could predict this variation in line with the hypothesized impact of these alleles on psychic functioning.[42]

For example, one cross-cultural sociogenetic hypothesis that potentially explains the observed variation is that the rise, spread, and prevalence of Christianity in the Early to Middle Ages may have contributed to the reduction of the wild-type variant across populations. Christianity has been historically associated with an extraordinary degree of cross-cultural success, both in terms of the extent of its spread and temporal persistence across populations, relative to other religious creeds. The historical spread of "Western Church" Christianity, or Roman Catholicism, measured using an indicator of historical Church exposure, was found to be responsible for psychocultural variation among contemporary Western populations, including low rates of consanguineous mating, high rates of monogamous marriage, and individualism.[43] This would be consistent with the action of culture-gene co-evolutionary selection pressures stemming from the historical (and contemporary) tendency for Christianity to favor these sorts of behavioral and reproductive patterns. Christianity also strongly proscribes mystical and psychic experiences, such as mediumship, outside of a limited range of contexts (e.g., monasticism in some cases). Thus, as part of this broader psycho-cultural "syndrome," Christian cultural values, once established, may have historically attenuated the fitness of those prone to these and other sorts of psychic experiences (i.e., wild-type carriers). Conversely, the alternate allele carriers' fitness (controls) may have been enhanced.

Another hypothesis is that relaxed negative selection against deleterious (loss of function) mutations, stemming primarily from modernization and its sequelae, may have promoted the alternate allele among economically and technologically advanced populations. This might have reduced the expression of psychic ability in these populations since mutation accumulation can be expected to result in a gradual loss of both mental and physical adaptations.[44]

We tested the potential validity of these two hypotheses using genome consortium data to yield information on cross-country

population variant frequency differences. The information was hierarchically regressed against cross-country population measures of both relaxed negative selection (selection against deleterious alleles) and also the duration of contact with Christianity. The interaction between these two variables was also estimated. The current percentage of Christians in each country was used as a weighting term in this regression.

Relaxation of negative selection

A variable measuring the intensity of relaxation of negative selection was obtained in the form of the Biological State Index (BSI).[45,46] This variable measures the opportunity for negative mortality selection to act as the probability that a randomly selected individual from a population will not survive through the entirety of their reproductively relevant years (i.e., up to age 50). A higher BSI value indicates a greater probability of survival, and thus a lower opportunity for negative mortality selection to act, as more people survive long enough to have the opportunity to fully participate in reproduction. Countries with high BSI values usually have greater levels of modernization, including lower rates of infant and child mortality and fertility, higher levels of access to health care, and greater industrialization. All of these features would have contributed to increased survival and opportunity for reproductive participation because deleterious variants would historically have proven to be more lethal without these scientific and social advances (e.g., mutations that predispose towards diabetes would have been lethal prior to the advent of insulin therapy). Critically, it is assumed that the opportunity for negative mortality selection serves as a proxy measure of negative selection, although such an association does not necessarily obtain. These data were sourced from supplementary material published as part of You and Henneberg (2018).[47]

Cross-country population differences

Using data from both the 1000 Genomes consortium and Gnomad,[48] we computed the wild-type to alternate allele ratios for 16 country populations. Data on the amount of time since the first introduction of Christianity in these countries was compiled from various sources, including *A World History of Christianity*.[49] This variable was scaled in terms of years before present to first recorded contact with Christianity (yielding a negative value). Christianity's current prevalence in these countries was also included as a weighting term in the regression model because the duration of contact with Christianity is not in and of itself sufficient to capture the success of this religion. For example, in some countries (e.g., China), there is a long Christian mission history but very little success in terms of spread. These data were sourced from *The CIA World Factbook*.[50]

A weighted least-squares (Type 1 Sum of Squares) regression analysis was then conducted using the population percentage of derived variant carriers as the dependent variable. The years since initial contact with Christianity was entered first, followed by the BSI variable, followed by the interaction between the two. All variables were normalized (i.e., *z*-transformed by setting the mean for each variable at 0 and the standard deviation at 1) prior to entry into the regression, allowing for the recovery of one additional model degree of freedom (intercept-free regression; see Supplemental Materials for analysis details). The results of this model are presented in Table 4.

The regression indicates that the duration of contact with Christianity is a weak predictor of the prevalence of the alternate allele. Net of this, the BSI is a stronger predictor of the prevalence of the alternate allele (controls), suggesting that the alternate form is most prevalent where negative selection has weakened to the greatest degree. There is no interaction between the two predictors, so they have independent effects on the percentage of derived alleles. Variance inflation factors (a standard test for multicollinearity) were below 10 for each predictor indicating acceptable levels of multicollinearity.[51]

The finding of cross-cultural sociogenetic correlates of the TNRC18 gene allele is suggestive of selection pressure, possibly mediated by culture-gene co-evolution and modernization. That countries with a longer duration of contact with Christianity and weaker negative selection have greater prevalence of the alternate-allele (controls) is consistent with the expectation that Christianity might have enhanced the fitness of alternate-allele carriers (controls) compared to wild-type carriers (cases). Of course, this cannot be taken as evidence that the wild-type determines psychic ability.

More broadly, the finding that the wild-type allele is generally much more common than the alternate allele has certain implications, if indeed this variant is associated with expressions of psychic ability of one sort or another. This distribution of alleles suggests that the prevalence of "low grade" psychic ability might be quite widespread. This would be consistent with self-report data on anomalous experiences among non-clinical populations, suggesting that experiences potentially consistent with the operation of psychic abilities might be "typical" of many people's everyday lived experience (e.g., purported premonitions, instances of telepathy).[52] The idea that most people have psychic abilities at some unconscious or low conscious level has been proposed by others.[53,54] These preliminary findings could be interpreted as lending support to this notion. Among those with psychic abilities, only extreme psychic talent is likely to be quite rare. The total absence of psychic ability might, in fact, be a relatively rare phenotype, given that the alternate allele is found in so few people worldwide yet is present in 7 of the 9 controls.

These cross-cultural sociogenetic relationships, while tentative, provide grounds for further exploration of the wild-type candidate allele in future research.

Future directions

A case-control design was deemed an appropriate basis for detecting potential genetic variants for psychic ability, given that prior familial studies of manifestations of psychic ability, such as "second sight," suggest a predominantly non-additive, specifically Mendelian autosomal dominant mode of genetic transmission.[16]

The structure of individual differences in certain other psychic abilities exhibits a pattern that is also consistent with a non-additive genetic architecture. Specifically, Varvoglis and Bancel (2016) found that two individuals had large individual effect sizes and contributed over 80% of the total high-low deviation in a sample of 91 individuals in a large-scale study of micro-psychokinesis (i.e., the mental influence of small-scale physical systems).[57] This suggests that while low-level psychic ability may be common, exceptional or specific types of psychic ability might be an "extreme" phenotype, with a possible genetic basis in unusual "emergenic" (i.e., larger than the sum of their parts) combinations of non-additively interacting genetic variants.

The possibility that certain manifestations of psychic ability might act in a more graded fashion must also be kept in mind. In these cases, the genetic trait architecture may be more dependent upon genes with additive (i.e., individually small, cumulatively large) effects.

To further explore the genetic contribution to psychic abilities, a large genome-wide association study could be performed to look for the effects of additive genetic variants. With a sufficiently well-powered study, coupled with an improved measurement model that examines both parametric and non-parametric variation in psychic abilities, and enough genetic resolution, it might be possible to screen for both rare variants (i.e., mutations with minor allele frequencies of <0.01) and non-additive variants with smaller effects. It may be possible to identify a range of genomic loci associated with psychic abilities using methods developed for elucidating the genetic contribution of other central-nervous-system-associated traits (e.g.,

depression, bipolar disorder, and anxiety). It is intriguing to speculate that, like recently described polygenic risk scores for various phenotypes,[58] it may eventually be possible to calculate a similar "psychic predisposition" or "risk" score, depending on the future results of genome-wide association studies.

Identifying those with extraordinary psychic talent for genotyping purposes would be another important avenue of research. Such individuals might yield a much clearer contrast relative to controls than we could obtain using the current case-control study design.

Finally, the possibility of historically recent declines in the frequency of extreme manifestations of "psychic" ability, as has been noted by some researchers,[55,56] being linked to genetic changes in human populations, could be explored via comparisons involving historical and modern genomes.

Implications

The identification of genes involved in psychic abilities has the potential to yield clues about their distribution within the general population and also their evolutionary origins. Such a finding may also have clinical value because it may help inform the development of pharmacological or environmental interventions to enhance or suppress such abilities, and clinical and performance applications could be used. Enhancing these abilities could augment decision-making in many contexts, stimulate creativity in art and science, and improve diagnosis of disease, insofar as these faculties and activities may be partly dependent on, or enhanced by, psychic ability.[59] For example, perhaps telepathic communication could be developed for individuals living with communication disabilities, such as aphasia or cerebral palsy. On the other hand, suppressing these abilities might alleviate psychotic symptoms in some individuals diagnosed with schizophrenia, insofar as "disordered" psychic manifestations may be a risk factor in these individuals.[60]

Ethical considerations are of the utmost importance when considering possible applications of these results. Paramount is the potential risk associated with gene therapies, particularly when engineering genes may affect future generations.[61] Fortunately, recent advances in gene-therapy technologies provide strategies to mitigate these hazards. For example, gene-therapy methods have been developed that deliver a time-limited effect on gene expression, such as RNA, plasmid, or naked DNA-based technologies, that do not integrate into the chromosomes.[62]

Conclusions

In summary, this case-control study did not yield significant results when probing coding sequences in DNA. However, the study did identify a noncoding variant that was largely restricted to non-psychic controls. A cross-cultural sociogenetic exploration of the variant revealed a significant relationship between the relaxation of negative selection and the spread of Christianity, consistent with the idea that these factors have influenced allele distribution between populations in ways possibly consistent with the alleles having effects on the target phenotype. The critical next step is to replicate and extend the results of this study.

Authors' contribution

Helané Wahbeh - Funding acquisition, Methodology, Project administration, Investigation, Data curation, Analysis Writing – original draft preparation, Review & editing. Dean Radin - Conceptualization, Funding acquisition, Methodology, Data curation, Analysis Writing – original draft preparation, Review & editing. Garret Yount - Funding acquisition, Methodology, Writing – original draft preparation, Review & editing. Michael A. Woodley of Menie - Formal analysis, Writing – original draft preparation, Review & editing. Matthew A. Sarraf - Formal Analysis, Review & editing. Marcela V. Karpuj - Sample and library preparation, Whole exome sequencing, Formal Analysis, Writing – original draft preparation, Writing – review & editing.

Declaration of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.explore.2021.02.014.

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