

あなたの性格についてのアンケート

このアンケートは、ご自身の性格や考え方、日ごろの習慣に関するものです。

各項目について、「全くあてはまらない」を0、「非常にあてはまる」を5としたとき、あてはまる程度の数字の1つに○をつけてください。

		全くあてはまらない				非常にあてはまる	
例	買い物で商品を選ぶときに、長い時間迷ってしまう	0	1	②	3	4	5
1	人にお世話になったときは、はっきりと感謝の気持ちを伝える	0	1	2	3	4	5
2	辛い時に、これが将来自分のプラスになると思って前向きに取り組む	0	1	2	3	4	5
3	日常、家族や近所の人に自分から挨拶をしている	0	1	2	3	4	5
4	辛い時に、くよくよ考えないように努力する	0	1	2	3	4	5
5	日頃、自分から声をかけて集団をまとめることが多い	0	1	2	3	4	5
6	何をすべきか悩むとき、いくつかの選択肢を比較する	0	1	2	3	4	5
7	日頃、新しい知識・技術・考え方を身に付ける機会を持つようにしている	0	1	2	3	4	5
8	困っている人を見ると放っておけない	0	1	2	3	4	5
9	人として従うべき道や教養を認識している	0	1	2	3	4	5
10	言いたいことはその場で言ってしまう	0	1	2	3	4	5
11	頑固で、自分の意思を通す	0	1	2	3	4	5
12	問題を解決するために、まず自分から動く	0	1	2	3	4	5
13	日頃、気分転換やストレス解消のための習慣を欠かさない	0	1	2	3	4	5
14	問題解決のためには、自分から関係者を集めて話し合いをする	0	1	2	3	4	5
15	人から頼られたり感謝されたりするのが好きである	0	1	2	3	4	5
16	自分が生きている、生かされている、ことを意識している	0	1	2	3	4	5

— アンケートは以上です。ご協力ありがとうございました —

実験者使用欄	記入年月日	ID	性別	年齢
	20 . .		男・女	

災害を生きる力の8因子 — その認知・脳基盤と計測ツール —

杉浦 元亮

東北大学 加齢医学研究所／災害科学国際研究所 〒980-8575 宮城県仙台市青葉区星陵町 4-1

E-mail: sugiura@tohoku.ac.jp

あらまし 「災害を生きる力」は災害を生き抜く際に有利に働く個人特性（性格・考え方・習慣）であり、東日本大震災の被災者を対象とした大規模調査から「気持ちを整える力」「問題に対応する力」「人を思いやる力」「きちんと生活する力」「人生を意味づける力」「人をまとめる力」「生活を充実させる力」「信念を貫く力」の8因子が抽出された。現在基礎研究として各因子の客観的行動指標、既存の個人特性概念との関係、集団ダイナミクス、脳内の情報処理過程の検討を進めている。また災害教育の現場では、質問紙を効果評価ツールやコンテンツとして活用し、成果を上げている。今後多分野の研究者・現場実践家の参集による融合研究分野の確立が待たれる。

キーワード 災害教育, 質問紙, 心理学, 脳科学

1. はじめに：災害を生きる力とは？

同じ状況に置かれても、それをどう認識・判断し、行動に結びつけるかは人それぞれである。こういった認知の個人差がその人の性格や考え方、日頃の習慣などの個人特性として表出されている。災害の状況においては、こういった個人特性が、様々な危機の回避や困難の克服の成否に影響する。

我々は2011年の東日本大震災の被災者としてこのことを実感した。残念なことに18,000人を超える死者の中には津波警報を受けて適切に避難していれば助かった人が数多く含まれる。避難所では劣悪な生活環境で日々憔悴を深める人々が数多くいた一方で、協力と工夫で非日常を楽しむ人々や人脈や情報技術を駆使して外部からの援助を呼び込む者もいた。その後の復興の過程でも、個人の生活再建や、自治体による合意形成や復興計画の優劣には、関連する個人の特性が大きく影響した。

我々は災害を生き抜く際に有利に働く個人特性を「災害を生きる力」と名付けた。災害には、発災から応急対応、復興や次の災害への備えに至るまで、多様な状況が存在し、そこで求められる生きる力も多様である。この複雑な関係性の中から、災害を生きる力の主要な因子を整理し、その計測技術を開発すること、またこれを各因子の脳内認知処理レベルでの基礎的理解から人材育成等の社会技術化にわたる融合研究分野の開拓につなげること、が本研究の目標である。

1.1. 災害対応における本研究の意義

東日本大震災は未曾有の地震・津波・原子力複合災害であり、被災地域の経済的背景と相まって復興の困難さを現在も示し続けている。これを契機として、防災の考え方の国際的趨勢は、対象とする「災害の質」を想定可能な単一災害から予測不能な複合災害へ、また対象とする「災害のフェーズ」を発災・応急時対応

から復興へ、と拡大しつつある。2015年3月の第3回防災世界会議で採択された仙台防災枠組み2015-2030[1]で「マルチハザード」「より良い復興“build back better”」が強調されているのもこの視野拡大を反映する。

災害を生きる力の研究は、この防災の視野拡大を受けた防災教育の課題に応えるものである(図1)。従来の防災教育は、想定される災害への備えや発災時・応急時対応の知識の普及を目的としていた。その重要性は何ら損なわれることはないが、この考え方だけでは現在の防災の視野拡大には対応できない。

予測不能な複合災害への対応や地域固有のより良い復興を、教育の面からサポートするには、多様な状況・文脈に柔軟・創造的に対応するため、多面的な力を持った人を育てる発想が必要である。このとき、育てるべき人物像の具体的な指標となるのが災害を生きる力である。

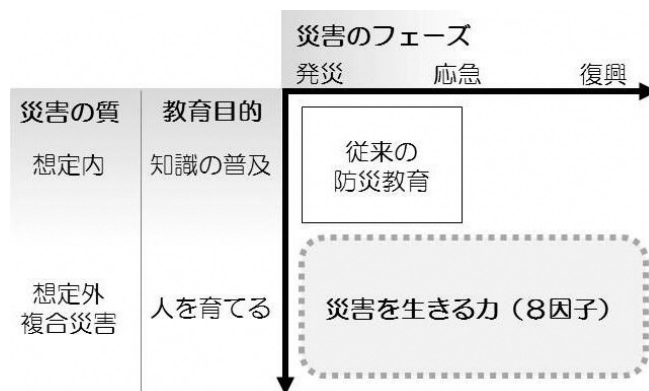


図1 防災の視野拡大と「災害を生きる力」の位置づけ

1.2. 一般教育的意義～なぜ「生きる力」か

災害を生きる力が意味を持つのが、狭義の自然災害の状況のみであるとは、むしろ考えがたい。人が人生

の様々な状況で危機を回避し、困難を克服するための能力を身につけさせるのが学校教育であるとすれば、そこで求める能力と災害を生きる力とは大きく重なるはずである。

この視点は「変化の激しいこれからの時代を生き抜く子供たち」に何が必要かを議論した 1996 年の中央教育審議会（中教審）の問題設定とも重なると思われる。中教審答申の生きる力の定義「自ら考え、主体的に判断し、行動し、よりよく問題を解決する資質や能力であり、また、自らを律しつつ、他人とともに協調し、他人を思いやる心や感動する心など、豊かな人間性である…」[2]は、そのまま災害を生きる力の定義と説明されても違和感がない。実はこの視点は東日本大震災の最中、本研究の構想時点から存在したものであり、研究の課題名に含まれる「生きる力」の名は中教審答申から拝借したものである。

災害状況に適応的な個人特性と一般教育目標との共通性に着目するこのような考え方は、決して珍しいものではない。例えば米国の教育心理学者 Al Siebert も、2001 年の米国 WTC テロ事件(9.11)を含む数多くの災害の生存者にインタビューを重ね、災害対応適者に特徴的な性格特性“Survivor Personality”を提案、従前の学校教育の見直しを提言している[3]。

1.3. 災害を生きる力の実証的研究

災害を生きる力とは何なのか。災害状況に適応的な個人特性については、これまでの実証的研究は被災者の Post-traumatic Stress Disorder (PTSD)への脆弱性に関する研究に集中している[4]。他により一般的な災害被害を指標にした研究も少数存在するが[5]、いずれにしても災害の多様な文脈や、個人特性の多様な側面を広範に扱ってはいない。一方で災害（あるいは人生）の幅広い文脈における適応性については、Al Siebert を始め定性的な論にとどまる。

本研究では災害を生きる力の主要な要素を、東日本大震災の被災者の実体験に基づいた見解の中から客観的な方法で抽出し、質問紙尺度を構築した。このような試みはこれまで世界中にも類を見ない。

2. 災害を生きる力の 8 因子

災害を生きる力の質問紙尺度構築についてはすでに詳細に報告済みである[6]。2012 年度冬に被災者 78 名を対象に、発災から約 2 年後の復興期までの間に経験した危機回避・困難克服の体験についてインタビューを行い、避難所生活・復興過程の困難克服に、個人の性格・考え方・習慣がどのように貢献したかについて、聞き取り調査をおこなった。様々な生きる力が発揮された状況を抽出し、クロス集計・コレスポンディング分析を行った結果、発災直後の危機回避文脈と、

復旧・復興の困難克服文脈で、貢献していた生きる力が質的・量的に異なることを見出した[7]。2013 年度冬に、生きる力に関する聞き取り調査対象者の見解を設問項目としてまとめ、震災時の行動・経験に関する設問と併せ、1412 名を対象とした質問紙調査を行った。その結果、災害を生きる力は 8 因子に集約され、その大部分で実際の震災時行動・経験との関係が確認された[6]。

以下、各因子について概説する。災害のフェーズで比較的早い時期（発災時）に重要性が高いと考えられる因子から順に並べた。F 1～F 8 の略号は因子分析で抽出された順番を示すもので、因子の意味や重要性とは無関係である。各因子の名称は質問紙尺度を構成する設問と先行心理学知見を元に解釈した結果である（今後の研究進展によって変更の可能性がある）。震災時行動・経験との関係については現在公表済みの地震の揺れを感じた際の迅速な津波避難や、避難所での問題解決、心身の健康との関係[5]についてのみ整理する。

2.1. 気持ちを整える力 (F6 感情制御)

「辛い時に、くよくよ考えないように努力する」「何かあったときに、慌てず冷静でいられるよう心掛ける」他、計 4 つの設問で構成される。この因子の得点は地震の揺れを感じた際の迅速な津波避難や、避難所での問題解決や心身の健康と関係していた。

2.2. 問題に対応する力 (F2 問題解決)

「何をすべきか悩むとき、いくつかの選択肢を比較する」「問題を解決するために、まず自分から動く」他、計 5 つの設問で構成される。この因子の得点は避難所での問題解決と関係していた。

2.3. 人を思いやる力 (F3 愛他性)

「人から頼られたり感謝されるのが好きである」「困っている人を見ると放っておけない」他、計 5 つの設問で構成される。この因子の得点も避難所での問題解決と関係していた。また避難時に他者を助ける行動とも関連が見られている（未公表データ）。

2.4. きちんと生活する力 (F5 エチケツ)

「日常、家族や近所の人に自分から挨拶をしている」「日頃、なるべく自分のことは自分でしている」他、計 3 つの設問で構成される。この因子の得点と避難時の共助の精神的側面との間に関係が見られている（未公表データ）。

2.5. 人生を意味づける力 (F7 自己超越)

「自分が生きている、生かされている、ことを意識している」「社会の中で自分が果たすべき役割を認識している」他、計 4 つの設問で構成される。この因子の得点と避難時に他者を助ける行動に関連が見られている（未公表データ）。

2.6. 人をまとめる力 (F1 リーダーシップ)

「問題解決のためには、自分から関係者を集めて話し合いをする」「人の心を動かす、気のきいた言葉が口から出てくる」他、計5つの設問で構成される。この因子の得点は震災後の心の健康と関係していた。また避難時に他者への声がけ行動とも関連が見られている(未公表データ)。

2.7. 生活を充実させる力 (F8 能動的健康)

「日頃、気分転換やストレス解消のための習慣を欠かさない」「日頃、新しい知識・技術・考え方を身に付ける機会を持つようにしている」他、計3つの設問で構成される。この因子の得点は震災後の心身の健康と関係していた。また避難時に他者への声がけ行動とも関連が見られている(未公表データ)。

2.8. 信念を貫く力 (F4 頑固さ)

「頑固で、自分の意思を通す」「自分の好きなもの、やりたいことに対する欲が強い」他、計5つの設問で構成される。この因子の得点は震災後の身体的健康と関係していた。また住宅再建の進捗とも関連が見られている(未公表データ)。

3. 基礎研究

本研究では、災害を生きる力の各因子について、基礎学術的な理解を深め、人材育成等の社会技術化応用研究の基盤を整える。これに向けて現状で4つの課題がある。まず1つめに各因子の客観的な行動指標を開拓すること、2つめに様々な心理学関連領域ですでに扱われてきた個人特性概念との関係を検証すること、3つめにこれら個人特性が集団での適応的反応に結びつくダイナミクスを検討することである。そして4つめに、これらの検討課題をより根源的なレベルで統合的な理解に結びつけるために、各因子について脳内の情報処理過程の検討を行う。

3.1. 客観的行動指標の開拓

これまで各因子との関係が示された震災時行動・経験はその大部分が主観的な自己申告であり、「社会的望ましさ」などの主観的バイアスの影響が想定される。より実証的な評価のためには、客観的な行動指標が望ましいことはいままでもない。

このための取り組みとして、実験室行動実験や災害を模した訓練の枠組みに、生きる力質問紙計測を取り入れ、参加者のパフォーマンスと各因子の関連を検証する研究を始めている。すでに、大学生約30名を対象に実験室で問題解決課題(図2)を行わせ、解決に要した時間への各因子の得点の効果や、いくつかの実験条件(難易度、タイムプレッシャー等)との交互作用を検証した。その結果、気持ちを整える力(F6)や問題に対応する力(F2)と実験条件の交互作用が有

意であることが示されている[8]。これは東日本大震災被災者に対する質問紙調査で見られた、避難所での問題解決とこれらの因子との関係を支持するものである。

3.2. 既存の個人特性概念との関係の検証

個人特性と状況への適応性の関係は、様々な心理関連学術領域において中心的なテーマの1つである。例えば、性格心理学や社会心理学はもちろんのこと、経済学の諸領域や組織・経営心理、人間工学などでも人間の個人特性が様々な行動パフォーマンスにどう影響するかが検討されている。災害を生きる力の各因子をこれらの既存知見を比較することで、各因子に関する基礎的理解が急速に進むとともに、今後様々な関連領域との融合研究基盤が整備されると期待される。

幅広い関連領域の文献調査には多大な時間がかかるが、すでにいくつかの因子について既存個人特性概念との共通性が見いだされている。例えば、人をまとめる力(F1)は主に組織心理学で着目されている「政治的スキル(political skill)」[9]と概念的に重なることが期待される。両概念の共通点は設問項目の類似性のみならず、一見意外な精神的な健康への好影響といった属性にも及ぶ。こういった興味深い関係を見だし、議論を共有することで関連学術領域との融合を広げてゆきたい。

3.3. 集団ダイナミクスの検討

災害を生きる力として抽出された8因子の中には、個人としてのサバイバルのみならず、集団としてのサバイバルを含意した因子が含まれる(人を思いやる力、人をまとめる力、等)。実際に東日本大震災における共助に関わる行動・経験との関係も示されている(未公表データ)。しかし、これら個人の特性がどのように集団としてのサバイバルに結びつくのか、そのプロセスについては、災害はもちろんのことそれ以外の文脈においても研究は少ない。

この課題に関する予備的なデータとして、8つの因子と東日本大震災における共助に関わる行動・経験との関係から興味深い知見も得られている。例えば避難時の共助行動の内容について詳細に分析を行うと、他者を助ける行動と関連の見られる因子(人を思いやる力、人生を意味づける力)と他者への声がけ行動と関連の見られる因子(人をまとめる力、生活を充実させる力)は異なることが見て取れる(未発表データ)。今後様々な研究領域と協働しながら、各因子がどのような過程で集団としての適応的反応に貢献するのか、そのメカニズムを明らかにする研究を進めていきたい。

3.4. 脳内処理過程の解明

どのような学術的知見を持って各因子の本質的な理解とみなすかは哲学的な問題であるが、認知神経科学的な研究知見はその1つの見解となりうるであろう。

各因子を、ある文脈における知覚・評価・判断・行動の脳内情報処理プロセスの個人差に還元できれば、少なくとも各因子の言語的定義のあいまいさ・恣意性が回避できる。脳計測実験の枠組みに持ち込むことで、客観的行動指標との関係づけも容易になるし、既存の個人特性概念に関わる脳科学知見とも照合しやすくなる。近年進展の著しい社会脳科学の成果は集団ダイナミクスの説明にも援用が期待される。

典型的には、健常被験者を対象に危機回避と困難克服場面を模した実験課題を MRI 装置内で実施させ脳活動を計測する。事前に質問紙で計測した被験者の生きる力因子得点と脳活動が相関する領域を探索し、抽出された領域に関する先行神経科学知見に基づいて、各生きる力因子がどのような文脈でどのような脳内情報処理プロセスで説明されるのか、推測することが出来る(図2)。

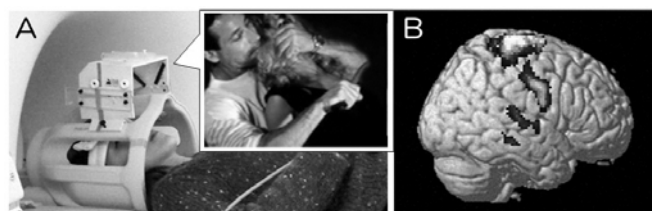


図2 機能的MRIを用いた脳活動計測実験例。A：健常大学生被験者が不快な画像を提示されているときの脳活動を計測。B：気持ちを整える力(F6)と脳活動の負相関が感覚情報処理領域に同定され、この因子が感覚情報処理レベルと制御プロセスで説明される可能性が示された(未発表データ)。

4. 質問紙の現場応用実践

防災教育の現場で、教育プログラム(授業・訓練)前後で質問紙を用いると、参加者の災害を生きる力の変化を評価することが出来る。また、災害対応の現場では、災害対応組織の構成にあたり、災害を生きる力の得点を参考にすることが可能かもしれない。このような災害を生きる力質問紙の現場応用実践は、基礎研究と平行して実施してゆくことで相乗効果が期待できる。基礎研究は現場における質問紙因子得点のより深く適切な解釈を可能にし、現場応用実践から得られた質的・量的データが基礎研究の新たな課題や研究技術を開拓する。現場応用実践の状況を以下概説する。

4.1. 2種類の質問紙

オリジナルの災害を生きる質問紙は「日頃～」といった設問文言に代表されるように、回答者が自身の「現在」として思いをはせる過去の時間的な範囲について評価を求める。従って、この質問紙で得点が短期間に変化することはあまり自然ではなく、例えば半日や1時間といった防災の授業の前後で教育効果を検証する

ためには使いにくい。そこで我々は短期間で変化する側面を計測できるように「状態質問紙」を開発した。これはオリジナル質問紙の文言を変更して、各設問について重要性の意識(～ことは重要である vs. 重要でない)と自信(～ことに自信がある vs. 自信がない)を計測するようにしたものである。この状態質問紙の導入によって防災授業や訓練などの教育効果評価の目的で幅広い現場での応用が可能となった。一方オリジナルの「特性質問紙」には妥当性が学術的に検証済みである[6]という圧倒的な強みがあり、例えば群間比較(例：プログラム実施群 vs. 対照群)や、3ヶ月間といった長期間での変化を評価するケースなど、使用が適切な現場では依然こちらが推奨される。

4.2. 教育効果の評価ツールとしての活用

災害を生きる力質問紙(状態質問紙あるいは特性質問紙)はすでに様々な学校(中学校・高校・大学)、自治体、NPOで主に防災教育プログラム(授業・訓練)の教育効果評価にご活用を頂いている[10,11]。この種の(確立された成績評価テストの存在しない)教育プログラムの効果評価は、これまでどうしても質的な評価(感想自由記述など)に頼らざるを得なかった。災害を生きる力質問紙を導入頂いた現場には、何かしらの量的な評価が期待されており、いずれもこの期待に対して応えることが出来たと認識している。もちろん量的な評価をただけでは評価「ツール」とは呼べない。その評価を教育プログラムに改善に繋げるなど、評価が「活用される」展開が望まれる。そのために、様々な現場で様々なデータ分析方法を検討しながら、現在評価ツールとしての有効性を模索中である。

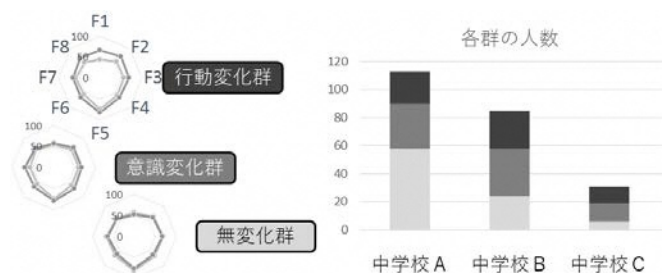


図3 教育効果の評価ツールとしての活用例。3つの中学校での個別の取り組みの成果を比較。得点変化パターンで全中学の生徒を3群に分けたところ、無変化群の存在が大規模校での課題であることが浮かび上がった。

最近の比較的先進的な成果として、某市での特性質問紙活用例を示す(図3)。3つの中学校(A～C)では学校固有の教育プログラムを実施しており、その教育効果を評価するために実施期間の前後3ヶ月で8因子の得点変化を計測した。得点の平均変化はおおむね

A < B < Cであったが、全生徒の得点変化パターンを群分けして検討すると、平均得点変化の違いは無反応群（得点の前後変化が見られない群）の割合で説明できることがわかった。3 中学では生徒の数が A > B > C であり、A・B の学校ではグループ学習を取り入れざるを得ない。もともとやる気のある生徒とない生徒との間で効果に差が出てしまうグループ学習の弱点が露呈したものと考えられた。

4.3. 防災教育コンテンツとしての活用

これは研究開始当初は想定していなかった質問紙活用法であるが、防災授業の中で質問紙をコンテンツとして使う取り組みも展開中である。生徒は授業の中で質問紙に回答し、その場で自己採点を行う。授業ではその点数について発表しあったり、比較したり、関連する意見を述べたり、様々な活用を行う。すでにこれまで多数の実践例があり、少なくとも授業が盛り上がることは間違いない。これは各生徒が主体的に授業に参加できる点が大いと思われる。また、質問紙には「災害」への言及が一切ない一方で、災害時に求められる力や考え方について多面的に、選りすぐりの言葉で表現されているため、ある種、究極の被災体験記になっている点も見逃せないであろう。すなわち「生きる力」の意識化ツールとしての活用と言えるかもしれない。これらの教育効果やそのプロセスについても今後実証的な検証を進めてゆく。

5. むすび：今後の研究展開

このように基礎研究、応用実践とも、多少の進展は見られるが、災害を生きる力の理念が学術、社会貢献として結実するまでの道としてはまだ端緒に着いたばかりである。残念ながら現状では基礎研究を進める上でマンパワー・資金的な制約が大きく、応用実践の現場も限定されており、研究進展のスピードアップに向けた方策が期待される。

今後は基礎研究、応用実践それぞれを進めてゆくのみならず、両者を融合した研究分野の開拓を意識的に進めてゆく必要がある。既存の研究分野や文系理系の枠を超えた多分野の研究者、また災害教育や災害対応の専門家・現場実践家が一堂に会し、基礎研究や現場実践の新しい方向性・方法について議論・検討する。それによって災害を生きる力の理念と具体的な将来性をより広く周知し、学問分野として確立することで多くの研究者の参加と資金的なサポートも期待できる。

さらに、これまで主に国内で進めてきた研究を国際展開することも重要である。本研究の内容国際的な学会や研究会で発表すると、これまで欧米中心に進められてきた災害科学の中で、アジアからボトムアップに立ち上げられた新しい研究として注目を浴びる。今後

質問紙の多言語対応などを皮切りに、国際共同研究にも積極的に取り組みたい。

以上、いずれの方向への展開も、関連分野の研究者および現場の方々との協働なしには実現はあり得ない。本研究の趣旨に賛同して頂ける方々からのお力添えを切に乞う次第である。

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Article

Psychological Processes and Personality Factors for an Appropriate Tsunami Evacuation

Motoaki Sugiura ^{1,2,*}, Shosuke Sato ¹, Rui Nouchi ², Akio Honda ³, Ryo Ishibashi ⁴, Tsuneyuki Abe ⁵, Toshiaki Muramoto ¹ and Fumihiko Imamura ¹

¹ International Research Institute of Disaster Science, Tohoku University, Sendai 980-8572, Japan

² Institute of Development, Aging and Cancer, Tohoku University, Sendai 980-8575, Japan

³ Faculty of Informatics, Shizuoka Institute of Science and Technology, Fukuroi 437-8555, Japan

⁴ Smart-Aging Research Center, Tohoku University, Sendai 980-8575, Japan

⁵ Graduate School of Arts and Letters, Tohoku University, Sendai 980-8576, Japan

* Correspondence: sugiura@tohoku.ac.jp

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Abstract: Although various factors related to the environment (perception of earthquake and warning) and knowledge (oral history and scientific knowledge) affect individual differences in evacuation behavior before a tsunami, the roles of psychological processes and personality factors in such relationships are poorly understood. We addressed this research gap by applying hierarchical regression analyses to survey data from survivors of the 2011 Tohoku earthquake and tsunami disaster. Previously-known contributions of environmental and knowledge factors were mostly replaced by the perception of a tsunami risk and threat, and these background factors were shown to facilitate these psychological processes. Several personality factors directly contributed to voluntary evacuation, particularly leadership and active well-being in the Power to Live scale, and extraversion in the Big Five scale. Overall, these results seem to indicate the need for formulating two independent targets when developing measures to enhance appropriate tsunami evacuation. Facilitation of the perception of a tsunami risk and threat may basically be pursued by developing existing approaches. Addressing the relevant personality factors may be done in a broader context of disaster or general education and sociocultural activities.

Keywords: earthquake; education; normalcy bias; personality; risk perception; threat perception; tsunami evacuation; warning

1. Introduction

A massive tsunami event is often preceded by an environmental cue, such as an earthquake, or by an official warning, which allows people to protect themselves by evacuating to high ground. Nevertheless, the response varies across individuals [1–6]. In an early quantitative survey of the 1960 Hawaiian tsunami, only 41% of residents who recognized the warning responded [7]. In the recent 2011 Tohoku (or Great East Japan) earthquake and tsunami disaster, which we address in this study, only 57% of residents evacuated immediately, even after experiencing the severe earthquake and hearing the rapid warning [8]. The importance of educational measures to promote rapid evacuation has been increasingly emphasized, given the limited effectiveness of structural countermeasures for a massive tsunami [9,10].

Psychological processes seem key to understanding such individual differences, but remain poorly understood. The importance of the perception of a hazardous risk and threat has repeatedly been suggested for evacuation behavior in the event of a tsunami [1–6], but empirical data are missing. In addition, although dissociable contributions of risk and threat perception have been demonstrated for

other types of disasters, such as hurricanes, tornadoes, earthquakes, and volcanoes [11–15], the issue is yet to be addressed for a tsunami. Understanding the likelihood of a hazard (risk perception) is a cognitive process considered less effective in triggering a protective response than affective responses (e.g., fear, worry, or preoccupation) or the expectation of personal consequences of a hazard (threat perception). This concept is not necessarily applicable to a tsunami evacuation, given its unique characteristics, including in terms of the time period and methods available [6]. The contribution of a mnemonic process to the decision to evacuate is also of interest. Empirical surveys have demonstrated a positive association between past experience of a tsunami [7] and evacuation drills [16,17] with an adaptive response. However, it has yet to be examined whether these experiences are remembered in the face of a cue of an impending tsunami and can promote evacuation.

Furthermore, it is important to know whether these psychological processes mediate the associations between various background factors and evacuation behaviors. Qualitative studies have suggested the importance of knowledge (passed down orally and accrued at school) in evacuation from a tsunami [1–3,5]. In addition, various other background factors, such as demographic (age and sex) and environmental (perception of the severity of an earthquake and warning) factors, have been empirically demonstrated to be associated [6,16]. With respect to the dissociable contributions of risk and threat perceptions, various sociocultural, environmental, and demographic factors are thought to explain this dissociation [11,12]. If a relationship can be found between a key psychological process and such a factor, this would enable a causal explanation for the association. Furthermore, with regard to the identification of environmental or knowledge factors, the process may lead to an index for successful environmental or educational intervention for disaster mitigation.

Personality traits are potentially predictive of adaptive evacuation. There are major individual differences in psychological and behavioral responses to an environment, which are typically measured using self-rated questionnaires. These traits appear to be relevant to the psychological processes described herein and may be a good target for educational interventions, but few studies related to disasters have explored this. Although some have discussed the issue [7,18], empirical findings have been limited: only the “locus of control” [19] has been discussed, and only in terms of tornado or hurricane disasters [20,21]. This line of research appears promising, given the demonstrated relationship between scores on the Big Five basic personality dimensions and the perceptions of various types of risky social behaviors [22]. We previously explored survival-oriented personality factors (Power to Live scale) in a broad context related to the 2011 Tohoku earthquake and tsunami disaster and found that of the eight factors identified, emotion regulation, leadership, and problem solving were associated with immediate evacuation [23]. However, that analysis did not consider the psychological processes and various background factors.

Understanding the roles of psychological processes and personality factors in adaptive tsunami evacuation will contribute to the literature on risk perception, which has been dominated by research on technological or social risks. However, unique characteristics of disasters linked to natural hazards with respect to risk have been suggested. For example, the psychometric structure of the risk concept seems to be three-dimensional for such natural disasters [24], in contrast to the two dimension characterizing other types of risks [25]. Cultural effects seem to be particularly important in natural disasters [21,26], while their importance is controversial in other contexts [27]. Concerning social amplification or attenuation of risk perception [28,29], despite some studies on media coverage [30], the effects of social information [31,32] and the gap between experts and the lay population [33] in the context of natural disasters have not been integrated within a unified framework [6,34,35].

In fact, the integration of various factors and processes relevant to risk perception and protective action across different types of natural or technological disasters is recognized as an essential research target for the achievement of disaster-related sustainable development goals, which are embodied in the Sendai Framework (2015–2030) [36]. Understanding the contributions of psychological processes and personality factors is key to this endeavor, given that they are an invariant component of human–environment interactions. Centering on an understanding of human nature, we may draw

an integrated cross-contextual picture covering the diverse patterns of interactions among various components of the environment in various types of disasters in various sociocultural contexts.

In this study, we explored the psychological processes and personality factors that lead to appropriate tsunami evacuation. We also analyzed the effects of various background factors on evacuation behavior and relevant psychological processes. To this end, we analyzed the data from survivors of the 2011 Tohoku earthquake and tsunami disaster [23]. The environmental cues associated with that tsunami were probably very clear to the residents due to the severity of the earthquake, as well as to the effective tsunami early warning system and mitigation policies in place in Japan [8]. We first examined whether the perception of risk or threat of the tsunami, or the remembrance of a past experience of a tsunami or evacuation drill, explained immediate or spontaneous evacuation after controlling for other background factors. If some of these psychological factors had significant effects, we then examined whether they were associated with background factors. In both analyses, we also examined whether personality factors had additional explanatory power. Eight factors related to the Power to Live [23] and Big Five personality scales were included as personality traits.

In these analyses, we were also interested in three specific practical questions. First, we explored whether normalcy bias in the evacuation context is a class of general optimistic bias. Normalcy (or normality, normalization) bias is the tendency to underestimate the risk or threat of a warned hazard, which hampers appropriate evacuation [37–39]. It is theoretically tempting to identify this context-specific bias with a general optimistic bias (or positive illusion), which is considered a characteristic of mentally healthy normal humans and promotes daily productivity [40]. However, this entails a tradeoff between disaster preparedness and a mentally healthy, productive daily life. We tested whether this dilemma is true by examining whether appropriate risk perception was predicted by personality traits negatively associated with the advantage of general optimistic bias; that is, a high degree of neuroticism [41] and a low degree of emotion regulation [42]. Second, we examined the relationship between the decision to evacuate and past experience of a tsunami evacuation. We were particularly interested in the psychological effects of there being no damage after a disaster, which lessens the subsequent perception of risk in various types of disasters linked to natural hazards [43–46]. That is, an experience of an unnecessary evacuation from a tsunami may enhance normalcy bias for a similar subsequent warning (i.e., a “cry wolf” effect), which could call for reconsiderations of warnings made “to be on the safe side”. To test this possibility, we examined whether appropriate risk perception was inhibited by experience of an unnecessary past evacuation. Finally, we examined the contributions of past evacuation drills and three knowledge factors relevant to educational measures for disaster mitigation. Participation in evacuation drills was associated with more effective evacuation [17] and fewer casualties [16] during the 2011 Tohoku earthquake and tsunami disaster. Oral transmission of information regarding a past disaster improved the likelihood of appropriate evacuation by residents [3,47,48]. Scientific knowledge taught in schools about the link between an earthquake and a tsunami has also been shown to facilitate evacuation after an earthquake [1]. Additionally, tsunami memorials (memorial stones, shrines, and temples) are expected to help build awareness and help maintain memory of past events, as well as to ensure readiness for possible future events [10].

2. Materials and Methods

2.1. Survey

The participants in the original survey were 1412 survivors of the 2011 Tohoku earthquake and tsunami disaster [10]. A questionnaire battery was sent to 3600 residents who were randomly sampled from the electoral registers (and thus were aged ≥ 20 years) of tsunami-affected districts or temporary settlements in the four most populous coastal cities (Ishinomaki, Kesen-numa, Natori, and Sendai) in Miyagi Prefecture, where the damage caused by the earthquake and tsunami was most severe (3957, 1426, 993, and 937 dead or missing persons among the total populations of 160,826, 73,489, 73,134,

and 1,045,986, respectively [49]). In total, 1412 questionnaires (39%) were anonymously completed and returned by mid-January 2014. Among the respondents, 68% evacuated to avoid the tsunami on 11 March 2011; 8% lost family members; 38% lost friends; 48% lost their homes entirely; and 40% had partially-damaged homes. While we intended to include representative samples of tsunami survivors, the sociodemographic status of the selected cities, as well as various factors differing between responders and non-responders comprised potential sources of bias. The survey was approved by the Ethics Committee for Surveys and Experiments of the Graduate School of Arts and Letters, Tohoku University (2012–1019–190749) and conducted with support from Survey Research Center Co., Ltd. (Tokyo, Japan); see [10] for further details. The original questionnaire is available as Supplementary Information. The current analysis used data from 959 subjects who reported that they eventually evacuated to avoid the tsunami on 11 March 2011.

2.2. Variables

Self-evaluation data regarding whether the respondents evacuated immediately following the earthquake, and did so of their own volition rather than being prompted by someone else, were used as dependent variables for an appropriate tsunami evacuation. Four psychological processes, which were used both as independent and dependent variables, included two perception items (whether they perceived the risk and threat of the tsunami) and two remembrance items (whether they remembered a past tsunami experience and evacuation drill). In the original language (Japanese) “threat” has explicit connotations of fear, but “risk” does not. The background factors, which were used only as independent variables, included two demographic factors (sex and age), two environmental factors, five experiential factors, and three knowledge factors. The environmental factors concerned the perception of environmental cues associated with the tsunami, including earthquake severity (whether they observed phenomena that were informative regarding the severity of the earthquake, such as cracks, cave-ins, or liquefaction of roads soon after the earthquake) and warnings (whether they heard the official evacuation alert in any form, such as radio, TV, cell phone, or outdoor loudspeaker). The experiential factors included three types of experience pertaining to past tsunamis (whether they had observed a tsunami, experienced a flooded home, or were physically involved in a tsunami) and three related to evacuation experience (whether they had an effective, ineffective, or failed evacuation), as well as an item on evacuation drills (frequency of participation therein per year). Knowledge factors included familiarity with local tsunamis based on oral accounts (i.e., whether they had heard about past tsunami experiences from relatives often, occasionally, or never), the extent of their knowledge of the mechanism underlying the occurrence of a tsunami (detailed knowledge, some knowledge, little knowledge, or no knowledge), and “tsunami memorials” (whether they were aware of historical monuments related to previous earthquake disasters in that area). Table 1 lists the questions and basic statistics.

Table 1. Variables for evacuation, psychological processes, and background factors.

Appropriate Tsunami Evacuation	
1.	Immediate evacuation: <i>Did you evacuate immediately after the earthquake?</i> (yes: 510 (54%), no: 440 (46%))
2.	Voluntary evacuation: <i>Did you evacuate voluntarily soon after the earthquake before being encouraged by someone else?</i> (yes: 467 (50%), no: 475 (50%))
Psychological Processes	
1.	Perception of risk: <i>When you felt the quake, did you think there was a risk that a tsunami would follow?</i> (yes: 420 (44%), no: 529 (56%))
2.	Perception of threat: <i>Did you feel the threat of a tsunami coming soon after the quake?</i> (yes: 413 (44%), no: 529 (56%))
3.	Remembrance of tsunami experience: <i>Did you remember a past tsunami soon after a quake (if you had no experience of a tsunami, choose no)?</i> (yes: 168 (18%), no: 779 (82%))
4.	Remembrance of evacuation drills: <i>Did you remember evacuation or disaster prevention drills soon after a quake (if you had no experience of these drills, choose no)?</i> (yes: 223 (24%), no: 721 (76%))

Table 1. Cont.

Background Factors	
<i>Demographic Factors</i>	
1.	Sex (male: 376 (40%), female: 575(60%))
2.	Age (20s: 50 (5%), 30s: 95 (10%), 40s: 153 (16%), 50s: 183 (19%), 60s: 270 (28%), 70s: 198 (21%), 80 years or older: 3 (0%))
<i>Environmental Factors</i>	
3.	Earthquake severity: <i>Did you see any of the following phenomena on the roadway around you soon after the earthquake: cracks, cave-ins, or liquefaction?</i> (yes: 495 (53%), no: 437(47%))
4.	Warning: <i>Did you hear the call for an evacuation (evacuation recommendation) by any of the following methods? Radio, TV, cell phone, outdoor loudspeaker, others</i> (yes: 707 (77%), no: 213 (23%))
<i>Experience Factors</i>	
5.	Past tsunami: <i>Have you had any of the following experiences with a tsunami in the past? Observed, home flooded, been involved.</i> (yes: 231 (25%), no: 709(75%))
6–8. <i>Have you had one of the following experiences with a tsunami evacuation in the past?*</i>	
6.*	Past effective evacuation - <i>evacuated and escaped from a tsunami</i> (selected: 62 (7%), not selected: 850 (93%))
7.*	Past no-evacuation - <i>not evacuated and tsunami came</i> (selected: 109 (12%), not selected: 803 (88%))
8.*	Past vain evacuation - <i>evacuated but tsunami did not come</i> (selected: 204 (22%), not selected: 708 (78%))
9.	Past evacuation drills: <i>How often have you participated in evacuation or disaster-prevention drills? (per year)</i> (three times or more: 9 (1%), twice: 46 (5%), once: 266 (28%), never: 624 (66%))
<i>Knowledge Factors</i>	
10.	Oral history: <i>Have you heard of past tsunami experiences from relatives?</i> (often: 142 (15%), occasionally: 511 (54%), never: 299 (31%))
11.	Scientific knowledge: <i>Do you know the mechanism for the occurrence of a tsunami?</i> (detailed knowledge: 48 (5%), some knowledge: 414 (44%), little knowledge: 327 (34%), no knowledge: 160 (17%))
12.	Tsunami memorials: <i>Are you aware of historical objects, such as monuments, that tell of past earthquake disasters in the area where you live?</i> (yes: 182 (19%), no: 777 (81%))

For each variable, the text of the question (italics; originally in Japanese) and the frequency data (%) at each level are given. * Experience of tsunami evacuation was asked in one choice from four options (Items 6–8 and none) and coded for each option whether it was selected or not.

Two personality trait inventories were included (Table 2). The Power to Live scale includes eight factors: leadership, problem solving, altruism, stubbornness, etiquette, emotion regulation, self-transcendence, and active well-being. The questionnaire was comprised of 34 items describing ways of thinking, daily attitude, or habit, and each factor was composed of three to five items. The internal consistency and concurrent validity of the questionnaire have been demonstrated [10]. The participants rated the applicability of each description using a six-point scale (0: not at all; 5: very much). The Big Five personality scale includes extraversion, agreeableness, conscientiousness, neuroticism, and openness, which were measured using the Japanese version of the Ten-Item Personality Inventory [50,51], which includes one positive item and one reverse-scored item for each dimension. We adopted this very short version of the Big Five inventory to minimize respondents' fatigue or frustration, which may have decreased the rate and quality of the responses. The validity of this very short version of the Big Five inventory has been established in terms of convergent and discriminant validity, coverage of sub-dimensions, test-retest reliability, and patterns of external correlates [50,51]. The participants responded using a six-point scale (0: not at all; 5: very much), and the scores of reverse items were reverse-coded. For each factor or dimension, the sum of the scores was converted to a percentile of the maximum total score for the basic statistics (Table 2) and normalized to a mean of 0 and a standard deviation of 1 when entered into the statistical model.

Table 2. Variables for personality traits.

Power to Live	
1.	Leadership: <i>I gather together everyone involved to discuss how to resolve a problem.</i> (52 ± 19)
2.	Problem Solving: <i>When I am fretting about what I should do, I compare several alternative actions.</i> (66 ± 16)
3.	Altruism: <i>I like it when other people rely on me and are grateful to me.</i> (63 ± 16)
4.	Stubbornness: <i>I am stubborn and always get my own way.</i> (59 ± 17)
5.	Etiquette: <i>On a daily basis, I take the initiative when greeting family members and people living in the neighborhood.</i> (83 ± 15)
6.	Emotion Regulation: <i>I endeavor not to brood during difficult times.</i> (67 ± 16)
7.	Self-transcendence: <i>I am aware that I am alive and have a sense of responsibility in living.</i> (72 ± 16)
8.	Active Well-being: <i>In everyday life, I have habitual practices that are essential for relieving stress or giving me a change of pace.</i> (58 ± 21)
Big Five Dimensions	
1.	Extraversion: <i>I think I am enthusiastic and extraverted.</i> (51 ± 20)
2.	Agreeableness: <i>I think I am sympathetic and warm.</i> (70 ± 17)
3.	Conscientiousness: <i>I think I am dependable and self-disciplined.</i> (57 ± 20)
4.	Neuroticism: <i>I think I am anxious and easily upset.</i> (50 ± 19)
5.	Openness: <i>I think I like new things and have unusual ideas.</i> (48 ± 21)

For each variable, an example of the question (italics; originally in Japanese) and the mean ± standard deviation (SD) of the total score (%) are given.

2.3. Analysis

Logistic regression analyses were performed using IBM SPSS Statistics 25 (IBM Corp., Armonk, NY, USA). For exploratory purposes, we reported significant findings at $p < 0.05$ corrected for multiple comparisons using the Bonferroni method based on the number of independent variables entered in each analysis. We also reported findings significant at an uncorrected $p < 0.05$ level for a priori hypothesis testing.

2.3.1. Factors Determining an Appropriate Tsunami Evacuation

A hierarchical logistic regression analysis was performed separately including each of the two variables for appropriate tsunami evacuation as a dependent variable. For each analysis, 12 background-factor variables were entered as the first block to determine whether the effects of these variables would be replicated as demonstrated in previous studies. Then, we entered the four psychological-process variables as a second block, expecting their significant contributions and disappearance of the effects of the background factors if the former were indeed the principal mediators of appropriate evacuation.

Each personality trait variable was entered separately, rather than the 13 variables altogether, as the third block; that is, 13 separate analyses were performed on the third block only to avoid collinearity due to the relatively high correlations across personality trait scores. The condition index of the model including the first and second blocks was 15.82, while that of the model additionally including the 13 trait variables was 42.96, which would have a serious collinearity problem [52].

2.3.2. Factors Determining the Psychological Processes Related to Evacuation

If some of these psychological factors had a significant effect, we performed a hierarchical logistic regression analysis including each of these variables. Twelve background factor variables were entered for each analysis. For the analysis on threat perception, the risk perception was entered as the second block, given that the former was likely to depend on the latter. Each personality trait was then entered separately as an additional block.

3. Results

3.1. Factors Determining Appropriate Tsunami Evacuation

Tables 3 and 4 list the results of the hierarchical logistic regression analysis for an immediate tsunami evacuation. When the background factors were entered as the first block, oral history and scientific knowledge contributed significantly, while only the former survived the correction for multiple comparisons. When the psychological processes were entered as the second block, perception of risk and perception of threat revealed significant contributions, while the effect of oral history or scientific knowledge became non-significant (Table 3), implying the primary importance of these perceptual processes in immediate evacuation. Among the personality trait variables entered as the third block, extraversion and neuroticism revealed significant positive and negative contributions (i.e., Wald statistics of β), respectively, but neither survived the correction (Table 4).

Table 3. Contributions of background factors and psychological processes to an immediate tsunami evacuation.

	Block 1			+ Block 2		
	β	Wald	$Exp(\beta)$	β	Wald	$Exp(\beta)$
Block 1 Background Factors						
1. Sex	-0.233	2.257	0.792	-0.211	1.666	0.809
2. Age	-0.021	0.155	0.979	-0.034	0.361	0.967
3. Earthquake severity	0.186	1.629	1.205	0.054	0.121	1.055
4. Warning	0.184	1.025	1.202	-0.030	0.024	0.970
5. Past tsunami	-0.018	0.006	0.982	-0.062	0.063	0.940
6. Past effective evacuation	0.296	0.706	1.344	0.288	0.603	1.334
7. Past no-evacuation	0.100	0.133	1.105	0.146	0.253	1.157
8. Past vain evacuation	0.127	0.442	1.136	-0.106	0.264	0.900
9. Past evacuation drills	0.213	3.014	1.238	0.112	0.609	1.118
10. Oral history	0.374	9.175 **	1.453	0.246	3.529	1.280
11. Scientific knowledge	0.245	5.901 *	1.278	0.151	1.990	1.163
12. Tsunami memorials	0.370	3.263	1.447	0.281	1.693	1.324
Block 2 Psychological Processes						
1. Perception of risk				0.834	18.214 **	2.302
2. Perception of threat				0.752	14.501 **	2.122
3. Remembrance of a tsunami experience				-0.309	1.463	0.734
4. Remembrance of evacuation drills				0.171	0.623	1.186
			<i>df</i>			<i>df</i>
Block χ^2		50.203 *	12		75.014 *	4
Model χ^2		50.203 *	12		125.217 *	16
Nagelkerke R^2		0.079			0.189	
AIC		1107.476			1040.462	

The results of the hierarchical logistic regression analysis are given as β , Wald statistic, and $Exp(\beta)$ (odds) for each variable and block χ^2 , model χ^2 , Nagelkerke R^2 [53], and Akaike's information criterion (AIC) separately for each block. *: $p < 0.05$, uncorrected; **: $p < 0.05$ after correction for the multiple comparisons of the 16 variables (only for β).

Table 4. Contributions of personality traits to an immediate tsunami evacuation.

	+ Block 3			Model				
	β	Wald	$Exp(\beta)$	χ^2 (17)	Nagelkerke R^2	AIC		
Power to Live								
1. Leadership	0.152	3.328	1.164	117.857	*	0.195	950.488	
2. Problem solving	0.123	2.149	1.131	116.660	*	0.193	951.685	
3. Altruism	0.068	0.673	1.070	115.179	*	0.191	953.167	
4. Stubbornness	0.072	0.774	1.075	115.280	*	0.191	953.065	
5. Etiquette	0.028	0.100	1.028	114.605	*	0.190	953.740	
6. Emotion regulation	0.150	3.264	1.162	117.792	*	0.195	950.554	
7. Self-transcendence	0.001	0.000	1.001	114.506	*	0.190	953.840	
8. Active well-being	0.106	1.583	1.112	116.092	*	0.192	952.254	
Big Five Dimensions								
1. Extraversion	0.168	4.362	*	1.183	122.557	*	0.199	961.936
2. Agreeableness	0.134	2.709		1.144	120.876	*	0.197	963.617
3. Conscientiousness	0.038	0.205		1.039	118.363	*	0.193	966.131
4. Neuroticism	-0.162	4.006	*	0.850	122.189	*	0.199	962.305
5. Openness	0.077	0.894		1.080	119.052	*	0.194	965.441

The results of the hierarchical logistic regression analysis for each personality trait variable are entered as the third block. Each variable was entered separately to avoid a collinearity problem. Other details are the same as for Table 3.

Tables 5 and 6 list the results of the hierarchical logistic regression analysis for a voluntary tsunami evacuation. When the background factors were entered as the first block, sex (being female), earthquake severity, warning, and experience of past evacuation drills had significant contributions, but none of them survived the correction. When the psychological processes were entered as the second block, perception of risk and perception of threat revealed significant contributions, but the contributions of background factors became non-significant except that of sex (Table 5), suggesting the primary importance of these perceptual processes in voluntary evacuation. Among the personality trait variables entered as the third block, leadership, active well-being, and extraversion had significant positive contributions at the corrected level. Problem solving, altruism, stubbornness, emotion regulation, and openness had positive contributions, and neuroticism had a negative contribution at an uncorrected level (Table 6).

Table 5. Contributions of background factors and psychological processes to voluntary tsunami evacuation.

	Block 1			+ Block 2				
	β	Wald	$Exp(\beta)$	β	Wald	$Exp(\beta)$		
Block 1 Background factors								
1. Sex	-0.358	5.298	*	0.699	-0.376	5.135	*	0.686
2. Age	0.091	2.938		1.096	0.085	2.289		1.089
3. Earthquake severity	0.401	7.501	*	1.493	0.275	3.121		1.316
4. Warning	0.520	7.962	*	1.682	0.307	2.469		1.359
5. Past tsunami	0.033	0.022		1.034	-0.095	0.148		0.909
6. Past effective evacuation	0.146	0.177		1.157	0.078	0.043		1.081
7. Past no-evacuation	0.192	0.500		1.212	0.229	0.621		1.257
8. Past vain evacuation	0.201	1.109		1.223	-0.076	0.136		0.927
9. Past evacuation drills	0.305	6.225	*	1.356	0.158	1.211		1.171
10. Oral history	0.089	0.525		1.093	-0.101	0.585		0.904
11. Scientific knowledge	0.197	3.796		1.218	0.077	0.510		1.080
12. Tsunami memorials	0.123	0.377		1.130	-0.017	0.006		0.983

Table 5. Cont.

		Block 1			+ Block 2		
		β	Wald	$Exp(\beta)$	β	Wald	$Exp(\beta)$
Block 2 Psychological Processes							
1.	Perception of risk				0.925	22.492 **	2.522
2.	Perception of threat				0.737	14.105 **	2.089
3.	Remembrance of tsunami experience				-0.016	0.004	0.984
4.	Remembrance of evacuation drills				0.344	2.506	1.411
		<i>df</i>			<i>df</i>		
	Block χ^2	49.197 *	12		88.369 *	4	
	Model χ^2	49.197 *	12		137.566 *	16	
	Nagelkerke R^2	0.078			0.207		
	AIC	1108.020			1027.651		

Details are the same as for Table 3.

Table 6. Contributions of personality traits to voluntary tsunami evacuation.

		+ Block 3				Model			
		β	Wald	$Exp(\beta)$	χ^2 (17)	Nagelkerke R^2	AIC		
Power to Live									
1.	Leadership	0.327	14.835 **	1.387	133.398 *	0.219	935.283		
2.	Problem solving	0.203	5.753 *	1.225	123.891 *	0.204	944.789		
3.	Altruism	0.216	6.719 *	1.241	124.862 *	0.206	943.818		
4.	Stubbornness	0.224	7.215 *	1.251	125.392 *	0.207	943.288		
5.	Etiquette	0.027	0.092	1.027	118.156 *	0.196	950.524		
6.	Emotion regulation	0.175	4.385 *	1.191	122.497 *	0.202	946.184		
7.	Self-transcendence	0.123	2.118	1.131	120.189 *	0.199	948.492		
8.	Active well-being	0.281	10.645 **	1.325	128.934 *	0.212	939.746		
Big Five Dimensions									
1.	Extraversion	0.332	16.480 **	1.394	135.090 *	0.218	950.175		
2.	Agreeableness	0.090	1.244	1.095	119.313 *	0.194	965.952		
3.	Conscientiousness	0.046	0.310	1.048	118.376 *	0.193	966.889		
4.	Neuroticism	-0.228	7.863 *	0.796	126.048 *	0.205	959.217		
5.	Openness	0.202	6.124 *	1.224	124.262 *	0.202	961.003		

** $: p < 0.05$ after correcting the 13 variables for multiple comparisons (only for β). Other details are the same as for Table 4.

3.2. Factors Determining the Psychological Processes Related to Evacuation

Because perception of risk and threat significantly contributed to both immediate and voluntary evacuation, a hierarchical logistic regression analysis was performed for each of these processes.

Tables 7 and 8 list the results of the hierarchical logistic regression analysis on the risk perception of a tsunami. When the background factor was entered as the first block, earthquake severity, warning, past vain evacuation, oral history, and scientific knowledge revealed significant contributions, all of which survived the correction (Table 7). The personality trait variables were then entered as the second block, but none of them had a significant contribution, even at an uncorrected level (Table 8).

Table 7. Contributions of background factors to risk perception of a tsunami.

	β	Wald	$Exp(\beta)$
Block 1 Background factors			
1. Sex	−0.001	0.000	0.999
2. Age	0.041	0.523	1.042
3. Earthquake severity	0.452	8.575	** 1.571
4. Warning	0.626	9.909	** 1.871
5. Past tsunami	0.433	3.427	1.541
6. Past effective evacuation	0.111	0.096	1.117
7. Past no-evacuation	0.075	0.070	1.077
8. Past vain evacuation	0.709	13.195	** 2.032
9. Past evacuation drills	0.135	1.164	1.144
10. Oral history	0.565	19.076	** 1.759
11. Scientific knowledge	0.366	11.550	** 1.441
12. Tsunami memorials	0.216	1.108	1.241
Model χ^2 (12)		137.493	*
Nagelkerke R^2		0.203	
AIC		1032.399	

Details are the same as for Table 3.

Table 8. Contributions of personality traits to risk perception of a tsunami.

		+ Block 2			Model		
		β	Wald	$Exp(\beta)$	χ^2 (13)	Nagelkerke R^2	AIC
Power to Live							
1.	Leadership	0.076	0.832	1.078	118.774	* 0.195	941.403
2.	Problem solving	0.053	0.402	1.054	118.342	* 0.194	941.835
3.	Altruism	−0.011	0.018	0.989	117.957	* 0.194	942.219
4.	Stubbornness	0.025	0.092	1.025	118.031	* 0.194	942.145
5.	Etiquette	0.057	0.425	1.059	118.365	* 0.194	941.812
6.	Emotion regulation	0.062	0.565	1.064	118.505	* 0.194	941.672
7.	Self-transcendence	0.064	0.580	1.066	118.520	* 0.194	941.656
8.	Active well-being	0.031	0.138	1.032	118.077	* 0.194	942.099
Big Five Dimensions							
1.	Extraversion	0.062	0.586	1.064	124.392	* 0.200	956.932
2.	Agreeableness	0.089	1.206	1.093	125.014	* 0.201	956.309
3.	Conscientiousness	0.025	0.086	1.025	123.891	* 0.199	957.432
4.	Neuroticism	−0.087	1.150	0.917	124.958	* 0.201	956.365
5.	Openness	−0.010	0.014	0.990	123.819	* 0.199	957.504

Details are the same as for Table 6.

Tables 9 and 10 list the results of the hierarchical logistic regression analysis regarding threat perception of a tsunami. When the background factor was entered as the first block, warning, past vain evacuation, oral history, and scientific knowledge revealed significant contributions at the corrected level. The contributions of earthquake severity, past evacuation drills, and tsunami memorials were also significant at the uncorrected level. When the risk perception was entered as the second block, this revealed a highly significant contribution, and the contributions of most of the background factors became non-significant. However, the contributions of warning and past evacuation drills (at

an uncorrected level) remained significant, implying their specific contribution to threat perception (Table 9). The personality trait variables were entered as the third block, but none of them had a significant contribution, even at the uncorrected level (Table 10).

Table 9. Contributions of background factors and risk perception to threat perception of a tsunami.

	Block 1			+ Block 2			
	β	Wald	$Exp(\beta)$	β	Wald	$Exp(\beta)$	
Block 1 Background Factors							
1. Sex	-0.213	1.717	0.808	-0.335	2.799	0.715	
2. Age	0.031	0.307	1.032	0.009	0.015	1.009	
3. Earthquake severity	0.415	7.253	*	1.514	0.239	1.271	
4. Warning	0.785	14.967	**	2.193	0.649	1.914	
5. Past tsunami	0.247	1.119		-0.015	0.003	0.986	
6. Past effective evacuation	0.264	0.550		0.328	0.531	1.388	
7. Past no-evacuation	-0.127	0.199		-0.263	0.579	0.768	
8. Past vain evacuation	0.623	10.138	**	0.288	1.445	1.334	
9. Past evacuation drills	0.299	5.672	*	1.348	0.340	1.405	
10. Oral history	0.431	11.212	**	1.538	0.149	1.161	
11. Scientific knowledge	0.344	10.308	**	1.411	0.216	1.241	
12. Tsunami memorials	0.417	4.162	*	1.517	0.458	1.581	
Block 2 Psychological Processes							
1. Perception of risk				2.850	217.224	**	17.282
			<i>df</i>				<i>df</i>
Block χ^2		125.022	*	12	269.694	*	1
Model χ^2		125.022	*	12	394.716	*	13
Nagelkerke R^2		0.188			0.509		
AIC		1031.296			763.602		

Details are the same as for Table 3.

Table 10. Contributions of personality traits to threat perception of a tsunami.

	+ Block 3			Model		
	β	Wald	$Exp(\beta)$	χ^2 (14)	Nagelkerke R^2	AIC
Power to Live						
1. Leadership	-0.033	0.110	0.967	355.231	*	697.870
2. Problem solving	-0.046	0.204	0.955	355.325	*	697.775
3. Altruism	-0.089	0.779	0.914	355.903	*	697.198
4. Stubbornness	0.031	0.092	1.032	355.213	*	697.888
5. Etiquette	-0.062	0.309	0.940	355.430	*	697.671
6. Emotion regulation	-0.012	0.014	0.988	355.134	*	697.966
7. Self-transcendence	0.030	0.084	1.031	355.204	*	697.896
8. Active well-being	0.056	0.281	1.058	355.402	*	697.698
Big Five Dimensions						
1. Extraversion	-0.024	0.057	0.976	360.397	*	714.353
2. Agreeableness	-0.160	2.602	0.852	362.965	*	711.785
3. Conscientiousness	0.119	1.316	1.126	361.661	*	713.089
4. Neuroticism	0.042	0.180	1.043	360.520	*	714.230
5. Openness	-0.040	0.160	0.961	360.500	*	714.250

Details are the same as for Table 6.

4. Discussion

This study is the first to demonstrate the pivotal importance of the risk or threat perception of a hazard during appropriate evacuation from a tsunami, which has previously been demonstrated for other types of disasters [11,12]. Although several background factors contributed to immediate or voluntary evacuation, when these psychological processes were entered into the model, they mostly replaced the contributions of these background factors. The background factors contributed significantly to the psychological processes. Another striking finding was the contributions of some personality traits: leadership and active well-being in the Power to Live scale and extraversion in the Big Five dimensions added explanatory power to voluntary evacuation. Of note, these contributions directly affected voluntary evacuation; none of these traits contributed to risk or threat perception. The independent contributions of these psychological processes and personality traits were similar for immediate and voluntary evacuation, while their contributions were more robust for voluntary evacuation. Figure 1 presents a schematic summary of the dual contribution model formulated.

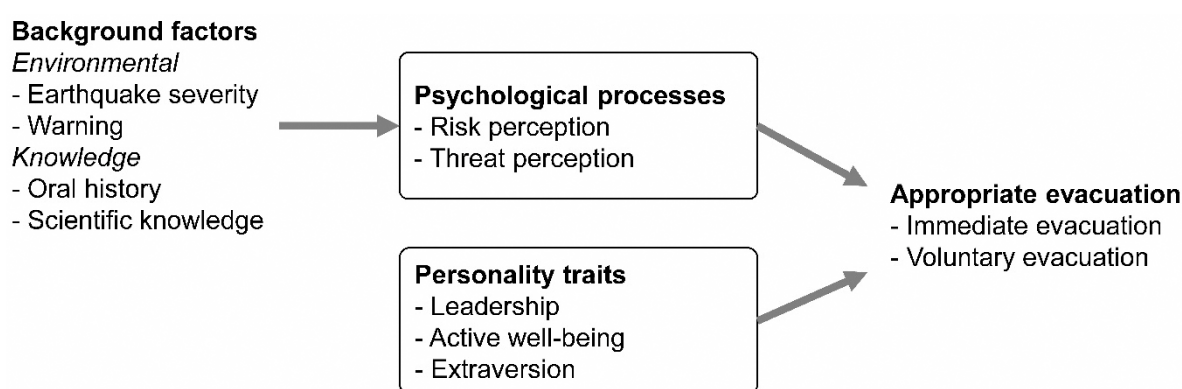


Figure 1. Schematic summary of the major findings: dual contribution model.

4.1. Perception of Risk and Threat

Our results illustrate the importance of risk or threat perception, showing that it mediates the facilitating effect of several environmental or knowledge factors on tsunami evacuation. The demonstrated contributions of the knowledge factors (i.e., existence of oral history and scientific knowledge) to immediate evacuation and those of the environmental (i.e., perceived earthquake severity and warning) and experience factors (i.e., past evacuation drills) to voluntary evacuation are consistent with the findings of previous studies [1,3,4,16,47,48]. However, these contributions disappeared when the psychological factors were entered into the hierarchical regression model, and the background factors were demonstrated to be strong predictors of perceived risk or threat. The only exception was the effect of sex; females were more likely than males to evacuate voluntarily, as has been reported for other disasters [54], and this tendency remained significant (although at an uncorrected level) after entering the psychological factors in the regression model.

Threat perception contributed to appropriate evacuation independent of risk perception and was specifically enhanced by warnings and past evacuation drills (while at an uncorrected significance level). The independent contribution of threat perception identified herein is congruent with research on other types of disasters [11–15], while the substantial contribution of risk perception appears unique to tsunamis. The specific contributions of warnings and past evacuation drills to threat perception seem consistent with the notion that personalization of risk is enhanced by information that is specific, consistent, frequently repeated, and from official sources [44]; these characteristics appear relevant to the information delivered during official warnings and evacuation drills. While the contributions of these factors to threat perception and appropriate evacuation are plausible and practically important, they remain matters for future validation. First, it is unclear to what degree our responders understood the risk and threat we assumed; in fact, 81 respondents (9%) replied that they did not perceive “risk”,

but perceived “threat,” which is a pattern to which existing data on the roles of risk and threat perceptions do not point. Second, the significance of the contributions of warnings and past evacuation drills remained at an uncorrected level. Finally, an alternative explanation is also likely: seeking warning information, participating in evacuation drills, and perceiving a tsunami threat may all be promoted by the same personality factor (while we did not identify such a personality trait in the current results).

4.2. Personality Traits

The finding of direct contributions of personality traits to voluntary evacuation is congruent with the results of previous research on hurricane preparedness [20]. This implies that risk or threat perception is important, but not a prerequisite for an appropriate evacuation decision; this is supported by the fact that among 465 voluntarily-evacuated respondents, 179 (39%) reported not perceiving “risk.”

The contributions of two Power to Live factors, leadership and active well-being, to voluntary evacuation seem congruent with the suggested association between an internal locus of control and appropriate evacuation behavior in the context of a tornado or hurricane [20,21]. People who have an internal locus of control are considered more likely to attempt to improve their life conditions by controlling their environment during important life situations [19]. Previous research has demonstrated that an internal locus of control is associated with a lower casualty rate [21] and higher levels of preparedness [20]. Previous studies have also shown that an internal locus of control is associated with leadership [55,56] and health-oriented behaviors [57,58], pointing to its relevance to leadership and active well-being, respectively.

The commonality and difference between the internal locus of control and two Power to Live factors may be formulated within the framework of social learning theory [59]. Social learning theory assumes that behavioral decisions in a specific situation depend on the expectancy that the behavior will result in a particular outcome, as well as on the value of that outcome. Expectancy is determined by generalizing the experiences of the outcome in the same, as well as similar situations. Importantly, here, the situation can be broadly or narrowly formulated. The locus of control is conceptualized as very general behavior-outcome expectancy placed at the broadest end of the continuum of situation formulation. On the other hand, the leadership and active well-being factors may be conceptualized as general behavior-outcome expectancies under relatively narrow situation formulations. Speculatively, these expectancies are relevant to the expected outcomes of the behavior (e.g., evacuation) that merit community and one’s own well-being, respectively.

However, the observed contribution of extraversion seems to lead to an independent story. The association between extraversion and voluntary evacuation in the current study appears consistent with the previously demonstrated association of extraversion with rational action [60] and problem-focused coping [61]. However, extraversion has been shown to be independent of the locus of control [62,63]. Further analysis of the contribution of this factor at the level of cognitive processes is not feasible because the cognitive mechanisms underlying the Big Five dimensions are unknown despite their popularity; surveys using twins have implied that each dimension is composed of multiple genetic and environmental factors shared among dimensions [64].

Before unequivocally accepting the contributions of these personality factors, the causal relationship between them and appropriate evacuation behavior should be discussed. The personality traits that we measured, particularly the eight factors captured by the Power to Live scale, are potentially affected by a disaster experience. Our attempt to identify the most evacuation-relevant personality factor was partially motivated by the possibility of devising an educational intervention pertaining to that factor, which assumes that it is amenable to change. There is also evidence that various personality factors are affected by traumatic experience (i.e., post-traumatic growth [65]). Accordingly, the following question is relevant: Did the personality factors affect the evacuation decision or did the specific decision affect personality? We consider the likelihood of the latter scenario to be very low. First, all of the responders whose data were analyzed eventually evacuated. Second, throughout

the three-year post-evacuation period, the responders made hundreds of decisions critical to survival; it is unlikely that, among them, the single evacuation-specific decision had a substantial effect on their personality traits three years later. Finally, the effect of a similar personality trait on evacuation decision has been previously reported in the context of other types of disasters [62,63]. Accordingly, we consider our conclusion reasonable.

We previously reported the significant association of leadership, problem solving, and emotion regulation with immediate evacuation at a liberal threshold in an analysis validating the newly-created inventory of the Power to Live [23]. In the current analysis, including various background and psychological factors in the statistical model, these associations were subthreshold for immediate evacuation. However, they were significant for voluntary evacuation at an uncorrected level.

It is important to note that we used the very short version of the Big Five inventory. Although its content validity has been established [50,51], the results might have differed if the full-length version had been used.

4.3. Practical Implications

Our dual contribution model (Figure 1) legitimates the formulation of two independent targets in measures to promote an appropriate tsunami evacuation: facilitation of risk or threat perception and empowerment of the relevant personality factors. These two targets may be pursued in different contexts. Risk or threat perception is related to relevant environmental or knowledge factors in a relatively specific context of reducing tsunami disaster risk, whereas empowerment may be addressed in a rather broader context of disaster or general education and sociocultural activities, given the relevance of personality factors to our daily life. The model may also provide a framework to integrate various factors and processes relevant to risk perception and preventative actions in various types of disasters. This framework could then be incorporated within the social amplification/attenuation model to achieve the outcome and goals laid out in a recent disaster risk reduction model [36].

Facilitation of the perception of tsunami risk and threat may basically be pursued by developing existing approaches. Facilitation involves two phases: action in the face of an imminent tsunami cued by an earthquake and daily tsunami disaster mitigation education. For the former, our results support the importance of developing better warning systems in terms of availability for residents and the content of information. It may be more efficient to enhance perception not only of the tsunami risk, but also of the severity of an earthquake that has occurred. Methods to enhance the affective response to, or personalization [44] of, the tsunami risk are also worth considering. Our results largely support the importance of daily disaster mitigation education, particularly orally-conveyed local history and scientific knowledge of tsunamis. It is important to encourage scientific education about tsunami mechanisms and disaster mitigation. Oral history also has impressive effects, although it can be technically difficult within an educational context; construction of a tsunami memorial for this purpose seemed to have a marginal effect. The limited contribution of past evacuation drills was alarming, while its potential unique facilitatory effect on threat perception is noteworthy.

The idea of empowering personality traits to facilitate tsunami evacuation may be new, and discussions should begin by questioning whether this is socially acceptable and technically feasible. With regard to social acceptability, it seems reasonable to take a cautious stance when proposing an educational intervention to enhance extraversion among people in an entire society. This is because such broadly-formulated basic dimensions are considered largely innate and value-free (i.e., neither being extroverted nor introverted means being superior as a person). The leadership and active well-being factors on the Power to Live scale appear to be readily accepted as the target of educational intervention. While they are conceptualized as personality, each factor was narrowly formulated and expected to be malleable and value-laden (i.e., survival oriented) [23]. With regard to technical feasibility, this issue remains for future studies. However, it appears promising that the framework of the social learning theory [59] led to the development of an educational intervention technique for leadership and active well-being. Theoretically, repeated experience of a favorable outcome contingent on one's

own behavior results in the acquisition of generalized behavior–outcome expectancies. Scholars should explore the types of behaviors, outcomes, and situations related to each factor; ideally, these can be implemented in education of daily life contexts to enhance that factor efficiently.

The dual contribution model provides a novel perspective on the issue of normalcy bias. A serious conceptual and practical concern was whether this bias is the opposite of optimism, which is assumed to support mentally healthy, productive daily life. Our results do not support this concern: neither risk nor threat perception (i.e., low normalcy bias) was predicted by high neuroticism or low emotion regulation, which had been implicated in those with low levels of optimism. Furthermore, low neuroticism and high emotion regulation did predict the likeliness of voluntary evacuation, which is opposite the prediction that optimism would hamper an appropriate evacuation. The implication of these results can be formulated into the framework of the dual contribution model as follows. On the one hand, in facilitating the risk or threat perception of a tsunami, we do not need to hesitate to demonize normalcy bias based on concerns about sacrificing the benefits of general optimism. On the other hand, for direct facilitation of tsunami evacuation regardless of risk perception, general optimism and related personality traits may be the target of empowerment (rather than suppression).

Our results do not support the “cry wolf” effect of experiencing an unnecessary evacuation before a tsunami, contrary to the findings of previous studies on other types of disasters [43–46]. Risk perception was positively, rather than negatively, associated with such an experience. Of course, it is unlikely that such an experience would enhance risk perception. It is likely that people who previously evacuated in vain would still tend to evacuate on the next occasion. The difference between the current and previous findings implies that the ‘cry wolf’ effect is dependent on the context or type of risk perception. Regarding tsunamis, we apparently do not need to be too cautious about avoiding unnecessary evacuations by issuing warnings that are on the safe side, although we do not know whether individuals would evacuate a third time.

4.4. Limitations and Future Perspectives

The survey was conducted nearly three years after the earthquake and tsunami. Any drawbacks common to such retrospective surveys, including the effect of limited memory accuracy and biases, also apply to this study. For example, it may have been difficult for the respondents to recall accurately what they were thinking soon after the earthquake, including whether they remembered a past tsunami experience or evacuation drills at that time. This limitation may explain the lack of association between these variables and appropriate evacuation in the current analysis. We also concede that some key terms in the survey questionnaire were not defined clearly enough, in part due to space and time limitations. In addition to the distinction between the “risk” and “threat” psychological processes, as already discussed, “immediate” evacuation was also somewhat ambiguous. Such ambiguity might have resulted in variation in the interpretation of these terms among responders, which in turn might have decreased the sensitivity of the analysis. This limitation should be considered when interpreting the negative findings. Several negative findings may also be attributable to suboptimal modeling. According to our interest in experiential and knowledge-related factors, and given concerns regarding multicollinearity, we decreased the number of variables in the analyses. For example, the effect of age was considered only in a linear manner, and the two environmental effects were entered only as binary variables. While more sophisticated modeling could have been performed, this would be more promising accompanied by further refinement of the survey itself (e.g., additional choice options for earthquake severity- or and warning-related items) in the future.

It is important to discuss the potential sample selection bias in this study: because the respondents were survivors, people who did not evacuate and died were “missing” from the sample. This bias may have had an impact on the results because it is tightly connected with the dependent variable (i.e., appropriate evacuation), although the magnitude of the effect was likely modest considering the casualty rate. This bias is likely to have caused false-negative rather than false-positive results. The factors facilitating evacuation would have been less relevant in the missing respondents, and the

sampling bias could have caused a spurious increase in the scores on these factors of the respondents who did not evacuate (or perceive risk) appropriately. Therefore, we must carefully interpret the negative findings taking this selection bias into account. Nevertheless, we consider the positive findings robust because the effects were significant even under such a bias. Although there are other sources of sampling bias, concerning for example those who survived, but migrated after the disaster or did not respond to the survey, they are not directly associated with evacuation behavior, and their effects on the results are difficult to quantify. We are unaware of any reason to suspect that individuals who had high scores for the pro-evacuation factors (i.e., environmental, knowledge, and personality factors) and made an inappropriate evacuation or psychological response selectively migrated or did not respond. Potential bias related to region-specific population dynamics and non-respondents is a common challenge in various types of disaster research and should be addressed further in future investigations.

In the current analysis, we did not take into consideration the contributions of social structure or community resources to evacuation behavior, which have been demonstrated in the context of a previous tsunami [48] and other disasters [11]. This limitation may be reflected in the less significant contributions of background and personality factors to immediate than to voluntary evacuation; that is, immediateness seemed to be more affected by community resources. In support of this, the effect of oral history, which is typically shared within the community, had an opposite pattern. The logistic regression analysis at the step before the psychological processes were entered revealed a strong contribution of oral history to immediate, but not voluntary, evacuation. In a community where such oral history is shared, people may be immediately encouraged to evacuate by other family or community members before they voluntarily decide to do so.

Our findings do not support a contribution of past tsunami experience to appropriate evacuation, as demonstrated previously [7]. Although we accept that this may be due to limitations in our survey and analysis, we consider that the impact of tsunami experience was minimal, given that the contribution demonstrated in previous research [7] was subtle, albeit significant. The negative finding is also somewhat consistent with the mixed results pertaining to the effects of disaster experience on risk perception reported for other types of disasters [46].

Research on factors promoting appropriate tsunami evacuation will require further accumulation of data from future events. Apart from the shortcomings discussed above, the current findings are yet to be generalized over different sociocultural contexts. Longitudinal surveys would provide evidence on causality, which we could only speculate in this study. The international research community should engage in future surveys that maximize shared knowledge and minimize the load on survey participants. This research should involve collaboration with cognitive sciences, including behavioral experiments and neuroscience, to clarify how the contributing factors affect the perception of risk or threat and behavioral decisions [11]. Such knowledge on the psychological processes and mechanisms may inspire new concepts and yield a strategic approach to develop tsunami disaster mitigation measures.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2076-3263/9/8/326/s1>: Original questionnaire (survey_questionnaire.pdf; Japanese); English translation of the questionnaire items relevant to this study (survey_questionnaire_translations.xlsx).

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