A Preface
This supplementary material describes the list of seed templates, the list of connectives, the English translations of our annotation manuals, and additional examples of contradiction, causality, and the causality hypothesis. Although this supplementary material may seem oversupplied, we believe that we must describe all of the details, since we propose a novel concept, Excitation, a novel task, Excitation knowledge acquisition, and novel knowledge acquisition methods based on Excitation in our paper.

B List of Seed Templates
In this section, we list the seed templates that we used to acquire the Excitation templates. We mentioned the seed templates in Section 3. In the following, each seed template is followed by its gloss and an English translation. ACC, DAT, NOM, and TOP denote Japanese accusative, dative, nominative, and topic case markers.

- excitatory seed templates:
  1. X を する (X ACC do) ‘do X’
  2. X を 行う (X ACC do) ‘do X’
  3. X に なる (X DAT become) ‘become X’
  4. X を 作る (X ACC make) ‘make X’
  5. X を つくる (X ACC make) ‘make X’
  6. X を 作成する (X ACC make) ‘make X’
  7. X が 有る (X NOM exist) ‘there is X’
  8. X が 出来る (X NOM possible) ‘X appears / X is possible’
  9. X は 出来る (X TOP possible) ‘X appears / X is possible’
  10. X を 引き起こす (X ACC cause) ‘cause X’
  11. X を 起こす (X ACC cause) ‘cause X’
  12. X を おこす (X ACC cause) ‘cause X’
  13. X が 起こる (X NOM happen) ‘X happens’
  14. X が 起きる (X NOM happen) ‘X happens’
  15. X が しようとする (X NOM happen) ‘X happens’
  16. X が 発生する (X NOM happen) ‘X happens’
  17. X を 発生させる (X ACC bring about) ‘bring about X’
  18. X を 持つ (X ACC have) ‘have X’
  19. X を 与える (X ACC give) ‘give X’
  20. X が 多い (X NOM abundant) ‘X is abundant’
  21. X が 進む (X NOM progress) ‘X makes progress’
  22. X が 進行する (X NOM progress) ‘X makes progress’
  23. X を 加える (X ACC add) ‘add X’
  24. X が 増える (X NOM increase) ‘X increases’
  25. X が 始まる (X NOM start) ‘X starts’
  26. X を 始める (X ACC start) ‘start X’
  27. X が 続く (X NOM continue) ‘X continues’
  28. X を 繰り返す (X ACC repeat) ‘repeat X’
  29. X を 得る (X ACC acquire) ‘acquire X’
  30. X に 繋がる (X DAT lead to) ‘lead to X’
C List of Connectives

This section lists the connectives mentioned in Section 3.1 that we used to acquire the Excitation templates. They are 169 connectives in total.

These connectives were first automatically extracted from our web corpus that was parsed by KNP, a Japanese dependency parser.\(^1\) KNP distinguishes connectives that have the same surface form but (slightly) different grammatical functions. We follow KNP in distinguishing these connectives and note below the connectives that have the same surface form to indicate what distinguishes them.

Connectives were manually classified by one of the authors into AND/THUS-type and BUT-type. AND/THUS-type connectives were further classified into causal connectives and non-causal connectives.

Causal connectives explicitly indicate a sort of causality or logical consequence between two events denoted by two phrases between which the connectives are placed. The functions of non-causal connectives include contrasting two phrases as alternatives to each other, juxtaposing two phrases on equal footing, inserting one phrase as an additional explanation or description on the other phrase, and sometimes indicating causality between two events described by two phrases between which the connectives are placed. BUT-type connectives indicate inconsistency between two events denoted by two phrases between which the connectives are placed.

Note that our “connectives” include some conjugation forms of Japanese predicates, since they can take on functional meanings that (authentic) connectives have.

Note also that, in the following connectives list, we distinguish connectives with the same surface form by their usages described in parentheses.

BUT-type connectives BUT-type connectives are as follows: が, くても, くも, けれども, も, であっても, であっても, でなくて, であり, は, は, は, （immediately followed by a predicate), くても, くても, くても, くても, くても, くても, （immediately followed by a predicate), （immediately preceded by a punctuation mark such as a comma), まり, に, に, に (immediately preceded by such specific nouns as 基, も, 前提, 中心, の, メド, 基準, 契機, きっかけ, 機, 機, and so on), において, にしろ, にせよ, について, にとって, に, に, によって, によらず, に並んで, に代わって,
D English Translation of Annotation Manuals

In this section, we present the English translation of our annotation manuals and annotation examples that we prepared in Japanese to instruct our annotators.

D.1 Excitation Template Acquisition

Figure I shows the English translation of our annotation manual for our Excitation template acquisition experiment. The following are examples that we prepared to instruct the annotators. The argument slot of the template was filled with a noun (underlined).

- Examples for excitatory
  - 津波が発生する (Tsunami NOM generate) ‘Tsunami is generated’
  - 財産が増える (fortune NOM increase) ‘fortune increases’
  - ゆとりが有る (capacity NOM exist) ‘have capacity’
  - 余裕を持つ (margin ACC have) ‘have a margin’
  - パイ菌が多い (germ NOM abundant) ‘germs are abundant’
  - 夕飯を準備する (dinner ACC prepare) ‘prepare dinner’
  - ジャガイモを茹でる (potato ACC boil) ‘boil potatoes’
  - 教科書を買う (textbook ACC buy) ‘buy a textbook’
  - 鉛筆を削る (pencil ACC chop) ‘sharpen a pencil’
  - ヒアルロン酸に変化する (hyaluronic acid DAT change) ‘turn into hyaluronic acid’
  - 人員を分ける (personnel ACC distribute) ‘divide personnel’
  - 勉強に集中する (study DAT concentrate) ‘focus on studying’
  - お金を消費する (money ACC consume) ‘consume money’
  - 脂肪を燃焼させる (fat ACC burn) ‘burn fat’

- Examples for inhibitory
  - 風邪を予防する (cold ACC prevent) ‘prevent colds’
  - 不安を取り除く (fear ACC eliminate) ‘eliminate a fear’
  - 自信が無い (confidence NOM absent) ‘have no confidence’
  - 心臓が止まる (heart NOM stop) ‘heart stops’
  - 機会を奪う (chance ACC deprive) ‘deprive of a chance’
  - 機会を奪われる (chance ACC be deprived) ‘a chance is deprived’
  - 予算が減少する (budget NOM reduce) ‘budget is reduced’
  - 成長が伸び悩む (growth NOM stagnate) ‘growth stagnates’
  - 法律に薙ぐ (law DAT violate) ‘violate a law’
  - 手順を間違う (procedure ACC make mistakes) ‘fail to follow a procedure’
  - 侵略を食い止める (invasion ACC stop) ‘repel an invasion’
  - クロロゲン酸から変化する (chlorogenic acid FROM change) ‘change from chlorogenic acid’
Excitation Template Annotation Manual

**Task**  Classify phrases that consist of a noun and a template such as “(Tsunami) is generated,” “prevent (colds),” and “in proportion to (population)” into excitatory, inhibitory, and neutral. The following are the classification criteria:

**excitatory** Phrases that entail or imply that the main function, effect, purpose, role, or influence of the referent of the argument is activated or prepared. In other words, the main function (effect, purpose, role, or influence) of the referent of the argument is generated, preserved, used, exploited, prepared, maintained, acquired, possessed, prospering, developed, improved in quality or quantity, decided, facilitated, satisfied, obtaining acceptance, revealed, contributed, exists, appears, manifests itself, or emerges.

**inhibitory** Phrases that entail or imply that the main function, effect, purpose, role, or influence of the referent of the argument is deactivated. In other words, the main function (effect, purpose, role, or influence) of the referent of the argument is absent, disappeared, lost, weakened, dismissed, removed, suspended, halted, unusable, suppressed, unavailable, in a slump, decelerating growth, degraded in quality or quantity, undecided, in shortage, having a misfortune, being violated, dissociated, contradictory, or losing its effect.

**neutral** Phrases that are neither excitatory or inhibitory. In other words, they do not entail or imply that the main function, effect, purpose, role, or influence of the referent of the argument is prepared, activated, or deactivated.

You may consult the web for the meaning of the phrases. However, do not consult other annotators. You may use the label ‘undecided’ when you are not sure about the Excitation status of the phrase or when you think that a phrase is too unnatural or awkward in Japanese.

**Note** excitatory/inhibitory is different from good/bad (or desirable/undesirable). For example, “become (an economic powerhouse)” and “suffer from (lifestyle-related diseases)” are both excitatory, but the former is good (or desirable) while the latter is bad (or undesirable). “resolve (a conflict)” and “abort (a project)” are both inhibitory, but the former is good (or desirable) while the latter is usually bad (or undesirable).

**Figure I:** English translation of annotation manual for Excitation template acquisition experiments

- 負荷を分散させる (load ACC distribute) ‘distribute a load’
- 勉強に飽きる (study DAT get bored) ‘get bored of studying’
- 将来を考える (future ACC think) ‘think about the future’
- 明日を思う (tomorrow ACC think) ‘think about tomorrow’

**Examples for neutral**

- 人口に比例する (population DAT in proportion to) ‘in proportion to population’
- 性格を診断する (personality ACC diagnose) ‘diagnose a personality’
- 心象を描写する (mental picture ACC describe) ‘describe a mental picture’
- 顔が不細工だ (face NOM ugly) ‘a face is ugly’

**D.2 Contradiction Extraction**

Figure II shows the English translation of the annotation manual for our contradiction extraction experiments. The following are examples that we prepared to instruct the annotators.

**Examples of contradictory phrase pairs:**

- 景気が良くなる ↓ 景気が悪くなる
  ‘economic conditions get better ↓ economic conditions get worse’
Contradiction Annotation Manual

**Task**  
Classify the phrase pairs that consist of a noun and a template such as *(economic conditions get better, economic conditions get worse)*, *(rise in temperature, increase in temperature)*, and *(develop cancer, study cancer)* as contradictory or not. The following are the classification criteria:

**Contradiction**  
Two phrases are contradictory if they satisfy one of the following conditions:  
1. Two events, actions, or states denoted by the two phrases cannot occur at the same time.  
2. If a tendency of the event, action, or state denoted by one phrase gets stronger, it will eventually be close to contradictory with the event, action, or state denoted by the other phrase.  
3. If the tendencies of events, actions, or states denoted by two phrases get stronger, they will eventually be close to a contradiction.

**Non-contradiction**  
Two phrases are not contradictory if they are not a ‘contradiction’ in the sense described above. Non-contradictory phrase pairs include a phrase pair between which paraphrase or entailment relations hold and a semantically irrelevant phrase pair.

You may consult the web for the meaning of phrases. However, do not consult other annotators. You may use the label ‘undecided’ when you are not sure about the contradiction status of a phrase or when you think that a phrase is too unnatural or awkward in Japanese.

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**Figure II: English translation of annotation manual for contradiction extraction experiments**

- 景気が良くなる  壮気を悪くする  
  ‘economic conditions get better  ↓  make economic conditions worse’
- 景気が良くなる  壮気を悪化させる  
  ‘economic conditions get better  ↓  make economic conditions worse’
- 信頼性が増す  信頼性が低下する  
  ‘credibility is enhanced  ↓  credibility is degraded’
- 癌に罹る  癌を予防する  
  ‘develop cancer  ↓  prevent cancer’
- デフレになる  デフレを脱却する  
  ‘stuck in deflation  ↓  overcome deflation’
- デフレが促進される  デフレを抑制する  
  ‘accelerate deflation  ↓  discourage deflation’
- 体力が上がる  体力を維持する  
  ‘improve physical strength  ↓  keep physical strength’
- 権限を失う  権限を保持する  
  ‘revoke authority  ↓  maintain authority’
- 気分がいい  気分が悪い  
  ‘feel good  ↓  feel bad’
- 負荷が少なくなる  負荷を伴う  
  ‘reduce a burden  ↓  add a burden’
- 凹凸が生じる  凹凸を避ける  
  ‘have bumps  ↓  avoid bumps’
- トラブルが生じる  トラブルを吸収する  
  ‘troubles occur  ↓  alleviate troubles’
- 音が放出される  音を軽減させる  
  ‘make noise  ↓  reduce noise’
- 場が激減する  場を得られる  
  ‘opportunity decreases drastically  ↓  opportunity is obtained’
- エストロゲンが作用する  エストロゲンが減少する  
  ‘estrogen exerts its effects  ↓  estrogen decreases’
- ピークに至る  ピークを避ける  
  ‘achieve a peak  ↓  avoid a peak’
- 揺れが軽減される  揺れを生ずる  
  ‘shaking is reduced  ↓  shaking occurs’
- 臭気が減少する  臭気を放出す  
  ‘reduce smells  ↓  emit smells’
- クッション性が軽減する  クッション性を生む  
  ‘reduce cushioning characteristics  ↓  cause cushioning characteristics’
- ロゴが出現する  ロゴをカットする  
  ‘a logo appears  ↓  remove a logo’
- Coenzyme Q-10 runs short \( \perp \) Coenzyme Q-10 is included

D.3 Causality Extraction

Figure III shows the English translation of the annotation manual for causality extraction experiments. The following are examples that we prepared to instruct the annotators.

- Examples of causality phrase pairs:
  - タバコを吸う \( \Rightarrow \) 肺癌になる
    
    smoke cigarettes \( \Rightarrow \) suffer lung cancer
  - 基礎代謝が落ちる \( \Rightarrow \) 消費カロリーが減る
    
    basal metabolism decreases \( \Rightarrow \) calories are burned reduce
  - 湿度が高い \( \Rightarrow \) カビが発生する
    
    humidity level is high \( \Rightarrow \) mold grows
  - 地震が少ない \( \Rightarrow \) 不安が少ない
    
    earthquakes rarely occur \( \Rightarrow \) anxiety is rarely felt
  - 好奇心が刺激される \( \Rightarrow \) 興味がわく
    
    curiosity is stimulated \( \Rightarrow \) have an interest
  - 脂質を大量摂取する \( \Rightarrow \) 脂肪を増加させる
    
    intake a large amount of fat \( \Rightarrow \) increase body fat
  - 金額が減る \( \Rightarrow \) 人が減る
    
    amount of money is reduced \( \Rightarrow \) number of persons is reduced
  (Given the context of company employment)

- Examples of non-causality phrase pairs:
  - タバコを吸う \( \not\Rightarrow \) 健康になる
    
    smoke cigarettes \( \not\Rightarrow \) become healthy
  - タバコを吸う \( \not\Rightarrow \) 会社に行く
    
    smoke cigarettes \( \not\Rightarrow \) go to work
  - 肺癌になる \( \not\Rightarrow \) タバコを吸う
    
    suffer lung cancer \( \not\Rightarrow \) smoke cigarettes
  - 不安が少ない \( \not\Rightarrow \) 地震が多い
    
    anxiety is rarely felt \( \not\Rightarrow \) earthquakes rarely occur
  - 子供が生まれる \( \not\Rightarrow \) 税率を上げさせる
    
    have a baby \( \not\Rightarrow \) raise taxes
E.3 Causality Hypothesis Generation
Table III shows additional examples of causality hypothesis pairs generated by PROPhyp. They were selected from the 100 evaluated samples of PROPhyp. ‘✓’ given to the hypotheses and their original causality pairs indicates that the pair has a causal relation.

D.4 Causality Hypothesis Generation
Figure IV shows the English translation of the annotation manual for causality hypothesis generation experiment. Examples used to instruct the annotators were identical to those in Section D.3.

E Additional Examples of Knowledge Acquisition
In the following sections we give additional examples of contradiction pairs, causality pairs, and causality hypothesis pairs acquired by our proposed knowledge acquisition methods.

E.1 Contradiction Extraction
Table I shows additional examples of contradiction pairs extracted by PROPcont. They were selected from the 200 evaluated samples of PROPcont. ‘Cont’ and ‘Quasi’ indicate whether the pair is contradictory or quasi-contradictory.

E.2 Causality Extraction
Table II shows additional examples of causality pairs extracted by PROPcaus. They were selected from the 100 evaluated samples of PROPcaus. ‘✓’ indicates that the pair has causality.
### Table I: Additional examples of PROP$_{cont}$’s outputs

| Rank | Contradiction Pairs | Label |
|------|---------------------|-------|
| 77,815 | 通行が確保される ⊥ 通行が制限される  
passage is ensured ⊥ passage is restricted | Quasi |
| 353,846 | 売上が激増する ⊥ 売上が倍増する  
sales drop sharply ⊥ sales are doubled | Cont |
| 749,952 | 人影がある ⊥ 人影はなくなる  
a human figure is present ⊥ a human figure disappears | Cont |

### Table II: Additional examples of PROP$_{caus}$’s outputs

| Rank | Causality Pairs | Label |
|------|-----------------|-------|
| 14,649 | 放送倫理を高める ⇒ 番組を向上させる  
raise broadcasting ethics ⇒ improve broadcast programs | ✔ |
| 533,106 | 棚板を増やす ⇒ 収納効率を良くする  
add shelves ⇒ improve storage efficiency | ✔ |
| 829,122 | 客まんだく度を向上させる ⇒ 収益を上げる  
improve client satisfaction level ⇒ boost revenues | ✔ |

### Table III: Additional examples of PROP$_{hyp}$’s output

| Rank | Causality Hypotheses (and their Origins) | Label |
|------|-----------------------------------------|-------|
| 19,220 | 体力を増進する ⇒ 老化を抑制する  
(increase physical strength ⇒ prevent aging) | ✔ |
| 69,913 | アレルギーを改善する ⇒ 茎麻疹は治る  
(relieve allergies ⇒ remedy for hives) | ✔ |
| 147,483 | 病気が少なくなる ⇒ 生育が促進される  
(diseases reduce ⇒ growth is facilitated) | ✔ |
| 725,268 | 便秘を解消させる ⇒ 老化を遅らせる  
(relieve constipation ⇒ delay aging) | ✔ |
| 874,036 | 消費をもたらす ⇒ 売上を増やす  
(encourage consumption ⇒ increase sales) | ✔ |
Causality Annotation Manual

Task  Classify the phrase pairs that consist of a noun and a template such as smoke cigarettes ⇒ get lung cancer, smoke cigarettes ⇒ get healthy, and smoke cigarettes ⇒ go to work as causality or not. The following are the classification criteria:

Causality A phrase pair such that the probability of the event, action, or state denoted by the right-side phrase becomes higher when the event, action, or state denoted by the left-side phrase happens compared to when it does not happen. Note that the event of the left-side phrase temporally precedes that of the right-side phrase.

Non-causality A phrase pair such that the probability of the event, action, or state denoted by the right-side phrase becomes higher when the event, action, or state denoted by the left-side phrase does not happen compared to when it happens. Alternatively, a phrase pair such that the left-side phrase’s event, action, or state does not affect the probability of the right-side phrase’s event, action, or state.

You may use the following linguistic test to make judgments by putting the left- and right-side phrases in the questions into X and Y and checking whether the resulting sentence is valid: causality if it is valid, and non-causality otherwise. Linguistic test: “Y becomes more likely when X happens compared to when X does not happen.” (X is the event, action, or state denoted by the left-side phrase, and Y is the event, action, or state denoted by the right-side phrase.)

A source sentence from which a target causality pair was extracted is given next to the causality pair. Your judgments must be based on these source sentences. You may consult the web for the meaning of phrases. However, do not consult other annotators. You may use the label ‘undecided’ when you are not sure about the causality status of phrase or when you think that a phrase is too unnatural or awkward in Japanese.

Note 1: Even if the right-side phrase denotes an event, action or state that happens only when multiple events, actions or states all happen, judge a phrase pair as causality if the left-side phrase denotes one multiple event, action, or state. In the case of propose marriage ⇒ a couple gets married, not only proposing marriage but also accepting the proposal are necessary for a couple to get married. But the phrase pair has causality, since the probability of a couple’s getting married is higher when marriage is proposed than when it is not proposed.

Note 2: A phrase pair that represents “causality” that is too exceptional or has no generality should be judged as non-causality. Istvan joins dinner ⇒ a vegetarian menu is adopted is an example.

Note 3: A phrase pair that represents “causality” with which not all persons agree should be judged as causality if you find evidence for it. drink black oolong ⇒ interfere with fat absorption is judged as causality if you find descriptions that validate its ability to interfere with fat absorption.

Note 4: A phrase pair may contain a noun that is semantically ambiguous. In that case, base your judgment on the most plausible sense for the noun given the meaning of the phrase pair. In the case of burden is imposed ⇒ suffer backache, burden should be interpreted as physical rather than psychological or economical.

Note 5: Compound nouns in the phrase pairs are split into base form single morphemes. Interpret them as if their morphemes have proper conjugation forms.

Note 6: Some phrase pairs were assigned irrelevant sentences as their origin, which was cased by a bug in the web corpus construction. In that case, do not consider the wrong sentences for making judgments.

Figure III: English translation of annotation manual for causality extraction experiments
Task
Classify phrase pairs that consist of a noun and a template such as smoke cigarettes ⇒ get lung cancer, smoke cigarettes ⇒ get healthy, and smoke cigarettes ⇒ go to work as causality or not. The following are the classification criteria:

Causality A phrase pair such that the probability of the event, action, or state denoted by the right-side phrase becomes higher when the event, action, or state denoted by the left-side phrase happens compared to when it does not happen. Note that the event of the left-side phrase temporally precedes that of the right-side phrase.

Non-causality A phrase pair such that the probability of the event, action, or state denoted by the right-side phrase becomes higher when the event, action, or state denoted by the left-side phrase does not happen compared to when it happens. Alternatively, a phrase pair such that the left-side phrase’s event, action, or state does not affect the probability of the right-side phrase’s event, action, or state.

You may use the following linguistic test to make judgments by putting the left- and right-side phrases in the question into X and Y and checking whether the resulting sentence is valid; causality if it is valid, and non-causality otherwise. Linguistic test: “Y becomes more likely when X happens compared to when X does not happen.” (X is the event, action, or state denoted by the left-side phrase, and Y is the event, action, or state denoted by the right-side phrase.)

Each line of the annotation file consists of columns: “Phrase 1,” “Phrase 2,” “Original Phrase 1,” “Original Phrase 2,” and “Source Sentence of Original Phrases 1 and 2.” Judge whether “Phrase 1” is a cause of “Phrase 2.” They were automatically generated from “Original Phrase 1” and “Original Phrase 2,” which were extracted from the “Source Sentence of Original Phrases 1 and 2.” When making judgments, check “Original Phrase 1,” “Original Phrase 2,” and the “Source Sentence of Original Phrases 1 and 2” and consider the meaning of the nouns and predicates in them. You may consult the web for the meaning of the phrases. However, do not consult other annotators. You may use the label ‘undecided’ when you are not sure about the causality status of the phrase or when you think that a phrase is too unnatural or awkward in Japanese.

(Read also Causality Annotation Manual.)

(The same six notes written in the manual for causality extraction in Fig. III follow.)

Figure IV: English translation of annotation manual for causality hypothesis generation experiment.