

Focus, Repacking, and the Judgment of Grouped Hypotheses

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ABSTRACT

Previous research has found that judged probabilities of two complementary singleton hypotheses sum to one. However, there may be important differences between judgment of singleton and disjunctive hypotheses. We suggest that because of a general preference for singletons as the focus of judgment, disjunctions are more likely to be repacked into singletons when focal than when alternative. This prediction of *differential repacking* implies that a given disjunction will be perceived as less likely when focal. Thus, we predict that when disjunctions are under consideration, the sum of judged probabilities for two complementary hypotheses will be less than one. We observe this pattern in judgment of both probability and relative frequency, and for both externally-generated and self-generated hypotheses. Copyright © 1999 John Wiley & Sons, Ltd.

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Consider asking ‘how likely is it that the next President will be a Democrat rather than a Republican or Independent?’ In contrast, consider asking ‘how likely is it that the next President will be a Republican or an Independent rather than a Democrat?’ These two questions differ in terms of which hypothesis is focal and which is alternative. The first question places the singleton hypothesis *Democrat* in the focal position and the disjunctive hypothesis *Republican or Independent* in the alternative position. The second question reverses this assignment.

Whether a hypothesis is focal or alternative may have different consequences for the evaluation of singleton and disjunctive hypotheses. Our analysis of this issue invokes two concepts: *unpacking* and *repacking*. Many studies have revealed that unpacking a singleton to form a coextensional disjunction increases judged likelihood. For instance, Rottenstreich and Tversky (1997) found that the judged frequency of deaths due to *homicide* was substantially lower than the judged frequency of deaths due to *either homicide by an acquaintance or homicide by a stranger* (for many other examples see Teigen, 1974a,b; Russo and Kolzow, 1994; Johnson *et al.*, 1993; Fischhoff, Slovic and Lichtenstein, 1978). Tversky and Koehler (1994) suggest that two psychological processes underlie the unpacking effect. First, unpacking a singleton into a disjunction may remind people of possibilities that would otherwise

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be overlooked. Second, the explicit mention of a particular component of a disjunction tends to increase its salience and hence its impact.

The inverse of unpacking is repacking. The studies cited above reveal that when a judge confronts an unpacked disjunction she is more likely to consider each of the listed possibilities than when she confronts a coextensional packed singleton. However, a judge presented with a disjunction may nevertheless ignore this formulation and consider the disjunction as if it were a singleton. Take, for example, the probability that a particular student majors in *chemical, industrial, mechanical, civil, or electrical engineering*. A judge presented with this hypothesis may find consideration of each individual discipline unwieldy, and consequently repack these disciplines to evaluate the singleton *engineering*. Because unpacking increases perceived likelihood, repacking decreases perceived likelihood. That is, a disjunction will be seen as relatively less likely to the extent it is repacked (see Rottenstreich and Tversky, 1997).

Does the position of the hypothesis (focal or alternative) affect the degree of repacking? We suggest that there may be a preference toward singletons in the focal position. For example, judging the probability that *Titanic* will win Best Picture rather than *either As Good As it Gets, Good Will Hunting, L. A. Confidential, or The Full Monty* seems quite natural. However, judging the probability that *either As Good As it Gets, Good Will Hunting, L. A. Confidential, or The Full Monty* will win Best Picture rather than *Titanic* seems more unwieldy. Put differently, it seems natural to compare the likelihood of a single possibility to that of a set of alternatives. On the other hand, it seems awkward to compare the likelihood of a set of possibilities to that of a single alternative. As a result, there may be a greater tendency to repack *either As Good As it Gets, Good Will Hunting, L. A. Confidential, or The Full Monty*, and more generally any disjunction, when it is in the focal than in the alternative position.

In testing for such *differential repacking* between focal and alternative disjunctions, we make use of a property called *binary complementarity*. Letting $P(A, B)$ denote the judged probability of A rather than B for disjoint hypotheses A and B , binary complementarity is the requirement that $P(A, B) + P(B, A) = 1$. That is, complementary probabilities should sum to one. Several researchers have found compelling evidence for the descriptive validity of binary complementarity (Fox, Rogers and Tversky, 1996; Redelmeier *et al.*, 1995; Tversky and Koehler, 1994; Wallsten, Budescu and Zwick, 1992). Interestingly, however, these researchers examined judgments involving only singleton hypotheses, and did not study judgments involving disjunctions.

The binary complementarity of singleton–singleton judgments is consistent with differential repacking, because with singletons there is simply nothing to repack. However, whenever a singleton S and a disjunction D are under consideration, differential repacking implies that the perceived likelihood of the disjunction will be lower in the focal than in the alternative position. As a result, we may observe departures from binary complementarity of the form $P(S, D) + P(D, S) < 1$. In the following experiments, we test the dual predictions of binary complementarity for singleton–singleton judgments, and violations of binary complementarity for singleton–disjunction judgments.

EXPERIMENT 1

We presented 147 Stanford undergraduates with a four-item questionnaire included in a packet consisting of several unrelated tasks. Subjects made judgments of the percentage of Stanford alumni working in various occupations. Subjects in the Singleton condition ($n = 75$) made judgments involving two singletons. For example, the first item encountered by these subjects was one of the following:

Consider Stanford alumni working as one of the following: **professor, engineer**. What percentage of these alumni are **professors** rather than **engineers**?

Consider Stanford alumni working as one of the following: **professor, engineer**. What percentage of these alumni are **engineers** rather than **professors**?

Note that the first question makes *professor* focal and *engineer* alternative, while the second question does the reverse.

For subjects in the Disjunction condition ($n = 72$), one of the singletons was replaced by a related disjunction. The first item encountered by these subjects was one of the following:

Consider Stanford alumni working as one of the following: **professor, electrical engineer, mechanical engineer, aeronautical engineer**. What percentage of these alumni are **professors** rather than **electrical, mechanical, or aeronautical engineers**?

Consider Stanford alumni working as one of the following: **professor, electrical engineer, mechanical engineer, aeronautical engineer**. What percentage of these alumni are **electrical, mechanical, or aeronautical engineers** rather than **professors**?

Note that in the first Disjunction question, a singleton is focal and a disjunction is alternative, while the reverse is true of the second Disjunction question. Subjects in the Disjunction condition made either only singleton-focal or only disjunction-focal judgments for all four questions.

We predict that the sum of the judgments will be approximately equal to one in the Singleton condition (where there is nothing to repack), and less than one in the Disjunction condition, where the repacking of the disjunction may be more pronounced in the focal than in the alternative position.

Results

The results, displayed by item in Exhibit 1, support our predictions. Overall, the sum of mean judgments in the Singleton condition was 0.98, while the sum of mean judgments in the Disjunction condition was only 0.90, revealing a violation of binary complementarity ($t(67) = 2.51, p < 0.05$). Moreover, the observed departure from binary complementarity is consistent with our analysis that repacking of disjunctions is more likely for focal than for alternative disjunctions. The average probability assigned to a focal singleton hypothesis pitted against an alternative disjunction was 0.27, implying a probability assignment of 0.73 to the alternative disjunction. However, when the disjunctions were focal they received an average probability of only 0.63 rather than 0.73. Evidently, there is a tendency to view a disjunction as relatively less likely when it is focal.

Exhibit 1. Mean judgments in Experiment 1

Problem	Singleton			Disjunction		
	$P(S_1, S_2)$	$P(S_2, S_1)$	Sum	$P(S_1, D)$	$P(D, S_1)$	Sum
Professor/engineer	0.28	0.68	0.96	0.25	0.72	0.97
Consultant/doctor	0.43	0.55	0.98	0.31	0.60	0.91
Programmer/financial	0.49	0.51	1.00	0.33	0.47	0.80
Salesperson/lawyer	0.29	0.69	0.98	0.22	0.72	0.94
Average	0.37	0.61	0.98	0.27	0.63	0.90

Notes: Subjects in the Singleton condition judged only singleton hypotheses, denoted S_1 and S_2 ; subjects in the Disjunction condition judged S_1 and a disjunction related to S_2 , denoted D . The disjunctions for the four problems were: electrical engineer, mechanical engineer or aeronautical engineer; family doctor, orthopedic surgeon, cardiologist, or dentist; stockbroker, bond trader, banker, or securities analyst; corporate lawyer, criminal lawyer, or tax lawyer.

EXPERIMENT 2

In Experiment 1, the objects of judgment, whether singletons or disjunctions, were pre-selected by the experimenters and then presented to the subjects. Often, however, a judge must herself generate the relevant possibilities before judging their likelihood. Accordingly, in the present experiment the subjects themselves generated the possibilities to be judged.

Sixty-seven Stanford students completed a short questionnaire as part of an hour-long session involving several unrelated tasks. In the Singleton condition, subjects were asked to provide a single member of various familiar categories. They were told to write down the first member of the category that came to mind. Categories considered included musical instruments, cable TV networks, airlines, cities in Texas, fruits, spices, salad dressings, team sports, internal organs, geometric figures, playwrights, and states in the eastern United States. After providing a response for a particular category, subjects either estimated the percentage of other subjects giving the Same answer ($n = 19$) or estimated the percentage of other subjects giving a Different answer ($n = 18$).

In the Disjunction condition subjects were asked to provide the first category member that came to mind as well as three additional category members. Four blanks, numbered 1 through 4, were provided. The first blank was preceded by the label 'First answer'; the remaining three blanks were on a single line labeled 'Other answers'. After providing four responses for a particular category, subjects either estimated the percentage of other subjects giving the Same *first* answer ($n = 14$) or the percentage of other subjects giving a Different *first* answer ($n = 16$).

We predict that the sum of the mean Same and Different judgments will be equal to one in the Singleton condition but less than one in the Disjunction condition. In the Singleton condition subjects must judge the likelihood of their chosen answer against the likelihood of the singleton hypothesis 'all other answers'. Judging the percentage of other subjects choosing the same answer obviously places that answer in focus, while judging the percentage of other subjects choosing a different answer places the singleton 'all other answers' in focus. In this case there is nothing to repack, and we expect to observe sums of judgments approximately equal to one.

In the Disjunction condition, however, subjects must judge the likelihood of their first answer against the likelihood of the disjunction composed of each of the other answers they have written down and all other possible answers. That is, when subjects write down three other answers, the singleton 'all other answers' has been unpacked into a disjunction. In this case, we expect to observe differential repacking, and sums of Same and Different judgments to be less than 1.

Results

To properly compare responses in the Same and Different conditions, we only consider answers for each category that were listed at least once in both the Same and the Different conditions. To illustrate, note that if a subject answered 'ukulele' for the category 'musical instrument' in the Same condition, but no subject answered 'ukulele' in the Different condition, no test of binary complementarity can be applied. On the other hand, if some subjects answered 'piano' in the Same condition, and others answered 'piano' in the Different condition, binary complementarity can be evaluated. As a result, we can compare only judgments for answers common to the Same and Different conditions. Overall, there were 73 common responses in the Disjunction case, and 62 common responses in the Singleton case. These common responses constitute roughly 80% of all responses gathered.

The results, controlling for the responses made in both conditions, are listed in Exhibit 2. The sum of mean judgments in the Singleton condition was exactly 1, while the sum of mean judgments in the Disjunction condition was only 0.90 ($t(72) = 4.6, p < 0.001$). Analysis of the individual responses also reveals this pattern. Of the 62 common Singleton responses, 33 yielded sums of Same and Different

Exhibit 2. Means (and SDs) of judgments in Experiment 2, controlling for common answers in the Same and Different conditions

	Singleton (List 1)	Disjunction (List 4)
Same	0.36 (0.19)	0.32 (0.21)
Different	0.64 (0.16)	0.58 (0.20)
Sum	1.00	0.90

judgments less than one, while 29 yielded sums greater than or equal to one. In contrast, of the 73 common Disjunction responses, 53 yielded sums of Same and Different judgments less than one, while 20 yielded sums greater than or equal to one.

Again, we have evidence of systematic violations of binary complementarity consistent with differential repacking. Note that the tendency to view the same disjunction as less likely when focal than when alternative creates a counter-intuitive result: a judge implicitly believes that a greater proportion of other subjects chose the same answer when focusing on the proportion that chose a different answer.

EXPERIMENT 3

In this experiment we consider an application of differential repacking to the study of confidence in knowledge. We presented 199 Stanford undergraduates with a general-knowledge quiz consisting of twelve items concerning world history, politics, geography, literature, and popular culture. For example, one question asked which state was represented by Robert Kennedy in the United States Senate.

Subjects answered the 12 general knowledge questions and also assessed their confidence in their answers. In the Two-Answer Forced-Choice (2AFC) condition, each question was followed by two possible answers. For instance, the two candidate answers for the Robert Kennedy question were New York and California. Subjects were instructed to circle the answer they thought was the right one, then to rate either the probability that their chosen answer was correct ($n = 55$), or the probability that their chosen answer was wrong ($n = 66$).

Following Koehler (1994), we also included a Generate (or 'fill-in-the-blank') condition, where for each question subjects provided an answer, and subsequently rated either the probability that their answer was correct ($n = 37$), or the probability that their answer was wrong ($n = 41$). The quiz was constructed so that several possible answers could come to mind for each question. Confronted with the question of which state RFK represented in the Senate, for example, subjects may have considered California and New York, but could also consider the possibility that RFK represented Massachusetts, Connecticut, Rhode Island, or some other state. Thus, whereas in Experiment 1 we pre-selected the items to be judged while in Experiment 2 subjects generated these items themselves, the present experiment consisted of one condition of each type.

We predict that the 2AFC condition will produce sums of probability-correct and probability-wrong equal to one, because the objects of judgment (the chosen and non-chosen answers) are both singletons. Indeed, Snizek, Paese and Switzer (1990) found complementarity in judgments of $P(\text{correct})$ and $P(\text{wrong})$ for 2AFC tasks.

On the other hand, we predict that the Generate condition will produce $P(\text{correct}) + P(\text{wrong}) < 1$, because one of the objects of judgment is a disjunction. Judging probability correct makes the chosen answer focal and the disjunction of considered but non-chosen answers alternative. Judging probability wrong moves the focus from the singleton chosen answer to the disjunction of considered but non-chosen answers. Thus, differential repacking has an opportunity to operate in the Generate

condition. To the extent that there is differential repacking we can expect the disjunction of non-chosen answers to be perceived as less likely when judging $P(\text{wrong})$ than when judging $P(\text{correct})$.

Results

Exhibit 3 contains the mean $P(\text{correct})$ and $P(\text{wrong})$ judgments for each question and condition. As expected, we observe approximate binary complementarity in the 2AFC case; the average sum of $P(\text{correct})$ and $P(\text{wrong})$ judgments is 0.97, quite close to 1. In contrast, in the Generate condition, the average sum of the $P(\text{correct})$ and $P(\text{wrong})$ judgments is 0.90, substantially less than 1.00 ($t(76) = 2.39, p < 0.05$). Again, we have systematic departures from binary complementarity consistent with differential repacking. In the Generate condition we observe the surprising pattern that confidence in the chosen answer is actually greater when we ask subjects about the probability that they made a mistake (the mean $P(\text{wrong})$ of 0.50 implies a $P(\text{correct})$ of 0.50) than when we ask subjects about the probability that they in fact chose correctly (the mean $P(\text{correct})$, however, was only 0.40). Once more, disjunctions are perceived as less likely when focal than when alternative.

The present results are somewhat similar to the work of Yaniv and Schul (1997), who found that in evaluating possible answers to knowledge questions, selecting likely items is not the complement of rejecting unlikely items. These authors asked some subjects to select candidates that were likely to be the correct answer, and other subjects to reject items that were unlikely to be correct. They found that the sum of the proportion of selected items and the proportion of rejected items was typically less than 1.

GENERAL DISCUSSION

Our results show a consistent pattern. Sums of judgments for complementary hypotheses are close to 1 when the hypotheses are singletons, and are less than 1 when one of the hypotheses is a disjunction. We observe this pattern in judgments of probability and frequency, and for judgments involving both externally and self-generated hypotheses. We attribute this result to differential repacking.

Exhibit 3. Means of judged $P(\text{correct})$ and $P(\text{wrong})$ for the twelve general knowledge questions in Experiment 3

Question topic	2AFC			Generate		
	$P(\text{correct})$	$P(\text{wrong})$	Sum	$P(\text{correct})$	$P(\text{wrong})$	Sum
World's smallest country	0.78	0.21	0.99	0.41	0.45	0.86
1st US President not born in colonies	0.74	0.22	0.96	0.14	0.81	0.95
Largest Mediterranean island	0.67	0.30	0.97	0.44	0.51	0.94
New England state without coastline	0.72	0.24	0.96	0.44	0.40	0.84
Year <i>Rain Man</i> won Best Picture	0.77	0.22	0.99	0.37	0.52	0.89
Location of Myrtle Beach	0.68	0.31	0.99	0.52	0.48	1.01
Author of <i>Ode on a Grecian Urn</i>	0.81	0.23	1.04	0.37	0.61	0.98
Robert Kennedy senatorial state	0.68	0.23	0.91	0.35	0.48	0.83
Location of Fort Knox	0.77	0.19	0.96	0.45	0.43	0.88
US President when Castro took power	0.66	0.27	0.93	0.34	0.47	0.81
Great Lake bordering Cleveland	0.63	0.31	0.94	0.37	0.48	0.85
Least-used letter in English	0.70	0.30	1.00	0.58	0.37	0.95
Average	0.72	0.25	0.97	0.40	0.50	0.90

Determinants of unpacking and repacking

This research has centered on one factor, whether a hypothesis is focal or alternative, that appears to affect the repacking of disjunctions. Recent work on likelihood judgment has been concerned with other factors that affect unpacking and repacking. Tversky and Koehler (1994), for example, noted that the size of their observed unpacking effects increased with the number of components in the unpacked descriptions. Unpacking causes of death into seven components yielded larger discrepancies between judged probabilities for singletons and for disjunctions than did unpacking causes of death into three components.

Rottenstreich and Tversky (1997) manipulated the similarity between components of a disjunction, and found that the tendency to repack was greater when components were more similar to each other. Thus, a disjunction such as *homicide in the daytime or homicide at night* tends to be repacked more readily than a disjunction such as *homicide by an acquaintance or homicide by a stranger*, because the former two components evoke similar images, while the latter two evoke quite disparate images.

Koehler, Brenner and Tversky (1997) noted that the strength of the focal hypothesis may affect the degree of discounting of the alternative hypothesis. They found that the alternative hypothesis received less weight to the extent that the focal hypothesis was strongly supported by the relevant evidence. For example, the degree of repacking or unpacking of a residual hypothesis (e.g. *not-psychology*) depends on the strength of the focal hypothesis (e.g. *psychology*).

The present results suggest that focus is yet another factor that affects the repacking of disjunctions. This particular factor is especially noteworthy because it entails a violation of binary complementarity, among the simplest rules of consistency in likelihood judgment. The presence of such violations is troubling in that one cannot take, say, a judged probability of a *Democratic victory* of 40% as implying a 60% probability of a *Republican or Independent victory*. Indeed, we have observed that when *Republican or Independent victory* is made focal, the elicited probability may well fall below the required 60%. Thus, just as the method used to elicit preferences partially determines the observed preferences (Grether and Plott, 1979; Lichtenstein and Slovic, 1971, 1973; Shafir, 1993), a judge's subjective belief may vary with the method used to elicit belief, as one hypothesis or the other is made focal.

AUTHOR NOTES

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