The Subjective Probability of Conjunctions

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Abstract

Previous experiments have demonstrated but not explained people's tendency to exaggerate the probability of conjunctive events. The present study explores this tendency in several different contexts designed to reveal how the overestimation process works; the events which served as stimuli were either repetitive or unique with or without causal links between them. The design was either a within-subject or a between-subject design. The response mode was either percentages or chances. The results suggest that people use different strategies to assess conjunctions in different situations, all of which lead to overestimation. These processes are discussed and some suggestions are made about ways to overcome their negative effects.

The Subjective Probability of Conjunctions

People's tendency to overestimate the probability of conjunctive events has been demonstrated in a number of studies. Bar-Hillel (1973), Cohen and Hansel (1978), and Slovic (1969) have used common gambling situations and choice between gambles as a response mode. As such, these experiments were quite restrictive in their possible applications and indirect in the way overestimation was inferred. Furthermore, none of the above experiments tried to explain the overestimation they found.

Goldsmith (1978) and Wyer (1970; 1976; also Wyer, & Goldberg, 1970) used a more natural and direct manipulation. Both had subjects assess the probability of conjunctive events with Wyer using a general social context (e.g., "What is the probability that Governor Smith will be reelected and that state aid to education will be increased?") and Goldsmith using a judicial context (e.g., "What is the probability that the lighter belonged to the accused who also left it in the car?"). After testing a variety of models, Wyer (1976) found that subject's overestimated responses were best fitted by a combination of multiplying and averaging:

$$P(A \cap B) = \frac{1}{2}\left[\frac{P(A) + P(B)}{2} + P(A)P(B)\right]$$

Although such an algebraic model may predict subjects' assessments, it gives little psychological insight into how people perceive conjunctive events or why they overestimate their probability.

Goldsmith (1978) concluded that subjects use different strategies for assessing a conjunction, depending on the components' order of magnitude, i.e., how large or small are the assessed $P(A)$ and $P(B/A)$. They are: (a) an averaging strategy (using the average of the two components as a cue) when the two components' probabilities are between .3 and .7, (b) a smaller probability strategy (using as cue whichever of the two components is smaller) when the larger of the components' probabilities exceeds .7, and (c) the larger probability strategy (using as cue whichever is larger) when the larger of the components' probabilities lies below .7 and the smaller lies below .3. As subjects assessed the conjunctive event after assessing its components, the compound character of the event was emphasized and subjects were actually compelled to use a recomposition strategy; that is, assessing the compound event by way of aggregating the assessed components' probabilities. This, however, may not have been their only available strategy. Whether a conjunctive event is perceived as a compound or a simple event may depend on the experimental manipulation (e.g., does assessment of the component events preceed the evaluation of the compound), and in itself may affect the assessment strategy.

How the event is perceived may affect the choice of assessment strategy in another respect. Kahneman and Tversky (1972, 1973) and Tversky and Kahneman (1980) have claimed that when people perceive an event as unique, they do not rely on relative frequency considerations when judging its probability, but adopt a number of heuristics. Thus, whether an event is perceived as unique or repetitive may affect the judgmental process; this is a second variable assumed to affect the judgment of conjunctive events.

The following experiments explore probability assessment for conjunctive events in several contexts and under different experimental manipulations designed to highlight the working of the overestimation process. Experiment 1-4 deal with events for which it is meaningful to interpret probability as relative frequency ('repetitive event'). In Experiments 1 and 2 a between-subject design was adopted; one group of subjects assessed the probability of conjunctive events while different groups assessed the components' probabilities. In these two experiments, the subjects' response mode was also manipulated. In a within-subject design (Experiments 3 and 4), subjects were asked to assess the probability of the conjunctive event as well as its components' probabilities.

Experiments 5 and 6 deal with highly unique events. In Experiment 5, subjects were asked about the probability that a given individual would perform two related or unrelated acts. In Experiment 6, subjects were asked about the probability of two events, A and B. The pairs of events chosen for this experiment were such that A was perceived as causing B and B was perceived as preventing A.

EXPERIMENT 1 AND 2: A BETWEEN-SUBJECT DESIGN

The first two experiments were designed to test whether subjects overestimate the probability of conjunctive events even when they don't assess the components' probabilities in advance. The stimuli were repetitive events in which it was natural to interpret probabilities as relative frequency. Here one can either ask subjects about the probability of an event or about its relative frequency of occurrence thus manipulating the response mode. In Experiment 1, subjects were asked to assess probabilities. In Experiment 2, different subjects were asked to assess relative frequency. Otherwise the design of the experiments was identical. To avoid complexity, the experiments will be described sequentially except for the discussion which will be combined and presented following the results of Experiment 2.

Experiment 1: Probability as Relative Frequency

Method

Stimuli. The following sample space was chosen: All male Israeli citizens above 18 years of age. From this sample space, fourteen pairs of events were selected, each event consisting of randomly sampling an individual with a specific characteristic. In half of the pairs, the two characteristics were independent of each other and in the second half, there was a small causal dependency between them. An example of an independent pair:

A - Men who weigh less than 95 kg.

B - Men who have at least a high school education

An example of a dependent pair:

A - Men who are married

B - Men who have life insurance

Pairs were constructed to vary in the relative frequency of subgroups A and B and in the strength and direction of dependency between the events (A and B) in the dependent pairs.

Design and procedure. For each pair of events the percentages of A, B, A given B, B given A, (A&B) and (B&A) in the given sample were assessed. Each of these percentages was assessed for all events by a separate group of subjects. Each group received a questionnaire with one page of instructions. The first paragraph was the same for all questionnaires, "A certain governmental office collected information about all male Israeli citizens above 18 years of age." Subjects were then told what particular percentage they were to estimate and given one example. Finally, subjects were told, "We don't expect you to know the exact answer to the above questions and many similar ones. We are only interested in your estimates concerning the percentage. Please answer in percentages; give any number between 0 (in the above population there is no one with this characteristic) and 100 (all the above population have this characteristic)."

The instructions to the specific tasks were as follows:

Group (A,B): The middle paragraph read: "In the following questionnaire, there are a number of questions in which you are asked to assess the percentage of men from the defined population possessing a certain characteristic. For example: 'Of all male Israeli citizens above 18 years of age, what percentage are teachers?'" Following this instruction, subjects received 4 pages of questions, with 7 questions on each page. The order of questions was randomized and the 4 pages were given in a different order to different subjects.

Groups ($A \cap B$) and ($B \cap A$): The middle paragraph for these groups read: "In the following questionnaire, there are a number of questions in which you are asked to assess the percentage of men from the defined population possessing certain characteristics. For example, 'Of all male Israeli citizens above 18 years of age, what percentage are both teachers and divorced?'" Two pages of seven questions each followed the instruction page. The order of questions was randomized and the order of the two pages was reversed for half the subjects.

The only difference between the two groups was the order of events within each pair. For example, in one group, the question was "What percentage are teachers and are divorced," and in the second group, the question was "What percentage are divorced and are teachers?".

Groups (A/B) and (B/A): The middle paragraph for these groups read: "In the following questionnaire there are a number of questions in which you are asked to think about a sub-group of the above defined population, and assess the percentage of men from this sub-group possessing a certain characteristic. For example: 'Of all divorced men, what percentage are teachers?'" The only difference between the two groups was in the order of events within each pair. The method of ordering and presenting the different questions was the same as for the previous two groups.

Subjects. One hundred fifty-seven soldiers (candidates for an officer's training course) took part in the experiment. The different questionnaires were distributed randomly among the subjects: N(A,B)=32, N(A∩B)=32, N(B∩A)=30, N(A/B)=32, N(B/A)=31.

Results

For each question in each group, median estimates were computed. As no significant differences were found between the (A∩B) estimate and the (B∩A) estimate in 13 out of 14 questions, the data from groups (A∩B) and (B∩C) were combined (see Table 1).[1] They are referred to as (A∩B).

Insert Table 1 about here

Normatively, P(A∩B) = P(A/B)P(B) = P(B/A)P(A). However, in all 14 cases the median percentages of (A∩B) were greater than the product of the median estimates for (A/B) and (B); in 12 of 14 cases they were greater than the product of the medians for (B/A) and (A), and in 13 of the 14 cases they were greater than the average of both products as shown in column 6 of Table 1.

A more modest normative requirement is that the conjunction be the smallest of all 5 estimates [P(A), P(B), P(A/B), P(B/A), P(A∩B)]. Examination of Table 1 reveals that this typically is the case. The last row presents mean ranks of the 5 estimates over the 14 rows.

No differences between responses to the dependent and independent events were detected.

Experiment 2: Probability Defined as Chance

Method

The only difference between Experiment 1 and 2 was that subjects were asked about the chances of events happening and not about their relative frequency. The first paragraph of the instruction page read:

> In a certain governmental office, there is a computer which stores a list of all male Israeli citizens above 18 years of age. One of the employees in the office is interested in getting a name of a person who is randomly selected by the computer out of its sorted list. In the following questionnaire, you will find a number of questions in which you are asked to assess the chance that the computer will randomly choose a person with a defined characteristic.

After this paragraph, a different example was given to each group.

Group (A,B). "What is the chance that the man chosen randomly by the computer is a teacher?"

Groups ($A \cap B$) and ($B \cap A$). "What is the chance that the man chosen randomly by the computer is a teacher and is divorced?"

Groups (A/B) and (B/A). "Assume that the man whom the computer randomly chose is a teacher. What is the chance that the same man is also divorced?"

Finally, all subjects were told: "We are interested in your estimation concerning the chances. Give any number between 0 (no chance) and 100 (for sure)."

Subjects. One hundred twenty-seven students from the School of Education and the School of Occupational Therapy in Jerusalem participated in the study. The questionnaires were randomly distributed between the subjects: $N(A,B) = 29$, $N(A \cap B) = 25$, $N(B \cap A) = 26$, $N(A/B) = 25$ $N(B/A) = 22$.

Results

The same analyses were performed here as in Experiment 1. Again, group $(A \cap B)$ and $(B \cap A)$ were combined, with no significant difference between $(A \cap B)$ and $(B \cap A)$ estimates in 13 of 14 questions. Table 2 presents medians.

Insert Table 2 about here

In every case, the median estimate of the conjunction (column 5) was greater than the mean of the two normative equivalents (column 6). The size of this effect (as expressed by the difference between columns 5 and 6) was greater here than in Experiment 1 (Mann-Whitney $U = 10$, $p < 0.05$). Indeed, the conjunction was so overestimated that it was not the smallest of the probabilities (see last row in Table 2). Whereas the estimates for (A), (B), (A/B), and (B/A) differed significantly between the two experiments (the Wilcoxon matched-pairs signed-ranked test)[2], estimates of $(A \cap B)$ were much greater in Experiment 2 ($T = 0$, $p < 0.0001$).

Again, there was no difference between the dependent and independent pairs.

Discussion of Experiments 1 and 2

With both response modes subjects overestimated the conjunction, however, the bias was larger when subjects were asked about chances than when asked about percentages. Although in Experiment 1 the conjunction was overestimated, it's relative frequency was still perceived as smaller than the relative frequency of each one of the components. This, however, was not the case in Experiment 2. Here subjects did not judge the probability of the conjunctive event as smaller than the probabilities of the components. This difference between the two experiments refutes one possible explanation as being the sole explanation for the over-confidence. According to it people do perceive the conjunction as the event with the smallest probability but as they tend to overestimate small numbers (Attneave, 1953; Muller, & Edmonds, 1967) the probability of the conjunction is overestimated. This can explain the results of Experiment 1 but not of Experiment 2.

Why is the conjunction overestimated more in Experiment 2 than in Experiment 1? One possible explanation assumes that subjects adopte a different strategy when assessing probability than when assessing percentages, even when the events in question are the same repetitive events. According to this explanation, the translation of a probability question about a specific person (What are the chances that he wears glasses?) into a relative frequency question about a population (What percentage of all people wear glasses?) is not immediate and natural, and not done often by subjects. Furthermore, when thinking about percentages, there is no reason to assume that subjects decompose the conjunctive event before estimating its relative frequency even though it may appear to them that the conjunction event has a smaller relative frequency than either of the component events. For the subjects there is no essential difference between a component event and a compound one.

This assumption may not hold for subjects who are asked to assess probabilities. For them, it may not seem obvious that the probability of a conjunctive event must be smaller than the components' probabilities. They also may find it more difficult to assess the probability of a conjunctive event than the probability of a component event, regardless of the interpretation they give to the probability question (as long as it is not consistently a relative-frequency interpretation). To overcome this difficulty, they may have decomposed the conjunctive event into its elements (A and B), assessed the relative probabilities and then recomposed the estimates in an inappropriate manner, thus giving biased conjunctive estimates. There is no reason to believe that subjects intuitively adopt a multiplication formula for aggregating the components' probabilities. Simple additive models will result in probabilities not significantly smaller than the components' probabilities. The assumed inappropriate integration of the assessed elements' chances is tested in Experiments 3 and 4.

EXPERIMENTS 3 AND 4: A WITHIN-SUBJECT DESIGN

Experiments 3 and 4 examined the integration process with a within-subject design. Each subject was given information about the chances of three events [e.g., (B/A), (A), (B)] and asked to assess the chances of a fourth [e.g., ($A \cap B$)]. In such a design, any bias in the estimates can be blamed upon a wrong integration since the decomposition was already done by the experimenter. In the discussion of Experiment 2, it was assumed that subjects perceived the conjunctive event as a compound one and therefore used the "decomposition-recomposition" strategy. No such strategy was assumed to be adopted for the evaluation of P(A), P(B), P(A/B), and P(B/A). However, in a within-subject design, in which subjects are presented with the probabilities of the essential components, any probability can be assessed by the "decomposition-recomposition" strategy depending on the experimental manipulation [e.g., present P(A/B), P($A \cap B$) and ask about P(B)]. Thus, in Experiments 3 and 4 subjects were asked to assess either the conjunctive event [given P(A), P(B), and one conditional] or the conditional one [given

P(A), P(B), and the conjunction].

Experiments 3 and 4 use somewhat different stimuli. The same demographic variables used in Experiment 1 and 2 were employed in Experiment 3, whereas Experiment 4 used symbolic variables in order to prevent subjects from using outside information not given by the experimenter. As with Experiments 1 and 2, the two following experiments will be described sequentially except for the discussion which will be presented, for both, following the results of Experiment 4.

Experiment 3: Demographic Variables

Method

Stimuli. The median percentages of (A), (B), (A/B), and (B/A) from Experiment 2 were given to subjects in this experiment. Rather than using the too-high median conjunctive estimates from that experiment, new ones were computed by taking $\frac{P(A/B)P(B) + P(B/A)P(A)}{2}$ for each pair of events and multiplying it by 100 to get percentages.[3]

Design and procedure. Four groups of subjects were given different combinations of the above information and were asked to estimate the likelihood of different events. Each group of subjects received 14 questions comprised of a set of data, and a request to estimate a missing datum. Three pieces of information were presented in each question: P(A), P(B), and one of the following three: P(B/A) in group 1, P(A/B) in group 2, and $P(A\cap B)$ in groups 3 and 4. The estimated datum was one of three: $P(A\cap B)$ in groups 1 and 2, P(B/A) in group 3, and P(A/B) in group 4. Each of the seven question pages contained a dependent and an independent question, they were randomly ordered for different subjects. All subjects received the same instructions:

> In a certain governmental office, there is a computer which stores a list of 100,000 men. Upon instruction, the computer

randomly chooses a name of a person from this list. In every one of the following questions, you will be given data about the chances of the computer to actually randomly choose a name of a person with one or more specific characteristics. With the help of this data, you will be asked to estimate the chances that the computer will randomly select a person with a characteristic related to those mentioned in the data. You are requested to rely only on the given data and not on any information you think you have. We don't expect you to know the exact answer to the questions; we are only interested in <u>your</u> estimates concerning the chances of such events. Please write your answers in percentages: give any number between 0 (no chance whatsoever) and 100 (for sure).

<u>Subjects</u>. One hundred first-year students in the Geography Department and School of Education in the Hebrew University in Jerusalem participated in this experiment. The experiment was administered as the previous ones, resulting in: $N_1 = 27$, $N_2 = 27$, $N_3 = 20$, $N_4 = 26$.

<u>Results</u>

The first three columns of Table 3 show the data presented to groups 1 and 2; column 4 presents the median estimated conjunction; column 5 presents the computed conjunction. Table 4 presents the data presented to groups 3 and 4 (columns 1, 2, and 3), the median estimated conditionals (column 4), and the computed conditionals (column 5).

Insert Tables 3 and 4 about here

The most striking results were the similarities between the conditionals given and the conjunctions estimated in Table 3 and between the conjunctions given and the conditionals estimated in Table 4. In 7 out of 28 cases, in Table 3, the median estimated conjunction is identical to the given conditional. Even more prominent is the situation observed in Table 4: In 12 out of 28 comparisons, the median estimated conditional is identical to the given conjunction and in 3 more cases, it is higher in one percent only.

Groups 1 and 2 (Table 3). Column 6 presents for each question the proportion of subjects whose estimated conjunctions was smaller than the given conditional; column 7 presents the results of a binomial test on each proportion. In 13 out of 28 cases, the estimated conjunction was as likely to be larger as to be smaller than the given conditional, reflecting the overestimation of the conjunction. For 14 of the remaining 15 questions (in which the estimated conjunction was significantly smaller than the given conditional), the estimated conjunction was significantly higher than the computed conjunction (columns 8 and 9). Out of 632 conjunction estimates, only 223 were smaller than all given elements.

Groups 3 and 4 (Table 4). In 23 out of 28 cases there was no significant difference between the estimated conditional and the given conjunction, reflecting the underestimation of the conditional (columns 6 and 7). For each of the remaining 5 questions the estimated condtional was still significantly smaller than the computed conditional.

Clearly, the conjunction is overestimated and similar to the given conditional, whereas the conditional is underestimated and similar to the given conjunction.

Experiment 4: Symbolic Variables

Method

Stimuli. Four pairs of probabilities [P(A), P(B)] were chosen for this experiment: (.70, .30), (.70, .70), (.30, .30), and (.50, .50).

For each pair, three different conditional probabilities were selected: $P(A/B) = P(A)$, $P(A/B) < P(A)$, and $P(A/B) > P(A)$. Thus, there were 12 groups of data (4 x 3). For each one $P(B/A)$ and $P(A \cap B)$ were calculated. Each problem was composed of three data pieces and one question. For the three cases in which $P(A) \neq P(B)$, three different problems were constructed for each case:

1. Data: $P(A)$, $P(B)$, $P(A \cap B)$ Question: $P(A/B)$
2. Data: $P(A)$, $P(B)$, $P(A/B)$ Question: $P(A \cap B)$
3. Data: $P(A)$, $P(B)$, $P(B/A)$ Question: $P(A \cap B)$

thus making 9 questions. For the nine cases in which $P(A) = P(B)$, only the first two problems were constructed for each to avoid redundancy [since if $P(A) = P(B)$ then $P(A/B) = P(B/A)$].

Design and procedure. The 27 questions (9 + 18) were distributed between six questionnaires so that no two questions based on the same data were in the same questinnaire. The phrasing of the questions was similar to Experiment 3, except for use of the terms "attribute A," "attribute A and B," etc., instead of the specified characteristics.

Subjects. One hundred ten students in a teachers' seminar in Jerusalem participated in this experiment. The experiment was administered as the previous ones.

Results

Tables 5 and 6 are analogous to Tables 3 and 4 from Experiment 3. In all but the five cases in which the given conditional was very high (70% or 90%), there was no significant difference between the conditional and the estimated conjunction (Table 5, columns 3 and 5). Except for the four cases in which the given conjunction was very small (9% or less), there was no significant difference between the conjunction and the estimated conditional (Table 6, columns 3 and 5).

Insert Tables 5 and 6 about here

Discussion of Experiments 3 and 4

The results of the last two experiments show that when we decompose the problem for the subjects, they show two biases: estimates of the conjunction are too high; estimates of the conditional are too low. In both cases, the estimates of the conditional and the intersection, are too similar. These results strengthen the proposed explanation for the results of Experiment 2. There it was suggested that subjects were conscious of the conjunction's composite character and that their error lay in non-normative integration of the estimated elements. Such awareness was due to the composite formulation of the conjunctive questions--"A and B." By way of contrast, they did not decompose the conditional question in Experiment 2 because its formulation does not call for it. In experiments 3 and 4, the two estimates (conjunction and conditional) were decomposed for the subjects forcing them to employ a recomposition strategy for both estimates.

How do we explain the similarity between the conjunction and the conditional? Though the verbal phrasing of conditional and intersection may be perceived as similar, thus causing some confusion between the two, this does not seem to explain the data. Such confusion should be manifested independently of the order of magnitude of the given data (a given conditional when assessing a conjunction and a given conjunction when assessing the conditional). However, this is not the case in Experiment 3, where the conjunctive estimates were clearly smaller than the given conditionals when the latter were high, and the conditional estimates were clearly higher than the given conjunctions, when the latter were very small.

Assuming subjects do differentiate between a conditional datum and a conjunctive question (and between a conjunctive datum and a conditional question), they integrate the data in a way that produces similar results, similar enough to avoid statistical differences (between the given conditional and the estimated conjunction and between the given conjunction and the estimated conditional). The similarity between column 5 and the last column in Table 5 suggests one possible way. For conjunction estimates, subjects may have averaged the given prior and conditional probabilities [either P(A) and P(A/B) or the given P(B) and P(B/A)]. However, only in 12 of 200 evaluations in which the given conditional was different from the prior probability, the estimated conjunction was similar to the above average, thus the simple averaging model can be rejected. Another possibility is that subjects anchored on the conditional when estimating the conjunction, whereas when estimating the conditional they anchored on the conjunction. In both cases, they changed their estimates some, but not enough to reflect the prior probabilities. Insufficient adjustment from a starting point (anchor) has been suggested previously as a possible explanation for the overestimation of conjunctive events and the underestimation of disjunctive events by Tversky and Kahneman (1974).

EXPERIMENT 5: CONJUNCTIVE PROBABILITY JUDGMENT FROM SPECIFIC DATA

All four previous experiments were done in a frequentistic context, one in which it is easy to view the event as a member of a set and equate probability with its relative frequency in that set. However, people often assess chances in situations in which it is hard to conceive of the event in question as a member of a group and thereby be able to rely on group frequencies. For example, the probability that an individual, with some known characteristics, is a member of a certain category (categorical prediction) can be assessed by thinking about the percentage of individuals with the same characteristics who are in that category. However, if we know much about that individual (the number of characteristics is high), it might be difficult to relate him to a group of people "similar to him" because it is such a small group, because it is an unnatural one to think about or because he is a unique person and there is no one similar to him.

In these cases, probability assessment will probably be based on other strategies. Kahneman and Tversky (1972, 1973) suggested that when the event in question is perceived as unique, people will rely on the "representativeness heuristic." Users of this heuristic judge an individual's membership in a category to be likely to the extent that the individual's description is similar to the category's main features.

The similarity between an individual's description and a category archetype can be manipulated by changing the description or the category. Letting D be a given description and A be a feature defining a category, one can add a feature B to A such that D will be judged as more representative of $(A \cap B)$ than of (A). Of course, normatively speaking, the probability of $(A \cap B/D)$ must be smaller than that of (A/D). However, if people rely on representativeness, the opposite will be true, that is, the probability of the conjunction will be judged higher than that of its components. Adding a feature C to the description D such that $(D \cap C)$ will be judged as more representative of A than D was when alone, will cause subjects to judge $P(A/D \cap C) > P(A/D)$. In doing so, however, they would not necessarily be violating any normative rule. The following experiment was designed to test these hypotheses.

Method

Stimuli. Three short life stories about three different characters were constructed fitting different Israeli stereotypes. For each story, three events (A, B, and C) were selected so that A and B would intuitively fit the character in the story, whereas event C would not and so that A would be perceived as relating to B, but not to C. The stories and events are listed in the upper part of Table 7.

Insert Table 7 about here

Design and procedure. Subjective estimates were elicited for the following probabilities: $P(A)$, $P(B)$, $P(C)$, $P(A \cap B)$, $P(A \cap C)$, $P(A/B)$, $P(B/A)$, $P(C/A)$, and $P(A/C)$. All probability questions had the same formulation: "What are the chances that David is __________?"

Seven questionnaires were constructed, each with the three stories on different pages, randomly ordered. After reading each story, subjects were asked one or two questions (see lower part of Table 7).

Subjects. One hundred and eighty-three soldiers (all high school graduates) participated in this experiment. The experiment was administered as the previous ones.

Results

Manipulation check. Table 8 presents the median probabilities. Our intuitions concerning their relative magnitude were justified: $P(A)$ and $P(B)$ were judged relatively high, whereas $P(C)$ was judged relatively low. However, the absolute magnitude of all three appears much too high, reflecting insensitivity to base rate (Bar-Hillel, 1980). The small amount of low-diagnosticity information given about Danny in Story 1 does not warrant an increase of probability from a very low base rate (i.e., the percentage of graphic students among 23 year-old adults in Israel) to a probability of .7. Similar arguments can be advanced for each one of the estimates in Table 8.

Insert Table 8 about here

Conjunctive estimates. The conjunctions (A∩B) and (A∩C) were overwhelmingly overestimated. None was smaller than the smallest of their components' estimates. Table 9 presents 12 comparisons between probabilities for conjunctions and for their components. The chances of (A∩B) were significantly higher than those of (A) in one out of three cases, and significantly higher than (B) in two out of three cases. The chances of (A∩C) were significantly smaller than those of (A) in two out of three cases and higher than (C) in one case. As expected, (A∩B) was judged significantly higher than (A∩C) in all three stories.

Insert Table 9 about here

Conditional estimates. Table 10 compares the conditionals. When P(A) = P(B), no difference is expected between P(A/B) and P(B/A). As the estimated chances of P(A) and P(B) were quite similar (Table 8) it is not surprising that no significant difference was found between the chances of (A/B) and (B/A)(row 2).

Insert Table 10 about here

In (B/A) and (A/B) the conditional event added positively related information to the given description. According to the representativeness hypothesis, the added information increases the similarity between the datum and the event, making the conditionals (B/A) and (A/B) seem more likely than (B) and (A), respectively. This expectation was confirmed in 5 out of 6 cases (rows 1 and 3).

The addition of (A) to data which were already judged as not very representative of C decreases the probability of (C) in one case only (row 4). The addition of C to the same description did not affect (A)'s probability judgment (row 6).

Because of the above similarities [between P(C/A) and P(C) and between P(A/C) and P(A)], and because the chances of (C) appeared smaller than those of (A), it is not surprising that the chances of (C/A) were smaller than those of (A/C)(row 5).

Discussion

It was hypothesized that with unique events subjects judge probabilities according to the extent that the data represents this event. Therefore, a conjunction, (A∩B) should be judged higher than the priors, (A,B), if the data appear more similar to (A∩B) than to A and to B. These predictions were confirmed. Similarly, the conditional (B/A) should be judged more likely than the prior (B) if (D∩A) is perceived as more similar to B than is D alone. This prediction was also supported.

These results confirm and expand upon a set of unpublished results by Tversky and Kahneman (Note 1). For each of several descriptions, Tversky and Kahneman selected five characteristics, one similar to the description, one dissimilar, and three unrelated. After each description, subjects were presented with all five characteristics as well as with the conjunction of the similar and dissimilar ones. Half the subjects ranked the stimuli according to their similarity to the description, half ranked them according to their probability given the description.

They found that the similarity ranking and the probability ranking were very similar and that the conjunctive (similarity and probability) ranking was the average of the similar characteristic ranking and the dissimilar characteristic ranking. These results are in line with the present ones concerning P(A∩C). The probability of this conjunction may be judged to be between that of A (a similar characteristic) and that of C (a dissimilar one).

These results also confirm some preliminary findings reported by Slovic, Fischhoff, and Lichtenstein (1976) for a similar task; the assessed probability of a scenario was a direct function of the number of its links (1, 2, or 3), when the linked events formed a coherent story; the more links the higher the assessed probability.

In categorical predictions, when subjects rely on the representativeness heuristic as a guide for probability assessment, the conjunction is perceived as a compound event for which no decomposition is needed and its probability is assessed according to how similar the data are to the compound event.

EXPERIMENT 6: CONJUNCTIVE PROBABILITY JUDGMENT IN TUROFF'S EVENTS

Judgment by representativeness is one possible strategy people adopt when assessing probabilities of unique events. Using it, subjects compare two images and judge their similarity. The possible effects of this strategy on conjunctive estimates has already been demonstrated. However, judgment by similarity is not the only strategy people rely on; causal reasoning is a second one, which has been recently perceived as an important determinant of judgment under uncertainty (Jones, Kanouse, Kelley, Nisbett, Valens, & Weiner, 1972; Tversky, & Kahneman, 1980). Whereas in judgment by representativeness one compares two images (events, categories) by way of assessing the similarity between the two, in causal reasoning one judges the causal effects of one event upon a following one. The perception of a time gap between the evidence and the event in question is a necessary condition for any causal reasoning.

The effect of causal reasoning on probability judgments of conditional events was studied by Tversky and Kahneman (1980). They claimed that in any conditional event (A/B) where there is a perceived causal link between

A and B, B can be perceived as causing A, thus B being a causal datum [given that David hit Danny (B), what is the probability that Danny broke his leg (A)?], or A can be perceived as causing B, hence B being a diagnostic datum [given that Mr. Jacob has abdominal pains (B), what is the probability that he has an appendix infection (A)?]. Tversky and Kahneman demonstrated how greater impact is assigned to causal than to diagnostic data of equal informativeness. Furthermore, they showed how the dominance of causal over diagnostic considerations can produce inconsistent and paradoxical conditional probability assessments. Specifically, they tested subjects' judgments of conditional probabilities in cases where the events A and B were such that the occurrence of B (e.g., the number of deaths attributed to mercury poisoning during the next five years exceeds 500) increases the perceived likelihood of the subsequent occurrence of A (within the next five years, Congress will pass a law to curb mercury pollution), but where the occurrence of A decreases the perceived likelihood of the subsequent occurrence of B. Such questions were originally introduced by Turoff (1972) in a discussion of the cross impact method of forecasting.

Subjects in Tversky and Kahneman's experiment judged that $P(A/B) > P(A/\bar{B})$ and $P(B/A) < P(B/\bar{A})$ in contrast to the rules of probability theory according to which, if $P(A/B) > P(A/\bar{B})$, then $P(B/A) > P(B/\bar{A})$. Subjects assume that the conditional event happens before the conditioned one and assess the causal strength from the conditional to the conditioned.

It is here assumed that causal reasoning in such pairs of events can affect the judgments of conjunctions as well as the conditionals' judgments and cause two biases: The first is that $P(A \cap B)$ will be judged higher than $P(A)$ and $P(B)$ because the same data will be perceived as explaining more in $(A \cap B)$ than in A or B alone. For example, when people judge the probability of "death from mercury poisoning," they probably look for relevant information (e.g., the free use of mercury today, etc.) and judge whether it causes or prevents the event in question and how much it explains it. When they have to judge the two events--"death from mercury poisoning" and "a law to cure mercury pollution"--this same data is perceived as explaining more in the sequence of events than in one of them alone, thus causing higher probability to $(A \cap B)$ than to A or to B alone.

The second assumed predicted bias is that $P(A \cap B)$ and $P(B \cap A)$ may not be judged as identical since people will perceive the first mentioned event as the cause and the second as the result. A (deaths) after B (law) will not be perceived as a probable sequence, but B after A will. The following experiment was designed to test these expectations.

Method

Stimuli. Five pairs of events were selected such that A causes B and B prevents A. All events were presented as future events projected to occur within the following year. All events were unique in the sense described in Experiment 5.

Design and procedure. Six statements were constructed for each pair of events: $P(A)$, $P(B)$, $P(A/B)$, $P(B/A)$, $P(A \cap B)$, and $P(B \cap A)$. All statements began: "There is a chance that in the next year...." Three different questionnaires were prepared. In two of the questionnaires, subjects were asked to rank $P(A)$, $P(B/A)$, and $P(B \cap A)$ in three pairs of events and $P(B)$, $P(A/B)$, and $P(A \cap B)$ in the additional two. The questions were manipulated in the two questionnaires so as to get both rankings for each pair of events. In the third questionnaire, subjects were asked to rank P(A) and P(A∩B) in 3 pairs of events and P(B) and P(B∩A) in the additional two.

Subjects. The 3 questionnaires were randomly distributed among 131 foreign students in the Hebrew University Summer School in Jerusalem ($N_1 = 45$, $N_2 = 44$, $N_3 = 42$). All questionnaires were in English, the subjects' native language.

Results

The triple comparison. For each pair of events, two tables were constructed, one for each triple (Table 11). The rows of the tables indicate the three probabilities considered, whereas the columns indicate the possible ranks. For each probability we circled the most frequent rank. The same was done for the combined results of the 5 event-pairs (lower part of Table 11).

Insert Table 11 about here

In 4 of the 5 tables $P(B/A) > P(A) > P(B \cap A)$. Also in 4 of the 5, $P(A \cap B) > P(B) > P(A/B)$.

The paired-comparison. For each of the 5 pairs of events, subjects indicated whether the conjunction probability was higher than, lower than, or as similar to the one component probability. Of the subjects who judged P(A∩B) to be different from P(A), 31/39, 29/39, and 26/36 judged the conjunction as higher for questions 1, 3, and 5, respectively ($z = 3.52$, $p < 0.001$; $z = 2.88$, $p < 0.002$; $z = 2.5$, $p < 0.006$). Of the subjects who judged P(B∩A) to be different from P(B), 27/40 and 28/37 judged the conjunction as smaller, for questions 2 and 4 ($z = 2.05$, $p < 0.02$; $z = 2.96$, $p < 0.001$). Thus, according to subjects' perceptions: $P(A \cap B) > P(A)$ and $P(B \cap A) < P(B)$.

Taken together, the results from the three questionnaires yield for questions 1, 3, and 5: $P(A \cap B) > P(A) > P(B \cap A)$ and for questions 2 and 4: $P(B \cap A) < P(B) < P(A \cap B)$.

Discussion

The results confirm our predictions. It is obvious that subjects judge the first element mentioned in the conjunction as happening first. The two elements together are perceived as one event; with "A and B" perceived as high (A causes B) but "B and A" perceived as low (A prevents B). Furthermore, $P(A \cap B)$ is judged more probable than $P(A)$ and $P(B)$.

As representativeness is blamed for conjunction overestimation in categorical prediction, so is causal reasoning blamed for the same bias in Turoff's events.

CONCLUDING DISCUSSION

In all but the first of these six studies, subjects overestimated the conjunction, often perceiving it as more likely than the priors and conditionals. Although these results were similar, I propose that they are best accounted for by rather different processes.

In assessing a conjunction, the subject can choose one of two general strategies:

(a) Decompose the problem to its elements A and B, assess their probabilities separately, and then combine these estimates.

(b) Assess the conjunction directly.

The strategy chosen depends on:

(1) Whether the subject receives the information necessary to compute the result. When the subject is faced with information about the probability of the relevant elements, he is actually directed to use the first strategy. If the problem is not presented decomposed, the subject is more free to choose between the two strategies.

(2) Whether there is a causal relation between the two events. When there is a causal relation, there is a tendency to see the two events as one and avoid decomposition.

(3) Whether the context is perceived as frequentistic or unique. A frequentistic context strengthens the tendency to decompose, whereas a unique context weakens this tendency.

Even when the task encourages decomposition, the integration of the estimated components need not fit the multiplicative model. Adding or averaging would result in a conjunction estimate higher than at least one of the priors or conditionals, as demonstrated in Experiment 3 and 4. In these, subjects were tested only for their integration processes since the relevant components were presented to them. On the basis of the similarity between the estimated conjunction and the given conditional, a reasonable hypothesis is that subjects do not use the multiplication model, but anchor on the conditional and change it a bit to get the conjunction.

Experiment 2 differs from 3 and 4 only in the first dimension; the problem is not decomposed for the subject and he is free to choose between the two strategies. However, in the two remaining dimensions, it resembles Experiments 3 and 4: frequentistic information was given and no causal relation existed between the two events. It is argued that subjects in this experiment chose the decomposition strategy. This explanation is consistent with the differences between the estimates of $(A \cap B)$ in Experiments 1 (percentage) and 2 (probability).

When the experimental design encourages holistic judgment (because there is a causal relation between A and B and/or the context is unique), subjects rely on judgmental heuristics such as representativeness and causal reasoning. In Experiments 5 and 6, all three factors (1, 2, and 3) strengthened the tendency to handle the conjunction as one event and to avoid decomposition. The problems were not decomposed for the subject, there was a causal relation between A and B, and no information was given concerning the sample space. In those situations, subjects do not rely on relative frequency considerations, but on different heuristics. In categorical predictions (like those in Experiment 5), subjects rely on the representativness heuristic and judge how similar the data are to the event in question. In Turoff's events (such as those in Experiment 6), subjects rely on causal reasoning and judge how the data explains the event in question. The rules of similarity judgment and causal reasoning do not necessarily obey the rules of probability. Specifically, data can be more similar to $(A \cap B)$ than to (A), or explain more in $(A \cap B)$ than in (A). However, in the light of the same data, the chances of $(A \cap B)$ are always smaller than those of A.

Practical implications. We have demonstrated the fallacy of the conjunctive overestimation and analyzed its causes. Next we should consider how this bias can be overcome. Planners in most of the fields engage (or should engage) in the assessment of conjunctive probabilities while considering the probability of event sequences. Since they frequently perceive the situation as unique, they probably rely often on representativeness and causal reasoning rather than decomposing the problem into its elements and recombining them. Those heuristics can easily bring about a situation in which the more elements the event has, the more probable its perceived probability.

Assessment by decomposition can partly overcome the biases caused by the above intuitive heuristics. Decomposition calls for:

1. Decompose the problem whenever possible.

2. Decompose it to its appropriate elements: P(A/B) and P(B) or P(B/A) and P(A).

3. Assess the components' probabilities.

4. Let the formula do the integrating.

These steps will ensure the correct inference of the conjunction's probability from the conjunction--components' probabilities and thus ensure that the conjunction's probability will be small. However, they do not overcome biases in the assessments of the components' probabilities which may be influenced by the same intuitive heuristics--representativeness and causal reasoning.

Reference Notes

1. Tversky, A., & Kahneman, D. Unpublished data.

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Footnotes

1. The medians were preferred to the means since most distributions were skewed to the right.

2. For each one of the 14 questions, the difference between the two medians of the two experiments was calculated. Under Ho, if we rank the absolute differences across the questions, we will expect the sum of the ranks relating to negative differences to be identical to the sum of the ranks relating to positive differences. T is the smaller of the two sums.

3. This was done for 13 out of 14 questions. In question 4, as the derived $(A \cap B)$ was higher than one of the component's chances (B), the chosen estimate for $(A \cap B)$ was based on the smaller of the two possible estimates (one derived from $P(A/B)P(B)$ and one derived from $P(B/A)P(A)$).

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Table 1

EXPERIMENT 1: Median Relative-Frequency Estimates

	Group Estimate	1 (A)	1 (B)	4 (A/B)	5 (B/A)	2,3 $(A \cap B)$	Derived $\frac{(A/B)(B) + (B/A)(A)}{2 \times 100}$
Independent pairs	1.	70	15	10	6.75	5	3.1
	2.	40	17.5	25	10	12.5	3.7
	3.	67.5	35	90	50	40	33
	4.	42.5	10	60	40	10	11.5
	5.	26.5	21	70	47.5	15	13.6
	6.	2.5	10	10	90	5	1.6
	7.	80	40	80	50	50	36
dependent pairs	8.	10	20	22.5	25	5	3.5
	9.	8	49	5	42.5	3	2.9
	10.	45	72.5	35	70	35	25.5
	11.	67.5	30	65	30	20	19.9
	12.	76	40	80	60	50	38.8
	13.	60	60	70	60	47.5	39
	14.	8	5	5	5	2	0.3
Mean Rank[a]		3.68	2.75	3.89	3.21	1.46	

[a] Rank 1 corresponds to the smallest value in each row.

Table 2

EXPERIMENT 2: Median Chance Estimates

	Group Estimates	1 (A)	1 (B)	4 (B/A)	5 (A/B)	2,3 (A∩B)	Derived $\frac{(A/B)(B) + (B/A)(A)}{2 \times 100}$
independent pairs	1.	65	10	10	10	25	3.7
	2.	43	25	32.5	15	30	7.3
	3.	65	42.5	77.5	70	70	39.2
	4.	40	10	50	50	40	12.5
	5.	30	25	60	40	30	13.5
	6.	5	20	25	90	20	4.7
	7.	70	40	87.5	55	70	36.7
dependent pairs	8.	20	25	10	20	20	3.2
	9.	10	40	5	27.5	10	2.4
	10.	40	80	40	80	60	32
	11.	70	20	50	25	40	13.7
	12.	80	50	62.5	42.5	65	32.6
	13.	70	77.5	60	55	70	42.5
	14.	5	9	5	7.5	5	0.4
	Mean Rank	3.14	2.71	3.14	2.96	3.03	

Table 3

EXPERIMENT 3: The Conjunction Estimates

from Given Priors and Conditional

Ques. No.	Data (A)	Data (B)	(B/A)[a] (A/B)[b]	Median Estimated (A∩B)	Calculated (A∩B)	Prop. of Est. smaller than given conditional p[c]	α[d]	Prop. of Est. greater than true conjunction p[c]	α[d]
1.	65	10	10[a]	5	6.5	12/15	0.02	8/19	-
			10[b]	10	1	12/18			
2.	43	25	15	11	6.4	11/17			
			33	25	8.2	18/21	0.001	23/25	0.001
3.	65	43	70	57.5	45.5	16/17	0.001	14/20	0.06
			78	50	33.5	20/21	0.001	20/24	0.001
4.	40	10	50	30	20	16/18	0.002	14/18	0.01
			50	30	5	15/16	0.001	22/24	0.001
5.	30	25	40	36.5	12	11/15			
			60	57.5	15	15/18	0.001	21/23	0.001
6.	5	20	90	40	4.5	13/18	0.05	15/19	0.01
			25	25	5	11/21			
7.	70	40	55	56	38.5	11/19			
			88	70	35.2	20/22	0.001	20/26	0.003
8.	20	25	20	10	4	14/17	0.006	18/18	0.001
			10	10	2.5	11/20			
9.	10	40	28	20	2.8	16/19	0.002	19/20	0.001
			5	5	2	10/19			
10.	40	80	86	40	32	18/18	0.001	14/19	0.03
			40	40	32	9/16			
11.	70	20	25	20	17.5	10/17			
			50	47.5	10	13/18	0.05	22/24	0.001
12.	80	50	42	43.5	33.6	9/13			
			62	62	31	12/21			
13.	70	77	55	60	38.5	7/17			
			60	60	46.2	7/19			
14.	5	9	7	2	6.35	18/19	0.001	20/20	0.001
			5	3	0.45	14/18	0.02	24/26	0.001

[a] Group 1

[b] Group 2

[c] The proportion was calculated only for those estimates which were different from the compared estimates

[d] Blank spaces indicate $\alpha > .05$

Table 4

EXPERIMENT 3: The Conditional Estimates

from Given Priors and Conjunction

Ques. No.	Data (A)	Data (B)	Data (A∩B)	Median Estimated Cond.	Calculated Cond.	Prop. of Est. greater than given conjunction p[c]	Prop. of Est. greater than given conjunction α[d]	Prop. of Est. smaller than true conditional p[c]	Prop. of Est. smaller than true conditional α[d]
1.	65	10	4	2.5	6.1[a]	9/23			
				4	40[b]	13/20			
2.	43	25	7	5	16.3	8/22			
				21	28	18/20	0.001	18/26	0.02
3.	65	43	39	39	60	12/23			
				40	90.7	14/21			
4.	40	10	5	6	12.5	14/20			
				15	50	16/19	0.002	25/26	0.001
5.	30	25	14	15	46.7	14/24			
				40	56	13/21			
6.	5	20	4	20	80	22/24	0.001	19/25	0.006
				5	20	15/20			
7.	70	40	37	37	52.8	12/22			
				50	92.5	16/19	0.002	25/26	0.001
8.	20	25	3	5	15	14/22			
				8	12	16/19	0.002	19/26	0.001
9.	10	40	2	2	20	12/16			
				2	5	9/15			
10.	40	80	32	40	80	15/22			
				32	40	12/20			
11.	70	20	14	18	20	16/24			
				18	70	14/20			
12.	80	50	33	33	41.2	12/22			
				33	66	12/22			
13.	70	77	42	42	60	13/23			
				42	54.5	12/20			
14.	5	9	1	1	20	8/17			
				1	11.1	11/16			

[a] (B/A) Group 3

[b] (A/B) Group 4

[c] The proportion was calculated only for those estimates that were different from the compared estimate

[d] Blank spaces indicate $\alpha > .05$

Table 5

EXPERIMENT 4: The Conjunction Estimates

from Given Priors and Conditionals

Ques. No.	(A)	(B)	Given Cond.	Median Estimated (A∩B)	Calculated (A∩B)	Prop.of Est. smaller than given conditional		Prop.of Est. greater than true conjunction		$\frac{(A/B)(B)}{2}$ or $\frac{(B/A)(A)}{2}$
						p[a]	α[b]	p[a]	α[b]	
1.	70	70	90	80	63	10/10	0.001	13/19	--	80
2.	30	30	90	60	27	10/11	0.006	14/15	0.001	60
3.	50	50	90	65	45	14/15	0.001	13/19	--	70
4.	70	30	90	85	27	9/10	0.01	15/18	0.001	60
5.	70	30	70	47.5	21	10/13	0.05	13/14	0.001	50
6.	70	70	70	70	49	3/ 5				70
7.	70	70	61	63	42.7	5/11				65.5
8.	50	50	50	50	25	5/ 9				50
9.	70	30	38.6[c]	38.6	27	8/16				54.3
10.	30	30	30	30	9	1/ 7				30
11.	70	30	30[c]	40	21	4/16				50
12.	70	30	23	23	6.9	7/16				26.5
13.	70	30	10[c]	30	7	0				40
14.	30	30	10	20	3	1/12				20
15.	50	50	10	40	5	1/13				30

[a] The proportion was calculated only for those estimates which were different from the compared estimates

[b] Blank spaces indicate α > .05

[c] The given conditionals indicated with a "c" were (B/A); all others were (A/B).

Table 6

EXPERIMENT 4: The Conditional Estimates from Given Priors and Conjunction

Ques. No.	Data (A)	Data (B)	Data (A∩B)	Median Est. Cond.	Calculated Cond.	Prop. of Est. greater than true conjunction p[a]	Prop. of Est. greater than true conjunction α[b]	Prop. of Est. smaller than given conditional p[a]	Prop. of Est. smaller than given conditional α[b]
1.	30	30	3	15	10	13/13	0.001	5/14	
2.	50	50	5	22.5	10	12/12	0.001	3/12	
3.	70	30	7	10	23	11/12	0.003	4/15	0.06
4.	30	30	9	20	30	11/15	0.06	10/16	--
5.	70	30	21	23	70	8/13			
6.	50	50	25	25	50	4/ 8			
7.	30	30	27	27	90	8/15			
8.	70	30	27	37	90	10/14			
9.	70	70	43	43	61	5/10			
10.	50	50	45	45	90	7/11			
11.	70	70	49	49	70	7/19			
12.	70	70	63	59	90	4/ 7			

[a] The proportion was calculated only for those estimates which were different from the compared estimates.

[b] Blank spaces indicate $\alpha > .05$

Table 7

EXPERIMENT 5: Distribution of Data (Stories)

and Questions (Events) across Questionnaires

	Story 1	Story 2	Story 3
Data			
	"In his childhood, Danny was prominent in his love for drawing and graphic work and took part in many relevant classes. After he finished high school, he went into the army and then spent two years abroad."	"Isaac is a member of a religious family. He is tall, well built, and a chatterer. He studied in a special 'Yeshiva', after which he served in the army in a combat unit. Today, he is 23 years old."	"David is 22 today. In his childhood, he used to run out of school and go walking around the country. He was very active in the Youth Movement, went with his group to the Nachal, but did not stay in the kibbutz. Today he is a student in the university."
Events			
(A)	He studied in a graphics art school	He is a member of "Gush-Emunim". *	He is an Archeology student.
(B)	He is a draftsman	He is a tourist guide	He is a member of the society of nature preservation
(C)	He works as an accountant	He is a clerk in the working ministry	He engages in meditation
Questionnaires			
1.	P(A)	P(B), P(C)	P(B), P(C)
2.	P(B), P(C)	P(A)	P(A)
3.	$P(A \cap B)$	$P(A \cap B)$	$P(A \cap C)$
4.	$P(A \cap C)$	$P(A \cap C)$	$P(A \cap B)$
5.	P(B/A), P(C/A)	P(A/C)	P(A/C)
6.	P(A/B)	P(A/B)	P(B/A), P(C/A)
7.	P(A/C)	P(B/A), P(C/A)	P(A/B)

*An Israeli right-wing movement that believes the West Bank is an integral part of the State of Israel. Most of its members are religious Jews who actively participate in establishing jewish settlements on the West Bank.

Table 8

Median Chances Estimates

	Story 1	Story 2	Story 3
(A)	55	65	50
(B)	70	50	50
(A∩B)	70	70	80
(A/B)	80	80	70
(B/A)	90	60	73
(A)	55	65	50
(C)	30	5	30
(A∩C)	40	45	50
(A/C)	50	70	40
(C/A)	10	25	30

*All medians are based on $24 \leq N \leq 28$

Table 9

Significance Tests for the Differences Between Medians

	Story 1			Story 2			Story 3		
	n*	χ^2	α	n	χ^2	α	n	χ^2	α
(A∩B) > (A)	52 (49)	0.02	--	53 (34)	0.19	--	51 (50)	13.54	0.001
> (B)	53 (43)	0	--	52 (45)	4.91	0.025	50 (50)	3.92	0.025
> (A∩C)	54 (41)	10.6	0.005	54 (50)	6.45	0.01	54 (52)	7.7	0.005
(A∩C) < (A)	50 (35)	6.41	0.01	51 (43)	4.14	0.025	53 (35)	0.03	--
> (C)	51 (43)	0.21	--	50 (46)	3.18	--	52 (38)	5.74	0.01

* Number of subjects in the two compared groups. Number in parentheses is number of subjects in χ^2 test.

Table 10

Significance Tests for the Differences between Medians

	Story 1			Story 2			Story 3		
	n*	χ^2	α	n	χ^2	α	n	χ^2	α
(A/B) > (A)	51 (36)	5.30	0.025	51 (36)	5.94	0.01	51 (50)	5.12	0.025
= (B/A)	54 (54)	0	--	53 (49)	1.02	--	53 (43)	0.64	--
(B/A) > (B)	52 (44)	7.29	0.005	50 (50)	0.72	--	51 (47)	6.44	0.01
(C/A) = (C)	52 (46)	6.97	0.01	50 (45)	1.97	--	51 (48)	0	--
< (A/C)	53 (48)	18.88	0.001	53 (45)	19.08	0.001	54 (51)	0.02	--
(A/C) = (A)	50 (36)	1.15	--	52 (43)	0.17	--	52 (42)	0.72	--

* Number of subjects in the two compared groups. Number in parentheses is number of subjects in χ^2 test.

Table 11

EXPERIMENT 6: The Distribution of Ranks Across Probabilities

	Question 1			Question 2			Question 3			Question 4			Question 5		
	1*	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Each Question Separately															
(A)	19	24	7	15	24	6	12	21	10	22	9	14	15	22	6
(B/A)	27	10	7	25	9	11	24	8	11	19	24	2	21	11	11
(B∩A)	4	10	30	5	12	28	7	14	22	4	12	29	7	10	26
	(B/A)>(A)>(B∩A)			(B/A)>(A)>(B∩A)			(B/A)>(A)>(B∩A)			(A)>(B/A)>(B∩A)			(B/A)>(A)>(B∩A)		
(B)	21	11	13	14	18	12	12	19	14	14	19	11	12	18	15
(A/B)	5	14	26	8	3	25	6	14	25	7	12	25	6	14	25
(A∩B)	19	20	6	22	13	9	27	12	6	23	13	8	27	13	5
	(B)>(A∩B)>(A/B)			(A∩B)>(B)>(A/B)			(A∩B)>(B)>(A/B)			(A∩B)>(B)>(A/B)			(A∩B)>(B)>(A/B)		

Across Questions

	1	2	3		1	2	3
(A)	77	90	43	(B)	73	85	65
(B/A)	116	62	42	(A/B)	32	57	124
(B∩A)	27	58	135	(A∩B)	118	71	34
	(B/A)>(A)>(B∩A)				(A∩B)>(B)>(A/B)		

* 1 = the highest probability, 3 = the lowest probability.