How are Experts' Uncertainty Intervals Perceived by Non-experts?

Estimated project costs can be described as an uncertainty interval where low (minimum), middle (expected or most likely) and high (maximum) values are specifically indicated (e.g., corresponding to P15, P50, and P85 in a cumulative probability distribution). We report the results of a questionnaire study where experts' estimated costs for a road project, illustrated by a bell-shaped graph, were presented to several educated samples (including students, employees in a major construction company, and judges). In line with findings from other domains, they underestimated the span of the uncertainty interval, and yet they believed that actual outcomes outside of this interval, especially excess costs, would be likely. When asked to suggest outcomes corresponding to verbal phrases, like "entirely probable", "not surprising" and "could cost", they mostly selected extreme values (at the top of the uncertainty distribution). Outcomes inside, or at the boundaries of an uncertainty interval were regarded as accurately predicted, while outcomes outside indicated that the estimates were wrong. It is concluded that even well-defined probabilistic estimates cannot be assumed to be understood as intended, even by educated readers, due to lay notions of probabilities, categorical thinking and the colloquial meaning of verbal terms.

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The Concept Symposia on Project Governance
The Norwegian Ministry of Finance and the Concept Research Program hosts every second year a symposium on project Governance. Project governance, in brief, is concerned about investments and their outcome and long-term effects. In view of the problem at hand, the aim is to ensure that the best conceptual solution is chosen, that resources are used efficiently and anticipated effects realized. Resource persons from ministries, governmental agencies, academia, international organizations, and industry are invited. In order to facilitate professional exchange and direct communication between participants, the number of individuals is restricted. The aim is to initiate further international cooperation and research on important issues related to project governance.

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How are experts' uncertainty intervals perceived by non-experts

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Estimates of uncertain amounts
e.g. predicted costs of a highway project

- Approximate **verbal** descriptors   «*Most likely* 1100 mill » «*Possibly* X mill» «*More than* Z mill»

- **Numeric probabilities**: 70% likely, 90% likely

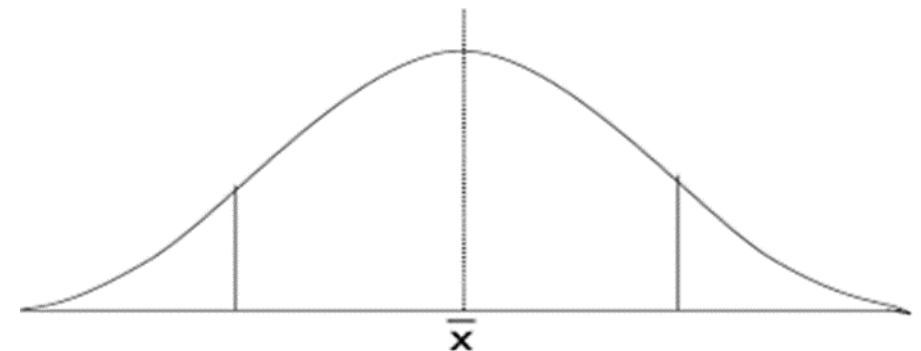- **Interval estimates**: 750 – 1450 mill NOK

- **Combinations**:

Intervals with probabilities added:

P15, P50, P85

Verbal descriptors added:

Minimum, expected, most likely

Graphs added

# Selected findings from judgment research with experts and non-experts

- **Verbal probabilities** are imprecise, directional, and contain surplus information

- **Numerical probabilities** are often exaggerated and inconsistent

- **Interval estimates** are often too narrow
  - They are insensitive to probabilities (Teigen & Jørgensen, 2005)
  - Recipients often consider narrow estimates as more certain (Løhre & Teigen, (2017)
  - The boundary effect: All outcomes within an interval estimate are considered correctly estimated (Teigen, Løhre & Hohle, 2018)

The current project

- How do non-experts perceive uncertainty intervals for project costs
- Cost estimates of a Norwegian highway construction project were presented as a bell-shaped probability distribution, with P50 = 1100 mill NOK (P15 = 750 mill and P85 = 1450 mill)
- Questionnaires presented to three educated samples
  - Employees in a large construction company (professionals)
  - Students attending courses in project management and the psychology of judgment and decision making
 - Judges of district and appeal courts

Q1: Estimated width of uncertainty interval

- An independent team has estimated costs for a highway project. Expected costs (P50) for recommended alternative is NOK 1100 mill (USD 135 mill).

- What do you think were the team's estimates for the minimum (P15) and maximum (P85) values?

x̄

(750 mill)   **1100 mill**   (1450 mill)
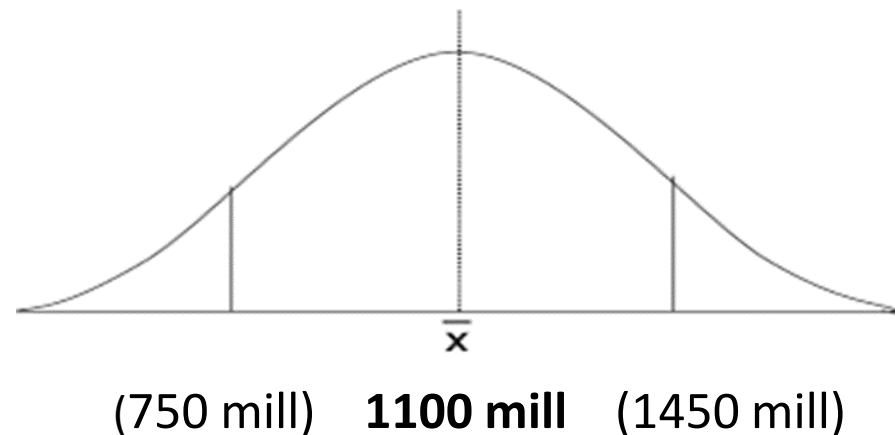
Findings 1: Magnitude of uncertainty intervals

- Professionals suggested intervals between P15 and P85 to be 350 mill instead of 700 mill

- Project students suggested 380 mill

- JDM students suggested 700 mill

- (Judges were not asked this question

(750 mill)   **1100 mill**   (1450 mill)
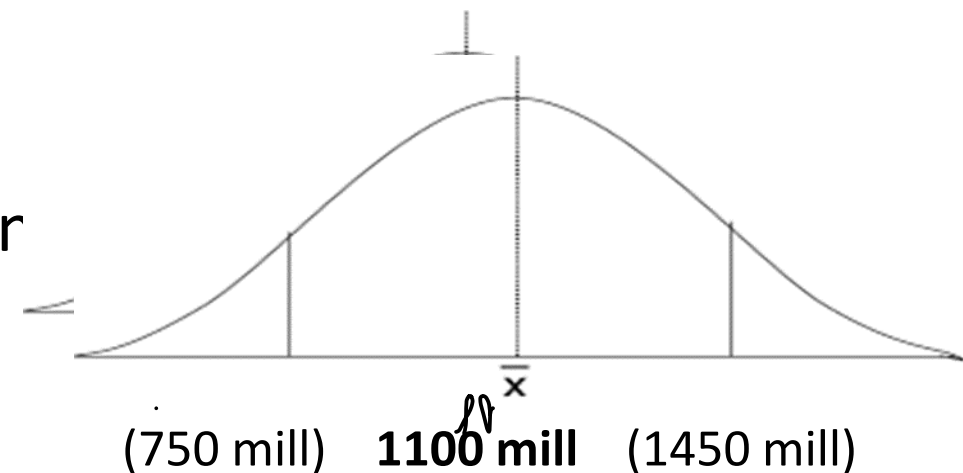
Q8: Accuracy of estimates

- Imagine that the actual costs turned out to be XXX mill (XXX = suggested maximum, P85)

- How would you rate the original estimate? 1-7 scale from completely wrong to completely correct

- Imagine that the actual costs turned out to be YYY mill (XXX – 100) (inside uncertainty interval)

- Imagine that the actual estimate turned out to be ZZZ mill (XXX + 100)

   (outside uncertainty interval)

The boundary effect: Accuracy judgments of estimates for actual costs inside or outside of interval bounds
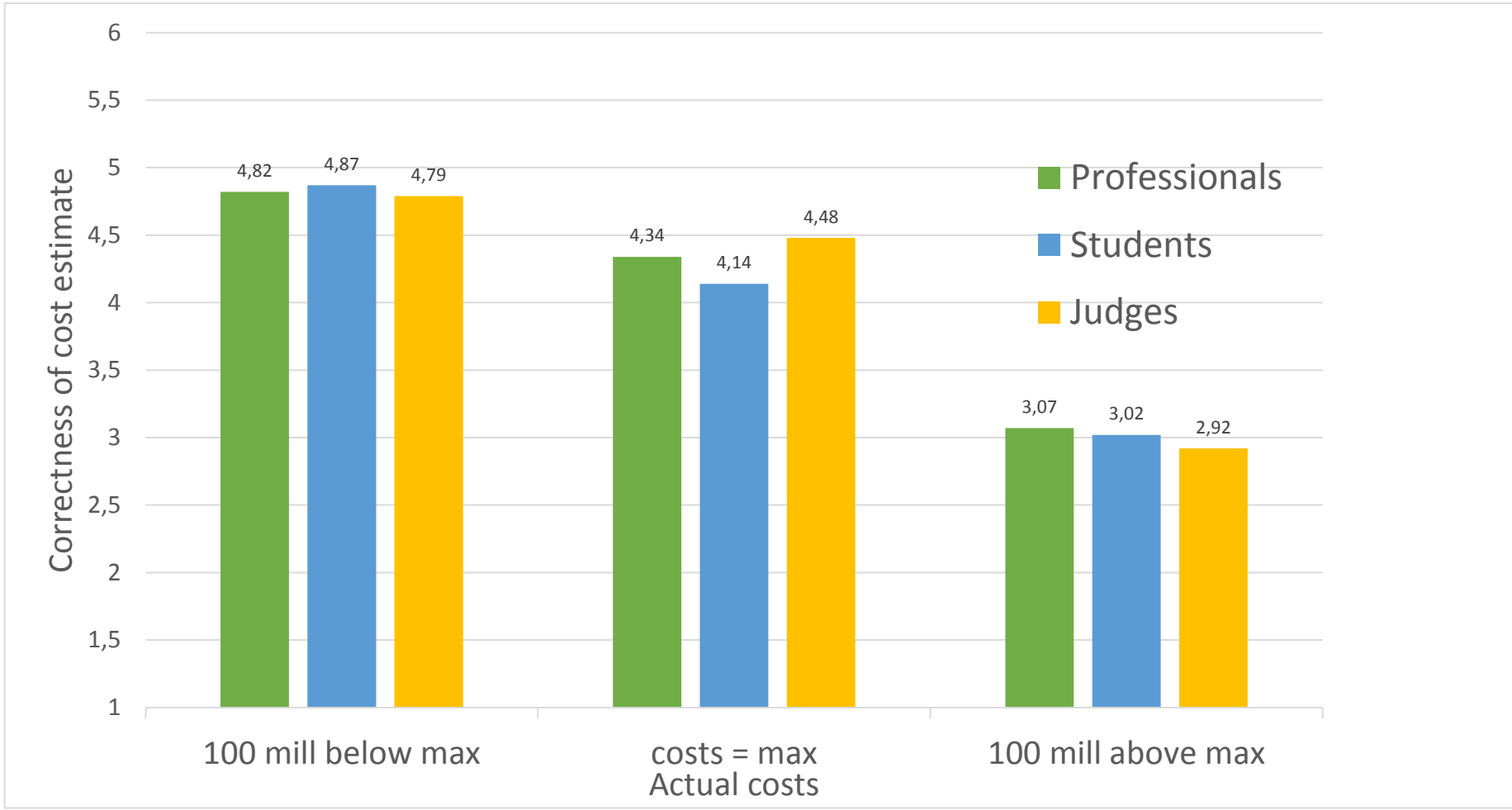
Q6 Numerical probabilities corresponding to estimates

- Imagine that the team responsible for estimates were asked about their probabilities (0-100%) of costs

Professionals (approximate point values)

- P of minimum cost estimate (plus minus 50 mill)
- P of most likely cost estimate (plus minus 50 mill)
- P of maximum cost estimate (plus minus 50 mill)

Students (segments of the distribution)

- Equal to or less than minimum
- Between minimum and maximum
- Equal to or above the maximum

Table 1. Mean probability estimates for costs corresponding to three approximate point values (Study 1)

	Study 1		Study 2
	Professionals		
Point estimates			
P15 (±50 mill)	28.0%		
P50 (±50 mill)	62.8%		
P85 (±50 mill)	50.9%		
Sum	141.7%		

Table 1. Mean probability estimates for costs corresponding to three approximate point values (Study 1) and three segments of the outcome distribution (Study 2).

	Study 1		Study 2			
	Professionals		Project students			JDM students
Point estimates		Intervals	With graph	Without graph		
P15 (±50 mill)	28.0%	≤ P15	13.2%	10.7%		16,6%
P50 (±50 mill)	62.8%	P15-P85	72.4%	83.6%		75.6%
P85 (±50 mill)	50.9%	≥ P85	28.9%	25.6%		30.6%
Sum	141.7%		114.5%	119.9%		122.4%

Q2 How would you describe the cost estimates in informal language?

Representative answers:

- "Small chances of road project becoming cheaper than supposed, great chances of considerable additional expenses"

- "Large uncertainties about solid rock and soil mechanics can produce a high chance of cost overruns"

- "Uncertainties about the cost frame in this case. Small chance of not meeting a surprise"

- "The road will most likely cost between 1265 and 935 mill, but a good chance of higher or lower costs"

Q3 Which estimates go with probabilistic verbal descriptors? (a)

Fill in amount of costs that make sense and appears natural in this context

- The project will cost more than ....

800-900 mill (low value)

- The project will cost less than ....

1300-1400 mill (high value)

- The project will probably cost ....

1100 mill (middle value)

Which estimates go with probabilistic verbal descriptors? (b)

- The project can cost ….

    high value (rather than middle or low value)

- I will not be surprised if it costs …

    high value (rather than middle or low value)

- It is entirely possible that it will cost ….

    high value (rather than middle or low value)

- It is not probable that it will cost ….

- It is unlikely that it will cost ….

    high *or* low value

«Entirely possible» and the extremity effect

Choices of 356 judges in two conditions.

Statement	Alternatives	Choice percentages
Condition A (N = 196)		
It is entirely possible that it will cost ……	750 mill. (P15)	6.1%
	1100 mill. (P50)	14.3%
	1450 mill. (P85)	**79.6%**
Condition B (N = 160)		
It is ………… that it will cost 1450 mill.	a low probability	16.9%
	entirely possible	**68.1%**
	Probable	15.0%

Q4 Preferred statements

- Which three of these statements would you use in a conversation with the project owner?

- Imagine a journalist listening to a conversation where these statements are used. Which three statements do you think he will write down for potential use in his newspaper report?

Verbal expressions preferred by journalist and in conversations with employer
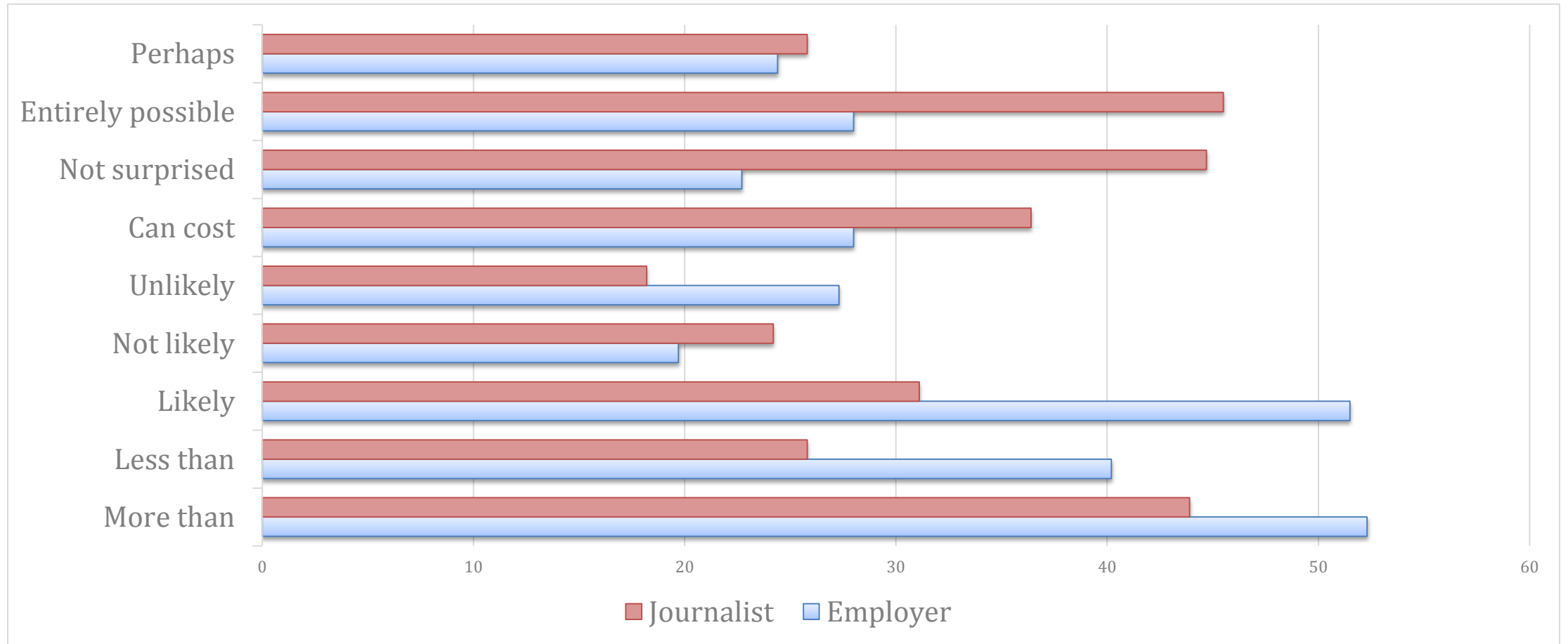
Some lessons from the study

- Experts presenting well defined uncertainty intervals cannot take for granted that people understand them as intended (even when aided by a visual representation of the probability distribution)
- Biases found in lay people's perception of probabilities apply also to well-informed samples (professionals, project students and judges)
- Their probability judgments are often excessive and inconsistent
- Interpretations contaminated by prior beliefs
- Point and interval predictions are easily confused
- Accuracy judgments are strongly affected by (arbitrary) boundaries of the uncertainty interval
- Verbal expressions that appear to describe medium probabilities are informally used to characterize extreme (high) values

Limitations

- We used a single illustrative case (a specific highway project)
- We assumed that the original estimates were not themselves biased. But some parts may have been based on fallible judgments
- We do not know how accurate the estimates were (the project was changed and not executed as planned)
- We did not study actual decision makers (the target readers of quality assurance documents)

Suggestions and speculations

- Point estimates like P50 should not be called «expected» or «most likely» since this or any other points are not likely in an absolute sense, but people may think that «most likely» and «likely» are interchangeable terms

- P15 and P85 should perhaps be called «low» and «high» estimates and not «minimum» and «maximum»

- To avoid boundary effects intervals of different width (e.g., of 90% and 50%) should perhaps be presented together

- All uncertainties and 'genuine surprises' cannot be captured in a single «one-size-fits-all» probability distribution (Parker & Risbey, 2018)

Thank you
for your attention!

References

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