英文寫作秘訣 011

如何於論文內精確應用"significant"的表達

難度：中階

有多少次於科學相關之論文的統計結果或重要性的討論中，見到'significant'被應用及使用？你知道該詞的意思因使用於統計觀念或非統計而有所不同嗎？

下列例句子，可有發現哪裡不對勁嗎？

Significant levels of bisphenol-A were detected in 47 of the 50 sites sampled (85.0%).
(50 個採樣中的 47 個双酚-A 的檢測達到顯著水平(85%))

在上一例句，就一般意義表達，'significant'清楚地表示出程度或範圍。但對於作者表達程度的重要性或相關性，或要代替統計上定量的解釋，則不明確。
我們將'significant'的用法分為'統計'及'非統計'兩類，以便您輕鬆依循本寫作秘訣，並能區分常見句型。
統計的表達使用
就統計意義，'significant'經常被使用於結果(Result)章節，依據 P 值(通常設定 P <0.05)，表達變數(variable)與虛無假設(null hypothesis)或與測量基準的差距。

There was a statistically significant difference between the experiment and control groups (P<0.05), leading us to reject our null hypothesis.
(實驗組與對照組的實驗有顯著的統計差距(P<0.05)，這樣的結果引導我們否定了虛無假設(或說肯定了對立假設)。)

這意味二個組別間的定量差距大到足以提供統計準則中的分析比較。
順帶一提，更有效及自然的方式是採副詞'significantly'搭配一形容詞，這樣讀者能更直覺地了解比較結果。

Okay 的表達：There was a statistically significant difference between the time taken by our nutrient extraction method to extract 1 kg of oleic acid and that taken by the leading conventional method (Robinson et al., 2015) (6.3±1.2 h vs. 8.0±0.5 h; p=0.032).
(以我們營養萃取方法與傳統方法萃取同樣一公斤的油酸，在時間的花費上有顯著的差異。)

Better 的表達：Our nutrient extraction method extracted 1 kg of oleic acid significantly faster than the leading conventional method (Robinson et al., 2015) (6.3±1.2 h vs. 8.0±0.5 h; p=0.032).

(我們營養萃取法萃取一公斤的油酸的時間花費顯著快於傳統方法。)

非統計的表達使用

'Significant'，一般說來，在非統計的意義是經常被使用於表達某事物的重要性或關聯性。

Iron ore is a significant export contributing to Australia's economy.
(鐵礦石對促進澳大利亞經濟有顯著的出口貢獻。)
或可換個方式表達：Iron is an important export contributing to Australia's economy.
(鐵礦的出口對澳大利亞經濟是重要的貢獻。)

Our finding that rice paddy runoff reduces salinity of adjacent lagoons bears significance on India's aquacultural policy.
(我們發現印度水產養殖政策受稻田的徑流降低鄰近潟湖鹽度的影響。)
或可換個方式表達：Our finding that rice paddy runoff reduces the salinity of adjacent lagoons has relevance to India's aquacultural policy.
(我們發現，印度稻田的徑流降低鄰近潟湖鹽度與該國的水產養殖政策相關。)

以上大多為一般意思表達，如第一個例句並不代表所有的澳洲出口商品都是被分析的範圍，且其統計結果僅對於鐵礦量的出口影響較其他商品較大。它僅說明澳洲出口大量的鐵礦(澳洲還出口小麥、羊毛等，但與此研究均無關。)

消除模擬兩可的語意 – 例 1

Significant levels of bisphenol-A were detected in 47 of the 50 sites sampled (85.0%).
(50 個採樣中的 47 個双酚-A 的檢測達到顯著水平(85%))

作者是要表達的是檢測含量高於一般標準？還是檢測結果的重要(應關注的重點：擔憂多數的樣本檢出双酚-A，註:双酚-A 是一有毒物質)？作者不論是否要同時表達此二意思，這個句子需大幅修改，因為：
1. 就文法而言，讀者可能會合理假設双酚-A 是好的物質，於是讀者可能會特別關注的是含量是否過低。
2. 沒有對應的比較對象：含量高於什麼呢？

著重於重要性表達的修改建議：The high levels of bisphenol-A detected in 47 of the 50 sites samples (85.0%) are cause for concern.
(50 個採樣中的 47 個樣本被偵測到双酚-A 的高含量(85%)值得被關注。)

統計上的顯著表達的修改建議：Levels of bisphenol-A significantly higher (p<0.001) than the amount EPA guidelines consider safe were detected in 47 of the 50 sites sampled (85.0%).
(50 個採樣中的 47 個樣本的双酚-A 的含量顯著高於 EPA 規範的安全考量範圍(P<0.001)。)

消除模擬兩可的語意 – 例 2

Our results agree with the significant findings of Kang et al. (2006), who found that β-carotene production was more efficient in 5% kerosene-supplemented media than in non-supplemented media.

(我們的研究結果與 Kang 等人(2006)發現 β 胡蘿蔔素產量於添加 5%煤油介質高於無添加的研究結果相同。)

從文法解讀，作者是要表達 Kang 等人的研究發現 5%煤油介質的添加與無添加的明確比較的統計重要性？或作者是要表達 Kang 等人的重要發現具開創性？

作者可能想兩者兼顧！如果 Kang 等人的研究發現統計結果顯著性的重要且具開創性，那原來的寫法是可被接受的。但，如果必要，我們也可以將意義縮減至其中一個，以便明確表達(如，Kang 等人的發現並非無開創性。)

著重於重要性表達的修改建議： Our results agree with the major findings of Kang et al. (2006), who found that β-carotene production was more efficient in 5% kerosene-supplemented media than in non-supplemented media.

(我們的研究結果與 Kang 等人(2006)發現 β 胡蘿蔔素產量添加 5%煤油介質高於無添加的主要研究結果相同。)

統計上的顯著表達的修改建議：Our results agree with the findings of Kang et al. (2006), who found that β-carotene production was significantly more efficient in 5% kerosene-supplemented media than in non-supplemented media ($F_{4,15} = 25.6$, $P < 0.001$).

(我們的研究結果與 Kang 等人(2006)發現 β 胡蘿蔔素產量於添加 5%煤油介質顯著地高於無添加的研究結果相同($F_{4,15} = 25.6$, $P < 0.001$)。)

結論

從上述例句歸納：

1. Significance 可被用來衡量數量、重要性、及相關性，及
2. 簡易區分統計、非統計二種用法

END OF TIP

How to significantly improve your usage of the term 'significant'

Difficulty: Intermediate

How many times have you seen the word 'significant' used in a scientific paper either with statistical results or to discuss the importance of something? Did you know its meaning is different depending on if it is used in a statistical or non-statistical sense?

For example, what's wrong with this sentence from a paper's Discussion section?

Significant levels of bisphenol-A were detected in 47 of the 50 sites sampled (85.0%).

What is clear is that 'significant' is used in a general sense, to indicate degree or extent. What is unclear is whether the author is referring to the levels' importance or relevance, or instead to a statistical, quantitative interpretation.

To make this writing tip easy to follow and distinguish common examples, we divide 'significant' into two categories: 'statistical' and 'non-statistical'.

Statistical Usage

In its statistical sense, 'significant' is commonly used in the Results section to indicate how much a variable differs from a null hypothesis or baseline measurement based on the P-value, usually $P<0.05$.

There was a statistically significant difference between the experiment and control groups ($P<0.05$), leading us to reject our null hypothesis.

This means the quantitative difference between the two groups was large enough to satisfy the statistical criteria of the analysis comparing the two groups.

By the way, it is often more effective and natural to combine the adverb form 'significantly' with an adjective, so that readers intuitively understand the axis of measurement.

Okay: There was a statistically significant difference between the time taken by our nutrient extraction method to extract 1 kg of oleic acid and that taken by the leading conventional method (Robinson et al., 2015) (6.3 ± 1.2 h vs. 8.0 ± 0.5 h; $p=0.032$).
Better: Our nutrient extraction method extracted 1 kg of oleic acid significantly faster than the leading conventional method (Robinson et al., 2015) (6.3 ± 1.2 h vs. 8.0 ± 0.5 h; $p=0.032$).

Non-statistical Usage

In its non-statistical sense, 'significant' is commonly used to express the importance or relevance of something, generally speaking.

Iron ore is a significant export contributing to Australia's economy.

This could be rephrased to: Iron is an important export contributing to Australia's economy.

Our finding that rice paddy runoff reduces salinity of adjacent lagoons bears significance on India's aquacultural policy.

This could be rephrased to: Our finding that rice paddy runoff reduces the salinity of adjacent lagoons has relevance to India's aquacultural policy.

The meanings here are general. For example, the first sentence does not mean that all of Australia's exports were analyzed, and our statistical results give us confidence that the quantity of iron was greater than another export. It just means Australia exports a lot of iron (it also exports a lot of wheat and wool, but that's not relevant here).

Resolving ambiguity - Example 1

Significant levels of bisphenol-A were detected in 47 of the 50 sites sampled (85.0%).

Does the author mean that the levels were significantly higher with respect to a standard or baseline measurement? Or that these results were important (and thus cause for concern)? This sentence requires major revision, even if both usages were intended:

1.) Based on the grammar alone, a reader is justified in assuming bisphenol-A is good, and that low levels are cause for concern.

2.) There is no object of comparison: what are the levels higher (or lower) than?

Important: The high levels of bisphenol-A detected in 47 of the 50 sites samples (85.0%) are cause for concern.

Statistically significant: Levels of bisphenol-A significantly higher ($p<0.001$) than the amount EPA guidelines consider safe were detected in 47 of the 50 sites sampled (85.0%).

Resolving ambiguity - Example 2

Our results agree with the significant findings of Kang et al. (2006), who found that β-carotene production was more efficient in 5% kerosene-supplemented media than in non-supplemented media.

Does the author mean that the Kang et al.'s findings were statistically significant? This is certainly suggested by the explicit comparison of '5% kerosene-supplemented media' and 'non-supplemented media'. Or does the author mean Kang et al.'s findings were important and ground-breaking? The grammar suggests this interpretation.

The author likely means both! If Kang et al.'s findings were both statistically significant and ground-breaking, this usage is acceptable. However, we can limit the word to one of these usages if warranted (e.g., if Kang et al.'s findings were not particularly novel).

Important: Our results agree with the major findings of Kang et al. (2006), who found that β-carotene production was more efficient in 5% kerosene-supplemented media than in non-supplemented media.

Statistically significant: Our results agree with the findings of Kang et al. (2006), who found that β-carotene production was significantly more efficient in 5% kerosene-supplemented media than in non-supplemented media ($F_{4,15} = 25.6$, $P < 0.001$).

Conclusion

The take-home messages from the above examples are:

1.)   Significance is used to measure quantity, importance, and relevance; and

2.)   Its usages can be conveniently categorized as 'statistical' and 'non-statistical'.

END OF TIP