

## 黃彥棕

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代表著作：

- 📖 **Yen-Tsung Huang\***, 2019, "Genome-wide Analysis of Sparse Mediation Effects under Composite Null Hypotheses", *Annals of Applied Statistics*, 13(1), 60-84.
- 📖 **Yen-Tsung Huang\***, 2019, "Variance Component Tests of Multivariate Mediation Effects Under Composite Null Hypotheses", *Biometrics*, 75(4), 1191-1204.
- 📖 **Yen-Tsung Huang\***, 2018, "Joint Significance Tests for Mediation Effects of Socioeconomic Adversity on Adiposity via Epigenetics", *Annals of Applied Statistics*, 12(3), 1535-1557.

簡評：

黃彥棕副研究員的研究著重於統計學中的因果中介模型。這是以數理方法研究因果關係學問中的一門新興領域。假設我們從統計資料發現某  $X$  事件發生時，某  $Y$  事件常常伴隨發生。除了  $X$  是否造成  $Y$  因果關係，因果中介分析進一步探討  $X$  透過何種機制造成  $Y$ 。在基因應用中，因果中介分析的一個困難是複合性的虛無假說檢定。黃博士在代表作中建立現行假說檢定中的聯合顯著檢定的統計理論基礎並將檢定方法從單一中介因子模型推廣到多重中介因子模型。相關應用如可解釋 DNA 甲基化是社經地位影響與肥胖之間的中介因子。黃博士的理論和方法均十分原創，並且漂亮地解決一些中介因子分析在基因應用中的重要問題。

簡歷：

黃彥棕博士 2003 年畢業於臺大醫學系，2005 年退伍後負笈美國哈佛大學，先後取得公共衛生碩士 (2006)、生物統計碩士 (2009)、流行病學及生物統計博士學位 (2012)。博士畢業後於美國布朗大學擔任助理教授 (2012-2016)，於 2016 返台加入中研院統計科學研究所擔任副研究員，目前也擔任臺大數學系、臺大流預所、中山應數所合聘副教授。他的研究涵蓋統計方法學及生物醫學應用。其中統計方法學的研究包含因果推論、存活分析及統計基因體學；而生物醫學方面的研究包含癌症分子流行病學、癌症基因體學、肝炎流行病學、代謝疾病。

代表作簡介：

### Hypothesis Testing of Causal Mediation

#### Background:

Causal mediation analyses have been a popular approach investigating the mechanism of an intervention on an outcome. Causal mediation involves two parameters, one for the intervention-mediator(s) association  $\alpha$ , and the other for the mediator(s)-outcome association  $\beta$  (Figure, left). Hypothesis test of causal mediation considers a null hypothesis:

$$H_0: \alpha\beta = 0$$

which has two methodological challenges: 1) the above null is a composite null hypothesis:

$$H_0: \{\alpha = 0, \beta = 0\} \cup \{\alpha = 0, \beta \neq 0\} \cup \{\alpha \neq 0, \beta = 0\},$$

2) inadequacy of gaussian approximation for the test statistics.

#### Approach:

In the series of the work, I start

with the single-mediator analyses where the single-mediator test is conducted for one time, and then extend to the multivariate settings, dividing the problem into: 1) multi-mediator testing for one time (Huang, *Annals of Applied Statistics* 2018), 2) single-mediator testing for multiple times (Huang, *Annals of Applied Statistics* 2019), and 3) multi-mediator testing for multiple times (Huang, *Biometrics* 2019).

#### Outcome:

For multi-mediator testing for one time, I propose intersection-union tests for mediation effects in multi-mediator analyses where mediators are without ordering (Figure, middle) or with ordering (right), and prove the tests have size alpha and more powerful than the product tests. For single-

mediator testing for multiple times, I derive the following approximation formula such that the composition of null mixtures can be adjusted to obtain a valid  $p$ -value:

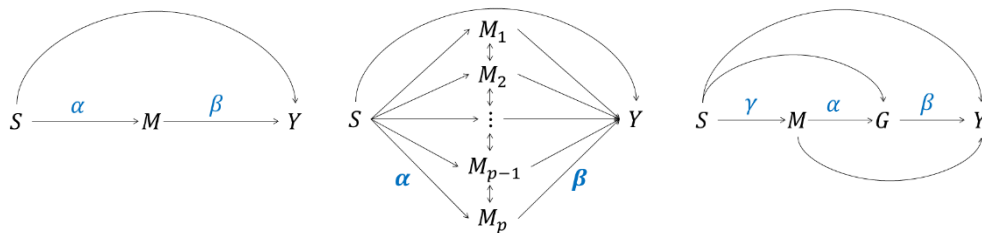
$$\hat{p}_{comp} = F\left(\frac{ab}{\sqrt{Var(a)}}\right) + F\left(\frac{ab}{\sqrt{Var(b)}}\right) - F(ab)$$

where  $F(t) = \int_{-\infty}^{+\infty} \int_{|t/u|}^{+\infty} \frac{1}{2\pi} e^{-\frac{u^2+v^2}{2}} dv du$ ,  $a$  represents z-statistic of  $S$ - $M$  association  $\alpha$  in Figure [left], and  $b$  represents z-statistic of  $M$ - $Y$  association  $\beta$ . Finally, for multi-mediator testing for multiple times, I propose variance

component score tests for both  $\alpha = \mathbf{0}$  and  $\beta = \mathbf{0}$ , where I further transform the mixture of chi-squared distributed test statistics to gaussians and account for the composite null hypothesis using the above formula.

#### Significance:

The series of work demonstrates and addresses the challenges of hypothesis testing for causal mediation. The propose methods are applicable to general testing problems under the composite null hypothesis.



**Figure. Causal mediation models.** Left: single-mediator model; middle: multi-mediator model with parallel mediators; right: multi-mediator model with sequentially ordered mediators.

得獎感言：

感謝評審及委員會的肯定，也感念陳建仁老師、博士班指導老師 Xihong Lin 教授及 Tyler VanderWeele 教授的多年指導和提攜，謝謝優秀的合作者、同事和團隊夥伴的努力及相互激勵。最後感謝我摯愛的家人：我的父母、妻子、瑄瑄和睿睿，謝謝你們無私的支持和陪伴，特別感謝我的妻子默默的付出。

因果，是宗教、是哲學，而我何其有幸，讓它也是科學。