Encouragement, experience and spillover effects in a field experiment on teens' museum attendance

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Introduction

- Understanding mechanisms in cluster encouragement interventions
- Encouragements may be source of alternative behaviors that may affect the outcome even without involving a change in the treatment received
- Social interactions occurring among individuals in the same cluster may give rise to interference or spillover effects
- Principal stratification useful to understand and, to some extent disentangle, such effects in cluster randomized experiments (Forastiere, Mealli, and VanderWeele, JASA, 2016)

Motivating application

- Field experiment conducted in Florence to study the effects of incentives offered to high school teens to motivate them to visit art museums and to identify best practices to transform this behavior into a long run cultural consumption
- Apart from Lattarulo et al. (2016), whose results we revisit, and Kisida et al (2014), this is a novel territory for field experiments
- All students aged 17-18, attend the same type of high school (Liceo Scientifico)
- Their **classes are randomly assigned to three encouragement levels** of increasing strenght

FLYER

Students receive a flier with basic information and opening hours of a main museum in Florence, Palazzo Vecchio

PRESENTATION

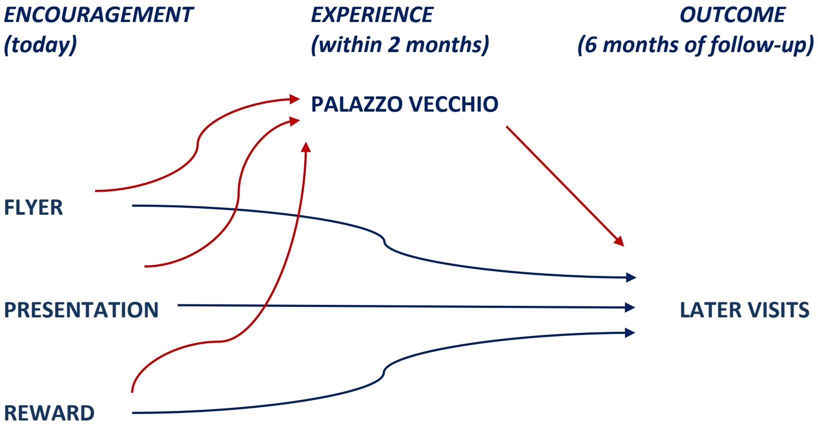
Students receive the flyer and a short presentation conducted by an art expert, which should act as an *intrinsic motivator* towards the visit to Palazzo Vecchio and museum attendance in general

REWARD

Students receive, in addition to the flyer and the presentation, also a nonfinancial reward in the form of extra-credit points towards their school grade. The reward should act as an *extrinsic motivator* towards the Palazzo Vecchio visit

Palazzo Vecchio

Motivating application

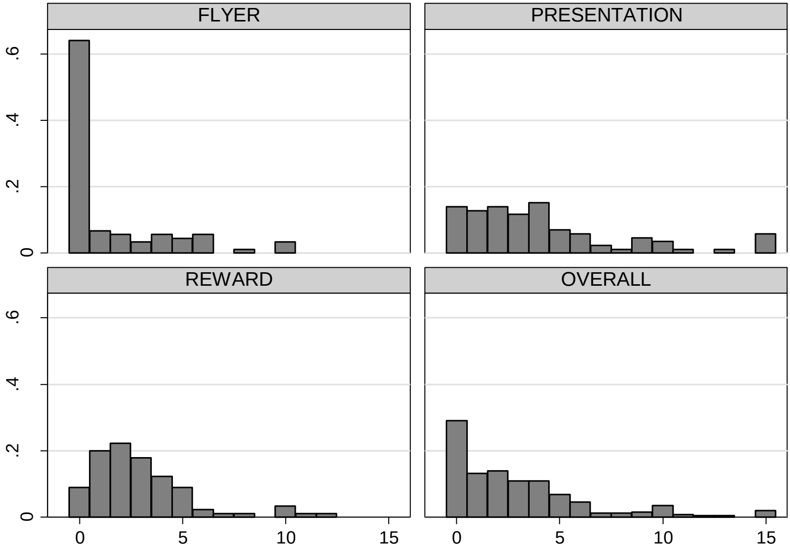


As students belong to classes, spillovers might also be at work

Descriptive Statistics

	A = F	A = P	A = R	Overall
PRIOR TO THE ENCOURAGEMENT				
Male (1/0)	0.19	0.29	0.53	0.34
Already visited Palazzo Vecchio (1/0)	0.66	0.75	0.72	0.71
Count of museums visited last year	3.31	4.75	3.54	3.86
GPA (0-10)	6.73	6.82	6.98	6.84
Uninterested in humanities (1/0)	0.36	0.15	0.41	0.31
Parents' education (1-5)	3.18	3.47	3.53	3.39
AFTER THE ENCOURAGEMENT				
No. of students performing the proposed visit (M=1)	3	10	40	53
Pr(M=1)	0.03	0.11	0.44	0.20
E(Y), Y is the count of later museum visits	1.49	4.39	3.00	2.95
Pr(Y>0)	0.36	0.86	0.91	0.71
No. of classes	5	5	5	15
No. of students	89	87	90	266

Outcome histograms under the three encouragements



The Potential Outcome Approach to Causal Inference

(Neyman, 1923; Fisher, 1925; Rubin, 1974, 1978)

- A_j: three-level cluster encouragement assignment

$$A_j = \begin{cases} F & \text{If class } j \text{ receives the flyer} \\ P & \text{If class } j \text{ receives the flyer and the presentation} \\ R & \text{If class } j \text{ receives the flyer, the presentation and the reward} \end{cases}$$

- M_{ij} : indicator for the post-encouragement individual visit to Palazzo Vecchio. This is the intermediate/treatment variable
- Y_{ij} : the count of later museum visits. This is the final outcome

Assumption 1.(Cluster-level SUTVA). A student's potential outcomes and potential values of the intermediate variable do not vary with encouragements assigned to classes other than the student's own class

Under Assumption 1, each ij has three potential outcomes for each post-treatment variable

- $Y_{ij}(A_j = a)$: Potential value of later visits given assignment to encouragement level a
- Potential value of the intermediate variable given assignment to encouragement a

$$M_{ij}(a) = \begin{cases} 1 & \text{If student } i \text{ visits Palazzo Vecchio} \\ 0 & \text{If student } i \text{ does not visit Palazzo Vecchio} \end{cases}$$

Note that the only observable potential outcome is $Y_{ij}(A_j = a, \boldsymbol{M}_j(a))$ that incorporates both the student's and classmates' response to a, be it direct or via PV experience

Principal Stratification

(Frangakis and Rubin, 2002)

- The units under study can be stratified in subpopulations, the so-called *Principal Strata*, defined according to the potential values of the intermediate/experience variable:

$$S^{m_F m_P m_R} := \{ i : M_{ij}(F) = m_F, M_{ij}(P) = m_P, M_{ij}(R) = m_R \}.$$

Assumption 2.(Monotonicity of Compliance). Every student for which encouragement *a* is a sufficient motivator towards the PV experience would do the same under a stronger encouragement

$$M_{ij}(F) \leq M_{ij}(P) \leq M_{ij}(R) \quad \forall i, j.$$

Under Assumption 2, these are the theoretical types of students that can be defined according to their compliance behavior to encouragements

M(A=F)	M(A=P)	M(A=R)	Stratum ID	Stratum Label
1	1	1	A	Always Takers (S^{111})
0	1	1	B	Presentation Compliers (S^{011})
0	0	1	C	Reward Compliers (S^{001})
0	0	0	D	Never Takers (S^{000})

Mixture of Principal Strata

Unfortunately, the strata that may be observed in the data often host several thoeretical types of students

	M=0	M=1
A=F	Never Takers, P-compliers, R-Compliers	Always Takers
A=P	Never Takers, R-Compliers	Always Takers, P-compliers
A=R	Never Takers	Always Takers, P-compliers, R-Compliers

- $\pi_{m_F m_P m_R} = Pr(S_{ij} = S^{m_F m_P m_R})$: probability of belonging to stratum $S^{m_F m_P m_R}$
- Randomized assignment of encouragements and the monotonicity assumption imply that

$$\pi_{100} = \pi_{010} = \pi_{110} = \pi_{101} = 0;$$
$$\pi_{111} = Pr(M_{ij} = 1 \mid A_j = F); \quad \pi_{000} = Pr(M_{ij} = 0 \mid A_j = R);$$
$$\pi_{001} = Pr(M_{ij} = 1 \mid A_j = R) - Pr(M_{ij} = 1 \mid A_j = P);$$
$$\pi_{011} = Pr(M_{ij} = 1 \mid A_j = R) - \pi_{111} - \pi_{001};$$

and also that

$$E[Y_{ij}(F) \mid S_{ij} = S^{111}] = E[Y_{ij} \mid M_{ij} = 1, A_j = F];$$
$$E[Y_{ij}(R) \mid S_{ij} = S^{000}] = E[Y_{ij} \mid M_{ij} = 0, A_j = R].$$

Definition of causal estimands

Principal Causal Effects (PCE)

$$PCE_{kh}(m_F, m_P, m_R) = \mathrm{E}\left[Y_{ij}(a_k) \mid S_{ij} = S^{m_F m_P m_R}\right] - \mathrm{E}\left[Y_{ij}(a_h) \mid S_{ij} = S^{m_F m_P m_R}\right]$$

Intent-to-Treat Effects : ITT is, then, a weighted average of PCEs, with weights given by the conditional probability of belonging to each principal stratum:

$$ITT_{kh} = \mathrm{E}\left[Y_{ij}(a_k)\right] - \mathrm{E}\left[Y_{ij}(a_h)\right] = \sum_{m_F m_P m_R} PCE_{kh}(m_F, m_P, m_R) \cdot \pi_{m_F m_P m_R}.$$

Interpetation of PCE in our application

	E[Y(P)]-E[Y(F)]	E[Y(R)]-E[Y(P)]	E[Y(R)]-E[Y(F)]
Always Takers	[D] Enc, Spill	[D] Spill	[D] Enc, Spill
Presentation Compliers	[A] Enc, Exp, Spill	[D] Spill	[A] Enc, Exp, Spill
Reward Compliers	[D] Enc, Spill	[A] Exp, Spill	[A] Enc, Exp, Spill
Never Takers	[D] Enc, Spill	[D] Spill	[D] Enc, Spill

Dissociative PCE [D] directly originate from encouragements or from spillovers arising from classmates' experience

- They usually include *pure encouragement* and *spillover mediated* effects
- As the reward does not apply during follow-up, some dissociative PCE can only be interpreted as classroom spillovers
- Separating *pure encouragement* and *spillover mediated* effects is unfeasible without additional assumptions

Associative PCE [A] originate from (but not only from) experience

- They usually include *experience*, *pure encouragement* and *spillover* effects
- As the reward does not apply during follow-up, one associative PCE can be interpreted as a combination of experience and spillover effects induced by experience
- Separating *experience* and its related *spillover mediated* effects is unfeasible without additional assumptions

Bayesian Inference for Causal Effects

(Rubin, 1978; Imbens and Rubin, 1997)

- Bayesian inference considers the observed values to be realizations of random variables and the unobserved values to be unobserved random variables
- Bayesian inference involves three choices:
  (1) Model for principal stratum membership: $\Pr\left(S_{ij} | \mathbf{X}_{ij}; \boldsymbol{\theta}\right)$
  (2) Model(s) for potential outcomes: $\Pr\left(Y_{ij}(F), Y_{ij}(P), Y_{ij}(R) | S_{ij}, \mathbf{X}_{ij}; \boldsymbol{\theta}\right)$
  (3) [weakly informative] Priors for the parameters $p(\boldsymbol{\theta})$.
- $S_{ij} = (M_{ij}(F), M_{ij}(P), M_{ij}(R))$ is unknown, and the likelihood involves mixtures
- Posterior computation via a Gibbs sampler with data augmentation (to sample PS membership for each unit)
- Additional assumption

Assumption 3. (Exclusion Restriction for always-takers):

$$\Pr(Y_{ij}(F) | S_{ij} = S^{111}) = \Pr(Y_{ij}(P) | S_{ij} = S^{111}) = \Pr(Y_{ij}(R) | S_{ij} = S^{111})$$

which implies that

$$PCE_{kh} = 0 \quad \forall k, h.$$

Model Specification

- **Model for principal strata**: Multinomial Logit random effect (Random intecepts account for cluster correlation in compliance behavior)

$$ln \frac{P(S_{ij} = k|\mathbf{X}_{ij})}{P(S_{ij} = S^{111}|\mathbf{X}_{ij})} = \gamma_k + \boldsymbol{\delta}_k^T \mathbf{X}_{ij} + \mathrm{a}_{kj}$$

$$\mathbf{a}_j \sim N(\mathbf{0}, \Sigma_a),$$

- **Model for outcome**: Zero-Inflated Poisson

$$Pr(Y_{ij}(a) = y|S_{ij}, \mathbf{X}_{ij}) = \begin{cases} p_{ij}(a, S_{ij}, \mathbf{X}_{ij}) + (1 - p_{ij}(a, S_{ij}, \mathbf{X}_{ij}))\, Pois(0; \lambda_{ij}(a, S_{ij}, \mathbf{X}_{ij})) & \text{if } y = 0 \\ (1 - p_{ij}(a, S_{ij}, \mathbf{X}_{ij}))\, Pois(y; \lambda_{ij}(a, S_{ij}, \mathbf{X}_{ij})) & \text{if } y > 0 \end{cases}$$

where $Pois(0; \lambda_{ij}) = exp(-\lambda_{ij})$ and $Pois(y; \lambda_{ij}) = \frac{e^{-\lambda_{ij}} \lambda_{ij}^y}{y!}$.
We model the parameter $\lambda_{ij}(a, S_{ij}, \mathbf{X}_{ij})$ of the Poisson part using a hierarchical generalized linear model with a log link (the random intercept accounts for cluster correlation):

$$log\left(\lambda_{ij}(a, S_{ij}, \mathbf{X}_{ij})\right) = \alpha_a^{S_{ij}T} + \boldsymbol{\beta}_a^{S_{ij}T} \mathbf{X}_{ij} + b_j$$

$$b_j \sim N(0, \sigma_b).$$

- To calculate the sample-average estimates, we assume the conditional association between $Y_{ij}(F), Y_{ij}(P)$ and $Y_{ij}(R)$ to be absent

Estimated posterior probabilities of PS membership

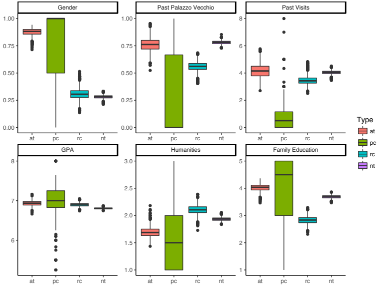
	Mean	SD	2.5%	5%	95%	97.5%
Always Takers	0.091	0.014	0.068	0.071	0.117	0.120
Presentation Compliers	0.001	0.003	0.000	0.000	0.004	0.008
Reward Compliers	0.317	0.039	0.244	0.256	0.383	0.395
Never Takers	0.591	0.034	0.519	0.530	0.643	0.654

Overwhelming majority of students taking part in the experiment not really attracted by the proposed visit of Palazzo Vecchio

- 59.1% are not interested whatever the encouragement
- 31.7% are available to perform it if they receive a reward
- Always takers are few
- Presentation hardly elicits sufficient motivation for the proposed visit experience

A gallery of four portraits

Posterior distribution of the proportion/mean of background covariates by PS



WHO ARE NEVER TAKERS?

Fairly successful females from educated families, museum-goers in their free time. They are likely to have visited PV in the past

WHO ARE REWARD COMPLIERS?

Good female students from a less educated family, more seldom museum-goers in their free time. They are less likely to have visited PV in the past than never takers

Results: Principal Causal Effects

Outcome is the count of later museum visits

	Never Takers						
	Mean	2.5%	5%	95%	97.5%	$Pr(\cdot > 0)$	Interpr.
Presentation vs Flyer	2.04	-0.26	0.15	4.12	4.78	0.96	Enc+S
Reward vs Presentation	1.72	-1.80	-1.10	5.21	6.11	0.85	S
Reward vs Flyer	3.77	1.02	1.41	7.12	8.21	1.00	Enc+S

	Reward Compliers						
	Mean	2.5%	5%	95%	97.5%	$Pr(\cdot > 0)$	Interpr.
Presentation vs Flyer	5.62	2.05	2.51	10.22	11.52	1.00	Enc+S
Reward vs Presentation	-2.27	-8.15	-6.95	1.79	2.62	0.17	Exp+S
Reward vs Flyer	3.35	0.72	1.08	6.34	7.42	0.99	E+E+S

Alternative outcome in the paper: probability of performing at least one visit in the follow-up period

Discussion and Concluding Remarks

- Large group of never takers allows to voice the direct effect of the intrinsic motivational encouragement towards later museum attendance provided by the presentation
- This principal effect is positive and possibly reinforced by classroom spillovers
- Considerable group of students that comply with the reward promise allows to voice the motivational reinforcement that the experience itself provides
- This principal effect is ambiguous, with reward compliers possibly reacting to experience in opposite ways
- This evidence suggests that it is the motivational encouragement, rather than experience, to play an important role in boosting teens museum attendance.