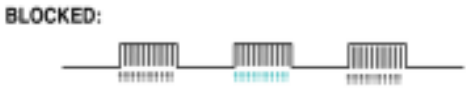
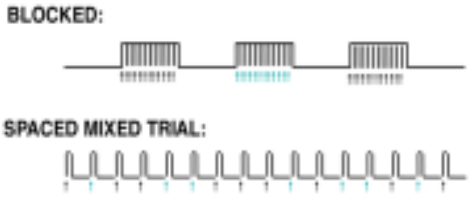
Experimental Design II

Block design



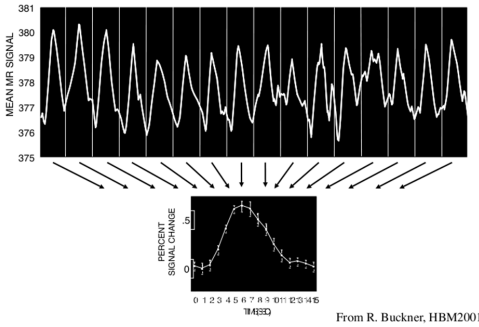
From R. Buckner, HBM2001

Slow event related design



From R. Buckner, HBM2001

Slow event related exp of language



From R. Buckner, HBM2001

Why event related designs?

- Randomize condition/stimuli order
  Cf. Confounds of blocked designs (Johnson et al., 1997)

From C. Ruff

Why event related designs?

Blocked designs may trigger expectations and cognitive sets

Event related designs can minimize expectation/strategy

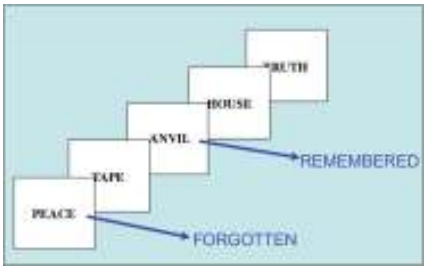
From C. Ruff

WHY EVENT RELATED DESIGNS?

- Randomize condition/stimuli order
  Cf. Confounds of blocked designs (Johnson et al., 1997)
- Post-hoc classification of trials
  e.g. According to subsequent recall (Wagner et al., 1998)

From C. Ruff

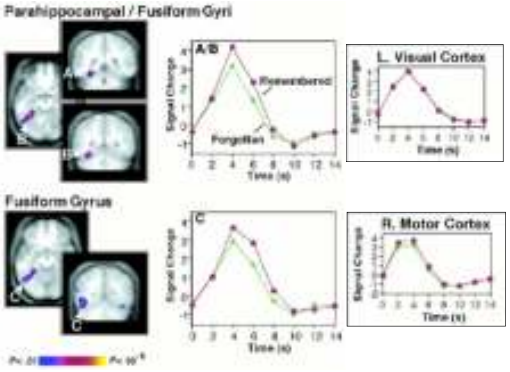
WHY EVENT RELATED DESIGNS?



fMRI Task: abstract or concrete word?
After scanning: recognition memory test
fMRI Data Analysis: Classify trials as hit (remembered) and miss (forgotten)

Wagner et al., 1998

WHY EVENT RELATED DESIGNS?



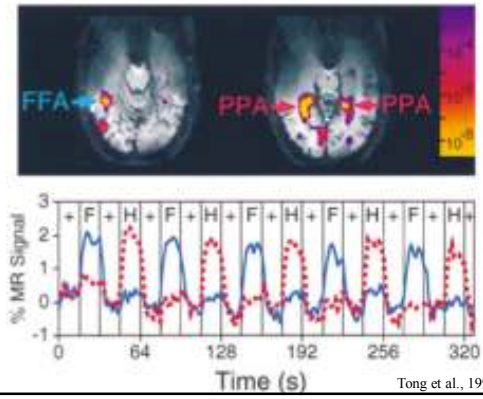
Wagner et al., 1998

WHY EVENT RELATED DESIGNS?

- Randomize condition/stimuli order
  Cf. Confounds of blocked designs (Johnson et al., 1997)
- Post-hoc classification of trials
  e.g. According to subsequent recall (Wagner et al., 1998)
- Some events can only be indicated by the subject (during the experiment)
  e.g. Changes in spontaneous perception (Tong et al., 1998)

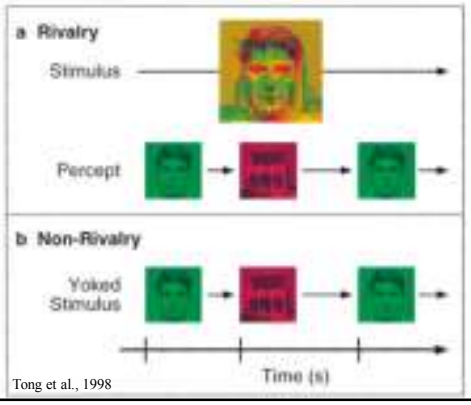
From C. Ruff

WHY EVENT RELATED DESIGNS?



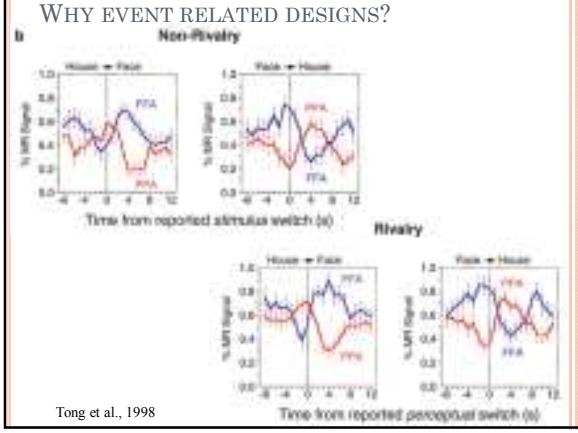
Tong et al., 1998

WHY EVENT RELATED DESIGNS?



Tong et al., 1998

WHY EVENT RELATED DESIGNS?



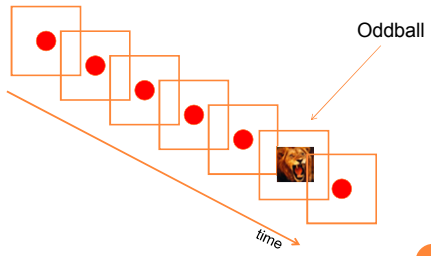
Tong et al., 1998

WHY EVENT RELATED DESIGNS?

- Randomize condition/stimuli order
  Cf. Confounds of blocked designs (Johnson et al., 1997)
- Post-hoc classification of trials
  e.g. According to subsequent recall (Wagner et al., 1998)
- Some events can only be indicated by the subject (during the experiment)
  e.g. Changes in spontaneous perception (Tong et al., 1998)
- Some trials cannot be blocked
  e.g. Odd-ball designs (Clark et al., 2000)

From C. Ruff

WHY EVENT RELATED DESIGNS?



Clark et al., 2000

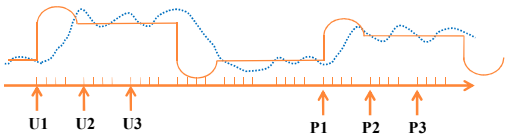
WHY EVENT RELATED DESIGNS?

- Randomize condition/stimuli order
  Cf. Confounds of blocked designs (Johnson et al., 1997)
- Post-hoc classification of trials
  e.g. According to subsequent recall (Wagner et al., 1998)
- Some events can only be indicated by the subject (during the experiment)
  e.g. Changes in spontaneous perception (Tong et al., 1998)
- Some trials cannot be blocked
  e.g. Odd-ball designs (Clark et al., 2000)
- Better model for blocked stimuli too?
  e.g. State-item interactions (Chawla et al., 1999)

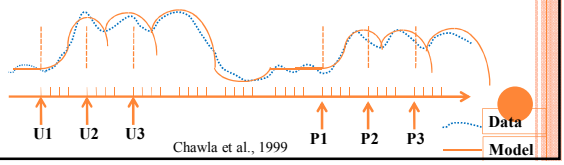
From C. Ruff

WHY EVENT RELATED DESIGNS?

"Epoch" model assumes constant neural processes throughout block

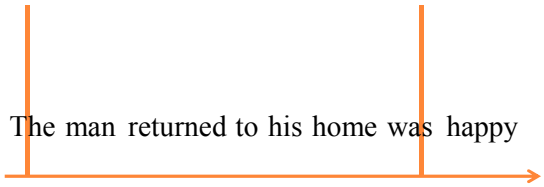


"Event" model may capture state-item interactions (with longer SOAs)



Chawla et al., 1999

WHAT/WHEN/WHERE IS THE EVENT?

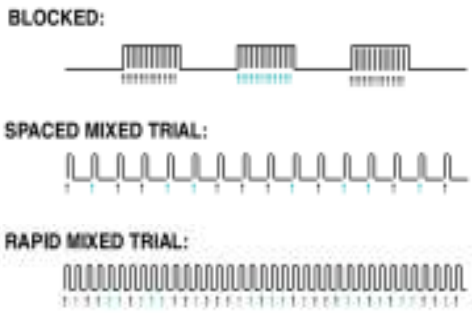


WHY NOT EVENT RELATED DESIGNS?

- Blocked designs are statistically more powerful
- Some psychological processes are difficult to switch on/off, better in blocks
  e.g., starting and stopping mental imagery
- Excessively complicated designs might confuse the subject

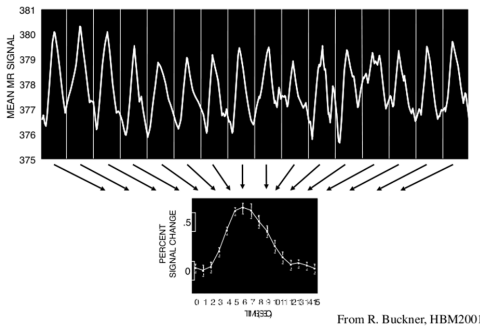
From C. Ruff

RAPID EVENT RELATED DESIGN



From R. Buckner, HBM2001

SLOW EVENT RELATED EXP OF LANGUAGE



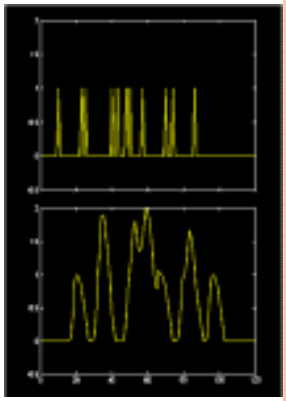
From R. Buckner, HBM2001

FAST EVENT RELATED

More trials, same experiment length!

But, hemodynamic response of different events now overlaps.

→ How to tease apart which part of the response comes from which event?



ASSUMPTION: LINEAR SYSTEM

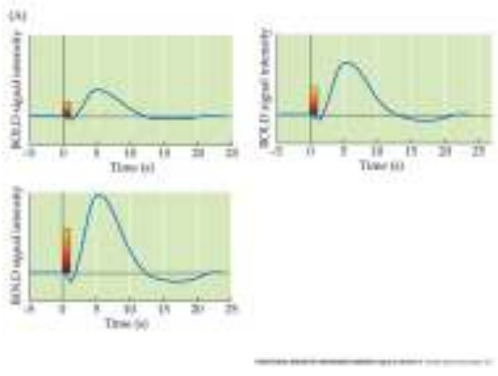
System = input → output
Neural activity → fMRI signal

A system is linear if it has two features:

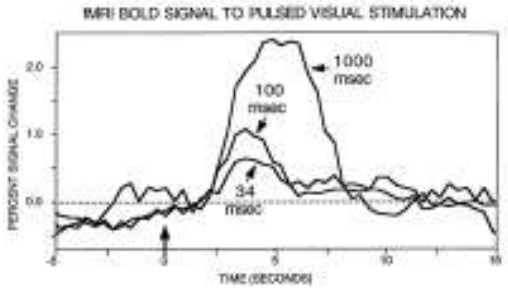
1. Scaling
2. Superposition

If a system is linear we can add/subtract responses coming from contiguous trials

ASSUMPTION I: SCALING

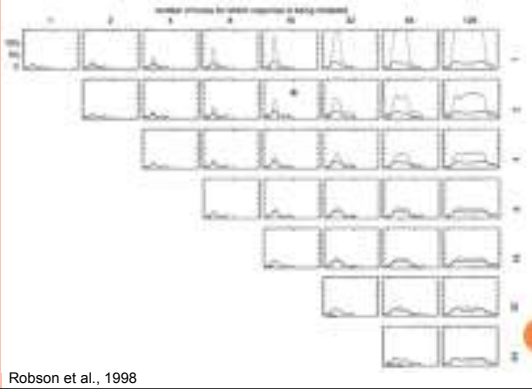


Can we assume scaling (I)?



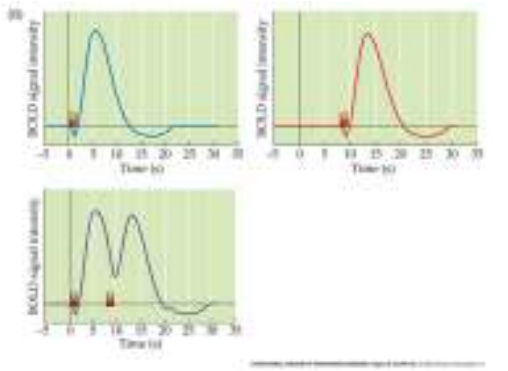
Data from Robert Savoy and Kathleen O'Craven (25).

Can we assume scaling (II)?

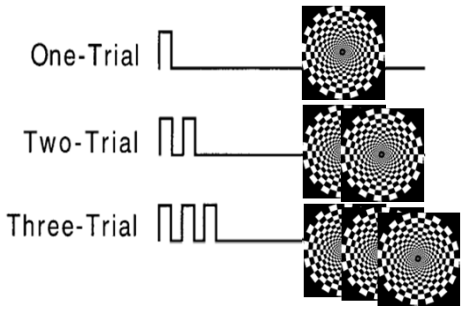


Robson et al., 1998

Assumption II: Superposition

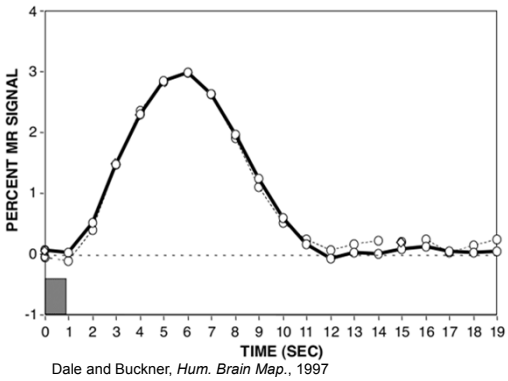


Can we assume superposition (I)?



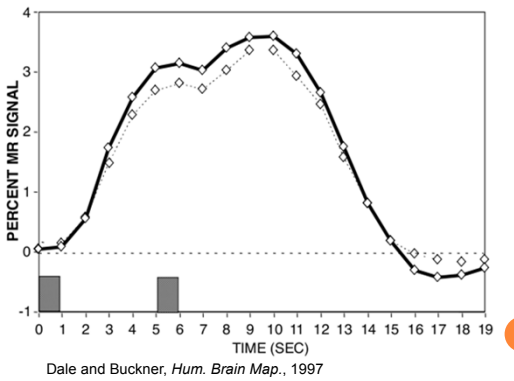
Dale and Buckner, *Hum. Brain Map.*, 1997

Can we assume superposition (II)?



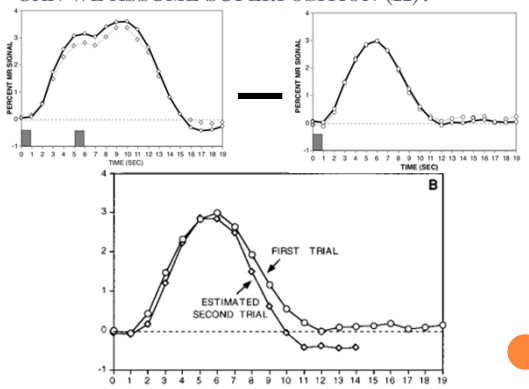
Dale and Buckner, *Hum. Brain Map.*, 1997

Can we assume superposition (II)?



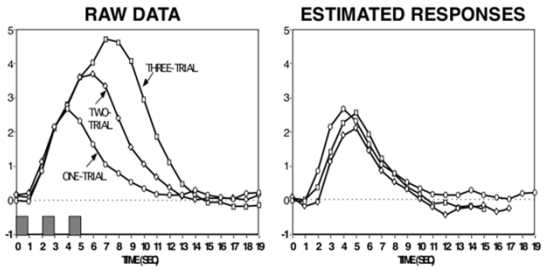
Dale and Buckner, *Hum. Brain Map.*, 1997

Can we assume superposition (II)?



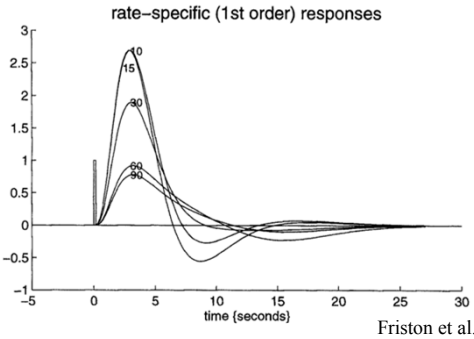
Dale and Buckner, *Hum. Brain Map.*, 1997

Can we assume superposition (II)?



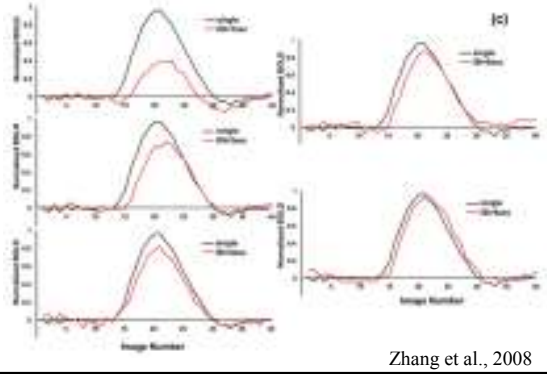
Dale and Buckner, *Hum. Brain Map.*, 1997

Can we assume superposition (III)? Effects of presentation rate



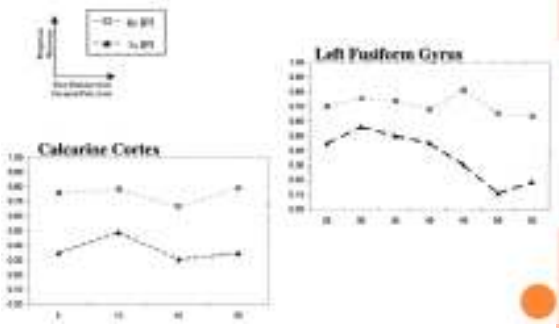
Friston et al., 1998

Can we assume superposition (IV)? Effects of ISI



Zhang et al., 2008

Different area different non-linearity



Huettel & McCarthy 2001

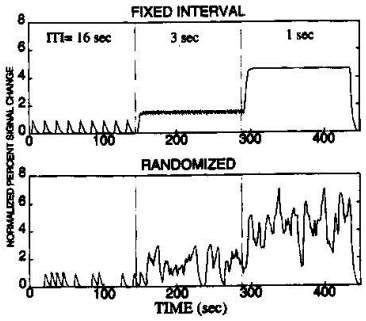
How to tease apart different trials?

1. Trial order: shuffle things around

- With rapid ER-fMRI, it is important that different trial types follow each other equally
  - Statistical (multicollinearity) & psychological reasons
- Early studies used counterbalancing
  - Must be done to several orders depending upon trial length
- Recent studies have used randomization (full/pseudo)
  - Works fine with large enough # of trials

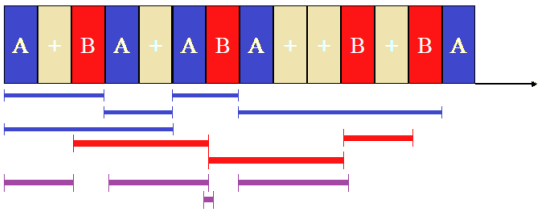
How to tease apart different trials?

2. ISI Jitter/Randomization

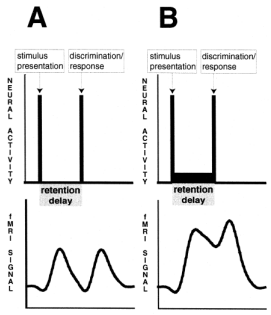


How to tease apart different trials?

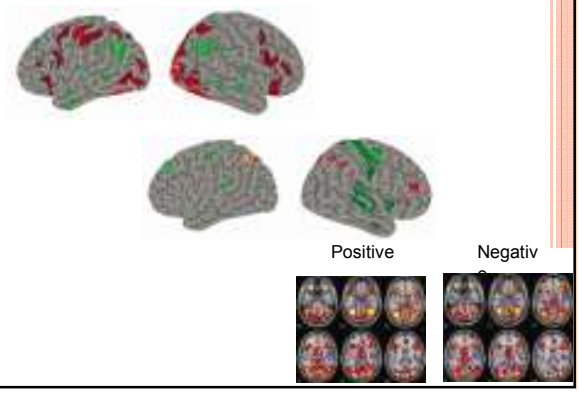
2. ISI Jitter/Randomization



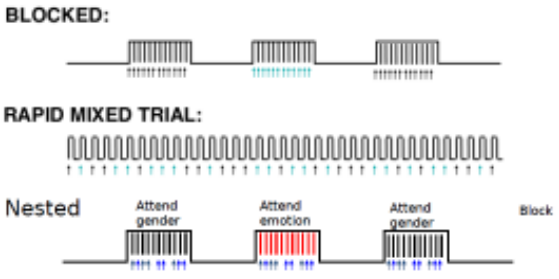
Teasing apart sequential processes



Stimulus & Response; Delay; Feedback



Nested/Mixed Designs



Efficiency

- A numerical value that captures the relative ability of a design to detect an effect of interest.
- Say you are interested in the difference between two tasks, A & B.

$$t \propto \frac{estimate(Av.B)}{\sqrt{var\,estimate(Av.B)}}$$

Contrast of interest

Noise

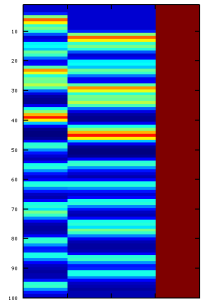
Experimental design

$$e(c,X) \propto \frac{1}{\text{var } estimate\ (AvB)} = \frac{1}{Var(\hat{c^T}\beta)} = \hat{\sigma}[c^T(X^TX)c]^{-1}$$

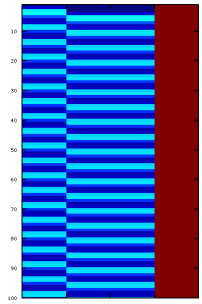
EFFICIENCY: EXAMPLES

- X Matrix: Task A, Task B, Mean
- Contrasts of interest:
  i. Direct comparison [1 -1 0]
  ii. Estimation of each effect against baseline [1 0 0], [0 1 0]
- Randomize or not?
- Event related or block?
- Use rest periods in between blocks?

RANDOMIZED

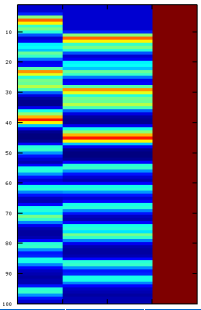


FIXED

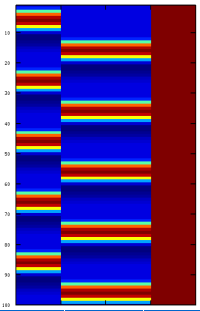


Design	df	e(c,X)	1 -1 0	1 0 0	0 1 0
Fix	100-3	0.31	1.35	0.80	0.83

RANDOMIZED

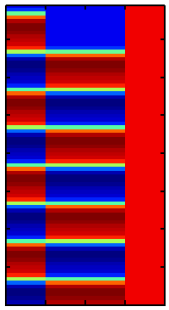


BLOCK

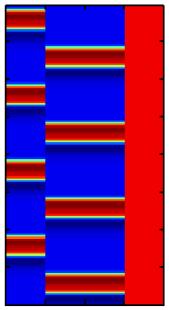


Design	df	e(c,X)	1 -1 0	1 0 0	0 1 0
Rdm	100-3	1.32	3.05	4.47	4.84

NO REST



REST



Design	df	e(c,X)	1 -1 0	1 0 0	0 1 0

GOOD PRACTICES (BUT YOUR EXPERIMENT MAY DIFFER …)

Bigger IS better: more trials, more TRs, more Ss.
ALWAYS counterbalance/randomize/pseudo-randomize your events!

Ask yourself questions:
- What's the best design for my cog process of interest?
- What's the best design for my task(s)?
- What psychological factors might be at play?
- What comparison(s) are you interested in?

Maximize efficiency for your contrast(s) of interest, compare multiple designs, simulate!
Be considerate: For how long do you think you can get ***good*** data out of a volunteer?