Nudging Habit Formation
for Long-Term Behavior Change

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Many public policy issues require chronic behavioral change

- **Poverty alleviation:** savings, planting of cash crops

- **Finance:** retirement planning

- **Education**

- **Health:** diseases of life-style (e.g. obesity, diabetes, CVD)
Nudge interventions successful in the short run

Volpp et al. (2009), Cawley & Price (2013): nudges increase weight loss, BUT...
Nudge interventions successful in the short run

Volpp et al. (2009), Cawley & Price (2013): nudges increase weight loss, **BUT**...

A. Intervention of financial incentives for weight loss

- Deposit contract plus lottery
- No treatment control

Nudge interventions successful in the short run

Charness & Gneezy (2009), Royer (2015): nudges increase gym attendance, **BUT**...
Nudge interventions successful in the short run

Charness & Gneezy (2009), Royer (2015): nudges increase gym attendance, **BUT** ...

**B. Intervention of payment for gym visits**

<table>
<thead>
<tr>
<th>Mean number of gym visits/week</th>
<th>Prior to intervention</th>
<th>5-week intervention</th>
<th>Post intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payment</td>
<td>2.5</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>No payment control</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

B: Mean gym visits per week prior to study (weeks -16 to -2), during 5 intervention weeks of payment for attending, and during 15 no-treatment weeks (weeks 6–21, \( N = 99 \)). Data are from “Incentives to Exercise,” by G. Charness and U. Gneezy, 2009, *Econometrica*, 77, p. 921, Figure 2b. Copyright 2009 by Wiley.
Nudge interventions successful in the short run

Volpp et al. (2008), Ginã£l' et al (2010): nudges increase smoking quit rates, **BUT**...
Nudge interventions successful in the short run

Volpp et al. (2008), GinÃľ et al (2010): nudges increase smoking quit rates, **BUT**...

C: Percentage of participants who quit smoking (biochemically verified) at 3 or 6 months and at 15 or 18 months following intervention of information about smoking cessation programs paired with financial incentives (N = 878). Data are from “A Randomized, Controlled Trial of Financial Incentives for Smoking Cessation,” by K. G. Volpp, A. B. Troxel, M. V. Pauly, H. A. Glick, A. Puig, D. A. Asch, ... J. Audrain-McGovern, 2009, New England Journal of Medicine, 360, p. 703, Table 2. Copyright 2009 by the Massachusetts Medical Society.
Nudge interventions successful in the short run

King et al. (2014) : nudges increase physical activity, **BUT**...
Nudge interventions successful in the short run

King et al. (2014): nudges increase physical activity, **BUT...**

D: Mean number of minutes per week of moderate to vigorous physical exercise during computer-delivered interventions or health program controls at 6 months of treatment, 12 months of treatment, and 6 months after end of treatment (Ns = 70 control and 75 computerized treatment at baseline, N = 61 computerized treatment at 18 months). Data are from “Exercise Advice by Humans Versus Computers: Maintenance Effects at 18 Months,” by A. C. King, E. B. Hekler, C. M. Castro, M. P. Buman, B. H. Marcus, R. H. Friedman, and M. A. Napolitano, 2014, Health Psychology, 33, p. 195, Figure 1. Copyright 2014 by the American Psychological Association.
Potential solution: Providing nudges for longer?

- Cost-effectiveness? Potentially for a subset of behaviors
  - paying for smoking cessation
  - re-motivating medication adherence
  - not as clear for other activities such as exercise or weight loss

- May lose effectiveness as participants lose interest, become bored or otherwise disengaged over time

- May require increasing incentive amounts (Gneezy et al., 2011)

- Potentially problematic for intrinsic motivation (Kamenica, 2012)
Potential solution: Defaults / structural change

- Save More Tomorrow (SMarT) significantly increased saving rates over a 3-year period (Thaler & Benartzi, 2004)
  - this required a **structural change to available savings options**
  - few employees (26.5%) self-selected into the treatment
  - saving rates were not impacted for the majority of employees

- *Opower* program using social comparison-based energy reports reduces household energy consumption over a 5-year period (Allcott & Rogers, 2014)
  - persistence likely due to significant **switch to energy-efficient appliances, not behavior change**
Outline

1. Existing literature on habits

2. A BE perspective on habits

3. Model

4. Empirical findings

5. Conclusion
1. Existing literature on habits

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Why are we excited about habits?

- Habits and “daily routines” cited as successful strategies for medication adherence and other chronic health behaviors (Phillips et al., 2013; Brooks et al., 2014)

- Two key characteristics:
  - Habits run automatically using system 1 (40% of daily behavior)
  - Habits mediate the effect of self-control and intrinsic motivation on health behaviors once they are established (Rebar et al., 2014; Galla et al., 2015)
Little work in the economics literature

► Economics models habits as the accumulation of a habit “stock” 
\[
\sum_{k=0}^{n} \delta^k c_{n-k}
\]
which increases the marginal utility for future consumption \((c_{n+1})\) (Becker & Murphy, 1988)

► This model is used to explain the behavioral persistence observed for a wide range of behaviors:

- List & Samek (2015), Loewenstein et al. (2016): diet
- Charness & Gneezy (2009), Royer (2015): exercise
Conceptualization of habits in the psychology literature

- Long history in psychology (e.g. Gollwitzer, Verplanken, Wood)

- Habits defined as “**automatic behavioral responses to contextual cues**” (Wood & Neal, 2009)
  - Habits form through the repetition of behavior in a specific context (Lally et al., 2010; Neal, 2007)
  - Context acquires the potential to activate behavior in the absence of awareness, conscious control, cognitive effort or deliberation (Bargh, 1994)
Drawbacks of existing habit formation interventions

- Effective for only a minority of study participants (often those with higher initial intrinsic motivation)
  (e.g. Prestwich et al. 2010; Gardner et al., 2014)

- Commonly used “implementation intentions” (action plans) infrequently reinforced during habit formation period
  (e.g Lally, Chipperfield, and Wardle, 2008)

- Habits investigated often self-selected by study participants
  (e.g. Wood and Neal, 2009) and/or outcomes self-reported
  (e.g. Judah, Gardner, and Aunger, 2013)
A BE perspective on habit formation

- Habit formation takes about 2-3 months (Lally et al., 2010)
- Eating: 3 times/day, \( \sim 100 \) times/month, \( \sim 300 \) times/habit formed
- Lot of room for error (Source: American Life Panel, unpublished study by the authors):
  - Q: “Did you make a health-related New Year’s resolution?”
    \( \rightarrow \) Yes: 31.2%
  - Q: “By now, do you carry this behavior out automatically?”
    \( \rightarrow \) Yes: 25.7%
Two key biases

- **Present bias**: due to long habit formation period requiring (multiple) daily, costly actions
Two key biases

- Present bias: due to long habit formation period requiring (multiple) daily, costly actions

- **Salience**: Attendance increases by 40% between December and January, then drops back to December levels...
Pathways from nudges to habit formation

- **NUDGES**
  - System 2 (deliberative)
  - Increase Salience
- **HABITS**
  - System 1 (automatic)
- **LONG-TERM BEHAVIORAL CHANGE**

1. Counter Present Bias
2. Increase Salience
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Modeling habit formation

1. Individuals maximize their health status which is directly produced from health activities/investments \( \{ h_t \} \)
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   e.g. going to the gym
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2. Health activities require mental energy drawn from a fixed amount of daily willpower \( \{W_t\} \)
Modeling habit formation

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2. Health activities require mental energy drawn from a fixed amount of daily willpower \( \{W_t\} \)
   
   e.g. continually motivating exercise, determining when to stop
Modeling habit formation

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2. Health activities require mental energy drawn from a fixed amount of daily willpower \( \{W_t\} \)
   
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3. Mental energy is also needed to initiate the health activities (\( \bar{K} \))
Modeling habit formation

1. Individuals maximize their health status which is directly produced from health activities/investments $\{h_t\}$
   
   e.g. going to the gym

2. Health activities require mental energy drawn from a fixed amount of daily willpower $\{W_t\}$
   
   e.g. continually motivating exercise, determining when to stop

3. Mental energy is also needed to initiate the health activities ($\bar{K}$)
   
   e.g. choosing gym clothes, exercise routine, travel route
Modeling habit formation

1. Individuals maximize their health status which is directly produced from health activities/investments $\{h_t\}$
   
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4. Mental energy that can also be used for habit formation $\{z_t\}$
Modeling habit formation

1. Individuals maximize their health status which is directly produced from health activities/investments \( \{h_t\} \)
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2. Health activities require mental energy drawn from a fixed amount of daily willpower \( \{W_t\} \)
   e.g. continually motivating exercise, determining when to stop

3. Mental energy is also needed to initiate the health activities \((\bar{K})\)
   e.g. choosing gym clothes, exercise routine, travel route

4. Mental energy that can also be used for habit formation \( \{z_t\} \)
   e.g. pairing gym attendance with end of workday or commute to work
Modeling objectives

- Habit formation activities are not directly valued
- Habits reduce the mental energy needed to initiate health activities

\[
\left( \frac{\bar{K}}{\sum_{k=1}^{P} \delta^k z_{t-k}} \right)
\]

- Past habits reduce the mental energy of contemporaneous habits

\[
\left( \frac{z_t}{\sum_{k=1}^{P} \delta^k z_{t-k}} \right)
\]

- Present-biased preferences \((\beta, \delta < 1)\) reduce the optimal level of habit formation, leading to lower long-run health status \(\{h_t\}\)
Three-period model

\[
\max_{\{h_t\}_{t=1}^3, z_1, z_2} U(h_1, h_2, h_3) = \max_{\{h_t\}_{t=1}^3, z_1, z_2} U(h_1) + \beta \sum_{t=2}^3 \delta^{t-1} U(h_t)
\]

\[
= \max_{\{h_t\}_{t=1}^3, z_1, z_2} \log(h_1) + \beta \delta \cdot \log(h_2) + \beta \delta^2 \cdot \log(h_3)
\]

subject to

\[
W = h_1 + \bar{K} + \rho z_1
\]

\[
W = h_2 + \frac{\bar{K} + \rho z_2}{z_1}
\]

\[
W = h_3 + \frac{\bar{K}}{z_2 + z_1}
\]
Three-period model

- Solving the constrained optimization yields the following functions for $z_1(z_2)$ and $z_2(z_1)$:

$$z_1(z_2) = \frac{\rho z_2 - \bar{K}}{\rho z_2^2 - \rho \bar{K} z_2 - \beta \delta^2 \bar{K}}$$

$$z_2(z_1) = \frac{\beta \delta^2 \bar{K} (1 - \bar{K} - \rho z_1) + \rho z_1 \bar{K} - \rho z_1^2}{\rho^2 z_1}$$

- From initial conditions $M = 10, \beta = .8, \delta = .9, \rho = 1, \bar{K} = 2$:

$$\frac{\partial z_1}{\partial \bar{K}} > 0$$

$$\frac{\partial z_1}{\partial \rho}, \frac{\partial z_1}{\partial \beta}, \frac{\partial z_1}{\partial \delta} < 0$$
Q: Is supplementing $h_1$ or $z_1$ more beneficial to $h_3$ and total utility over the three periods?
Q: Is supplementing $h_1$ or $z_1$ more beneficial to $h_3$ and total utility over the three periods?

1. A one-unit $h_1 \uparrow \rightarrow \uparrow 0.06$ in $h_3$ and $\uparrow 0.01$ in $\sum_{t=1}^{3} \log(h_t)$

2. A one-unit $z_1 \uparrow \rightarrow \uparrow 0.45$ in $h_3$ and $\uparrow 0.07$ in $\sum_{t=1}^{3} \log(h_t)$
Q: Is supplementing $h_1$ or $z_1$ more beneficial to $h_3$ and total utility over the three periods?

1. A one-unit $\uparrow h_1 \rightarrow \uparrow 0.06$ in $h_3$ and $\uparrow 0.01$ in $\sum_{t=1}^{3} \log(h_t)$

2. A one-unit $\uparrow z_1 \rightarrow \uparrow 0.45$ in $h_3$ and $\uparrow 0.07$ in $\sum_{t=1}^{3} \log(h_t)$

Q: What is the impact of reducing the relative cost of habit formation?
Q: Is supplementing $h_1$ or $z_1$ more beneficial to $h_3$ and total utility over the three periods?

1. A one-unit $↑h_1 \rightarrow ↑0.06$ in $h_3$ and $↑0.01$ in $\sum_{t=1}^{3} \log(h_t)$

2. A one-unit $↑z_1 \rightarrow ↑0.45$ in $h_3$ and $↑0.07$ in $\sum_{t=1}^{3} \log(h_t)$

Q: What is the impact of reducing the relative cost of habit formation?

1. $↓0.1$ in $\rho \rightarrow ↑0.21$ in $h_3$ and $↑0.04$ in $\sum_{t=1}^{3} \log(h_t)$
Outline

1. Existing literature on habits
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Study setting

- Rewarding Adherence Program (RAP) promoting HIV medication adherence in Kampala, Uganda

- Study intervention groups:
  - **Treatment group 1**: Incentivized conditional on timely clinic visits according to each patients’ pre-scheduled appointments
  - **Treatment group 2**: Incentivized conditional on MEMS-caps measured adherence $\geq 90$

- Prizes awarded with a 1/6 probability $\Rightarrow \sim$ $2\text{ USD per person/year}$
MEMS for Patient 319102: Months 1 - 3

Treatment Group: 2

Mean M1 = 0.983; Mean M2 = 0.948; Mean M3 = 0.933
Example of MEMS Cap data

MEMS for Patient 319102: Months 4 - 6

Treatment Group: 2

Mean M4 = 0.817; Mean M5 = 0.983; Mean M6 = 0.741
RAP Impact

Mean ART Adherence

- Control
- Combined Treatment Groups
- Treatment Group 1
- Treatment Group 2
Psychological measure of habitual pill-taking

- Self-report Behavioral Automaticity Index (SRBAI)
  (Gardner et al., 2012; Wood & Runger, 2015)

- “Taking my ART pills is something …”
  1. I do automatically
  2. I do without having to consciously remember
  3. I do without thinking
  4. I start doing before I realize I’m doing it

- respond on Likert scale (“Strongly disagree” to “Strongly agree”)
Definition of objective habitual pill-taking measure

- **Mean adherence**: \( \frac{\# \text{ pills taken}}{\# \text{ pills prescribed}} \)

- **Habitual pill-taking**: pills taken within a +/- 1-hour window around the participant’s moving modal pill-taking time

- **Mean habit score**: \( \frac{\# \text{ pills taken within +/- 1-hour}}{\# \text{ pills prescribed}} \)
  - mean habit score is always \( \leq \) mean adherence
High mean adherence $\neq$ high mean strong habits

Mean adherence through month 20 = \textbf{88.83}\%

Mean adherence 6-month post-intervention = \textbf{44.14}\%
Mean adherence through month 20 = 96.53%
Mean adherence 6-month post-intervention = 86.52%
Regression framework

Mean medication adherence for patient \((i)\) over the 6-month post-intervention period takes the following linear functional form:

\[
\overline{A}_{\text{post},i} = \alpha + \beta \cdot \text{Habits}_{\text{M20},i} + \gamma \cdot \overline{A}_{\text{M20},i} + \rho \cdot T_i + \sum \delta X_i + \epsilon_i \quad (1)
\]

where,

- \(\overline{A}_{\text{post},i}\) - mean adherence post-intervention
- \(\text{Habits}_{\text{M20},i}\) - cumulative habit score through month 20
- \(\overline{A}_{\text{M20},i}\) - cumulative mean adherence through month 20
- \(T_i\) - treatment group indicator
- \(X_i\) - socioeconomic controls
## Habit score predicts post-intervention adherence

The table below presents the mean adherence during 6-month post-intervention.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit score in M20</td>
<td>0.5274***</td>
<td>0.2200**</td>
<td>0.2199**</td>
<td>0.2009**</td>
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<tr>
<td></td>
<td>(0.095)</td>
<td>(0.091)</td>
<td>(0.091)</td>
<td>(0.087)</td>
</tr>
<tr>
<td>Cumulative mean adherence M20</td>
<td>0.7685***</td>
<td>0.7718***</td>
<td>0.8139***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.156)</td>
<td>(0.152)</td>
<td>(0.147)</td>
<td></td>
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<tr>
<td>Combined Treatment</td>
<td>-0.0036</td>
<td>0.0016</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.032)</td>
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</tr>
<tr>
<td>Age</td>
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<tr>
<td></td>
<td>(0.002)</td>
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<tr>
<td>Female</td>
<td>-0.0226</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(0.033)</td>
<td></td>
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<tr>
<td>Primary education</td>
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<td></td>
<td>(0.034)</td>
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<tr>
<td>Household assets</td>
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<tr>
<td></td>
<td>(0.010)</td>
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<tr>
<td></td>
<td>(0.033)</td>
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<tr>
<td>Observations</td>
<td>61</td>
<td>61</td>
<td>61</td>
<td>61</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
Includes RAP study participants with complete post-intervention data.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Habits reduce likelihood of “pill holidays”

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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</thead>
<tbody>
<tr>
<td>Cumulative mean habit score M20</td>
<td>-6.2285***</td>
<td>-3.4484*</td>
<td>-4.2767**</td>
<td>-5.5406***</td>
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<tr>
<td></td>
<td>(1.697)</td>
<td>(1.848)</td>
<td>(2.072)</td>
<td>(2.039)</td>
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<tr>
<td>Cumulative mean adherence M20</td>
<td>-9.8790*</td>
<td>-12.4542**</td>
<td>-14.4686**</td>
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<tr>
<td></td>
<td>(5.716)</td>
<td>(5.608)</td>
<td>(5.985)</td>
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<tr>
<td>Combined Treatment</td>
<td>1.5019*</td>
<td>1.7688</td>
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<td></td>
<td>(0.814)</td>
<td>(1.087)</td>
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<td>Age</td>
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<td>(0.038)</td>
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<td>Female</td>
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<td>Primary education</td>
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<td></td>
<td>(0.801)</td>
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<td>Household assets</td>
<td>-0.1072</td>
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<td></td>
<td>(0.189)</td>
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<tr>
<td>Married</td>
<td>1.7488*</td>
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<td></td>
<td>(0.918)</td>
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<td>61</td>
<td>61</td>
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</tbody>
</table>

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* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
RAP did not significantly promote habits

![Graph showing Monthly Habit Score for different groups over months](image)
Characteristics of initially strong habitual pill takers

Sample composition: High and low habit scores in Month 5

<table>
<thead>
<tr>
<th></th>
<th>Habit score &gt; 0.8</th>
<th>Habit score ≤ 0.8</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Two-sided p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>41.6182</td>
<td>37.2021</td>
<td>-4.4161**</td>
<td>1.7207</td>
<td>0.011**</td>
</tr>
<tr>
<td>Female</td>
<td>1.6909</td>
<td>1.6064</td>
<td>-0.0845</td>
<td>0.0819</td>
<td>0.304</td>
</tr>
<tr>
<td>Primary education</td>
<td>0.5273</td>
<td>0.5106</td>
<td>-0.0166</td>
<td>0.0854</td>
<td>0.846</td>
</tr>
<tr>
<td>Married</td>
<td>0.5782</td>
<td>0.4681</td>
<td>-0.1101*</td>
<td>0.0553</td>
<td>0.089*</td>
</tr>
<tr>
<td>Household assets</td>
<td>5.3273</td>
<td>4.7340</td>
<td>-0.5932*</td>
<td>0.3471</td>
<td>0.090*</td>
</tr>
<tr>
<td>Own home</td>
<td>0.8545</td>
<td>0.6702</td>
<td>-0.1843**</td>
<td>0.0736</td>
<td>0.013**</td>
</tr>
<tr>
<td>Monthly inc</td>
<td>277547.1698</td>
<td>204222.2222</td>
<td>-73324.9476*</td>
<td>40324.3032</td>
<td>0.071*</td>
</tr>
<tr>
<td>Travel costs</td>
<td>20272.7273</td>
<td>12085.1064</td>
<td>-8187.6209**</td>
<td>3431.2610</td>
<td>0.018**</td>
</tr>
<tr>
<td>Mental health index</td>
<td>0.4612</td>
<td>0.5600</td>
<td>0.0988</td>
<td>0.0721</td>
<td>0.173</td>
</tr>
<tr>
<td>Motivation index</td>
<td>0.8364</td>
<td>0.7660</td>
<td>-0.0704**</td>
<td>0.0285</td>
<td>0.015**</td>
</tr>
</tbody>
</table>

N 55 94
Characteristics of initially strong habitual pill takers

<table>
<thead>
<tr>
<th>Sample composition: High and low habit scores in Month 5</th>
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</thead>
<tbody>
<tr>
<td><strong>Habit score &gt; 0.8</strong></td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Primary education</td>
</tr>
<tr>
<td>Married</td>
</tr>
<tr>
<td>Household assets</td>
</tr>
<tr>
<td>Own home</td>
</tr>
<tr>
<td>Monthly inc</td>
</tr>
<tr>
<td>Travel costs</td>
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<tr>
<td>Mental health index</td>
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<tr>
<td>Motivation index</td>
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<td>N</td>
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</tbody>
</table>

- Stability of home environment significantly aids medication adherence (e.g. Wagner & Ryan, 2004; Gardner et al., 2014)
Empirical findings

- Habit score is significantly lower for those with present-bias at the start of RAP ($p$-value = 0.064)

- Habits are persistently weaker for those with present-bias through the 20-month intervention period
  - Likelihood of mean habit score $\geq 0.8$ at month 20 is 14.1% lower ($p = 0.041$) for those with present-bias

- Psychology literature similarly finds habits mediate the relationship between self-control and long-run, chronic behaviors
  (Galla & Duckworth, 2015)
Outline

1. Existing literature on habits
2. A BE perspective on habits
3. Model
4. Empirical findings
5. Conclusion
1. Short-term success of nudges

2. Long-term behavior change required for many public policy issues

3. Habits offer a mechanism to achieve long-term behavior change

4. BE model of habit formation

5. Nudges for habit formation: theory and some evidence
Intervention to combat instability and present-bias

Nudging Habit Formation to Improve Long-term Medication Adherence (NuHabit) study design:

PHASE 1 – Conduct Qualitative Interviews and Finalize Intervention Content
- Conduct 40 semi-structured interviews with HIV clients, providers, and clinic administrators
- Finalize intervention content and review with Mildmay’s Community Advisory Board for final feedback.

PHASE 2 – Pilot RCT of NuHabit
- Control group: Receives same information as intervention groups about importance of habit formation and a leaflet with habit strategies
- Message group: Daily text messages about habit-related information for 3 months
- Nudge group: In addition to the same text messages as the message group they will also have the chance of winning small rewards for timely medication adherence

PHASE 3 – Evaluate areas of improvement for future scale-up
- Conduct eight focus groups with participants and stakeholders to identify implementation challenges and areas for improvement
- Estimate mission-critical design parameters
Thank you!

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