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Treated individuals who progress to action or maintenance for one behavior are more likely to make similar progress on another behavior: Coaction results of a pooled data analysis of three trials

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Abstract

Objective—This study compared, in treatment and control groups, the phenomena of coaction, which is the probability that taking effective action on one behavior is related to taking effective action on a second behavior.

Methods—Pooled data from three randomized trials of Transtheoretical Model (TTM) tailored interventions (*n*=9461), completed in the U.S. in 1999, were analyzed to assess coaction in three behavior pairs (diet and sun protection, diet and smoking, and sun protection and smoking). Odds ratios (ORs) compared the likelihood of taking action on a second behavior compared to taking action on only one behavior.

Results—Across behavior pairs, at 12 and 24 months, the ORs for the treatment group were greater on an absolute basis than for the control group, with two being significant. The combined ORs at 12 and 24 months, respectively, were 1.63 and 1.85 for treatment and 1.20 and 1.10 for control.

Conclusions—The results of this study with addictive, energy balance and appearance-related behaviors were consistent with results found in three studies applying TTM tailoring to energy balance behaviors. Across studies, there was more coaction within the treatment group. Future research should identify predictors of coaction in more multiple behavior change interventions.

Keywords

Multiple behavior change; Coaction; TTM tailoring; Diet; Sun exposure; Smoking

Introduction

Coaction is defined as the probability that taking effective action on one behavior is related to taking action on another behavior (Prochaska, 2008). Coaction is a unique aspect of multiple behavior change research which focuses on the extent to which change on one behavior is associated with change on a second behavior at the same follow-up time point. Coaction was originally described as co-variation (Johnson et al., 2008; Mauriello et al.,

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2010). We have given a separate name because the term co-variation was being confused with covariance analyses and coaction specifically refers to taking action on two behaviors. Because the vast majority of behavior change research is on single behaviors, coaction has been understudied. More commonly, studies examine co-occurrence in which the focus is on clusters of behaviors that occur together in specific populations (e.g., Berrigan et al., 2003; deVries et al., 2008; Fine et al., 2004; Keller et al., 2008; Sanchez et al., 2008). Coaction assumes co-occurrence clusters in at-risk individuals at baseline, but focuses on how behaviors within such clusters change together or independently at follow-up. In a commentary on a special issue of Preventive Medicine on multiple behavior change, Prochaska (2008) identified coaction as perhaps the most promising phenomenon of multiple behavior change.

Despite the lack of published research focusing specifically on coaction, three randomized clinical trials (RCTs) for multiple behavior change provide some evidence on coaction rates. Each RCT used transtheoretical model (TTM) based computer tailored interventions (CTIs) for energy balance behaviors. The first study involved high school students treated simultaneously for physical activity, diet and TV exposure (Mauriello et al., 2010). Coaction results were reported for three pairs of behaviors at 2, 6 and 12 months, resulting in a total of nine Odds Ratios (ORs) for the treatment group and nine for the control group. Seven of the ORs for the treatment group were significant and none for the control group, indicating coaction within the treatment group only with the treatment ORs consistently being larger on an absolute basis.

The second study was with middle school students treated simultaneously for physical activity, diet and TV exposure (Velicer et al., 2011). Coaction results were reported for each of the three pairs of behaviors at 12 and 24 months. Again, the majority of the ORs (7 out of 9) for the treatment group were significant compared to ORs ≈ 1 for the control group. On an absolute basis, the ORs for the treatment group were greater than the control group for all nine comparisons.

The third study was with a national sample of overweight and obese adults treated simultaneously for exercise, healthy eating (including low-fat diet and calorie control) and emotional eating (Johnson et al., 2008). Coaction results were reported for each of the three pairs of behaviors at 6, 12 and 24 months. Eight of the ORs for the treatment group were significant and three for the control group. Once again, on an absolute basis, eight of the nine ORs were greater for the treatment group and one was tied.

Hypotheses suggest that coaction could occur equally among successful participants in control and treatment groups. It is important here not to confuse coaction with a treatment effect: an intervention might increase action on one or both behaviors in a treatment group relative to a control group, without necessarily increasing coaction. That is, a treatment effect on either or both behaviors could be independent of any possible coaction. Each of the above mentioned studies were limited to energy balance behaviors, which may produce more consistent patterns of coaction than less related behaviors pairs. Based on the energy balance coaction results described above, this study was conducted to examine whether the absolute coaction ORs would also be consistently higher in the treatment group than the control group in these studies and whether there would also be more significant ORs within the treatment condition, in spite of assessing coaction in very different types of behaviors than have been studied to date. The present study includes an addictive behavior (smoking), energy balance behavior (diet), and sun protection behavior and compares the magnitude of coaction in treatment and control groups on these three pairs of behaviors.

Methods

Participants

This pooled data analysis combined primary data from three population trials conducted by the same research group between 1995–2000, funded by a large National Cancer Institute Center grant with populations of parents, primary care patients, and employees. Each trial randomized participants to TTM-tailored multiple behavior interventions (smoking, diet, and sun protection) (*n*=4800) or an assessment only control group (*n*=4661). At baseline, participants had to speak English and provide informed consent. Baseline participants were at risk for 2+ of the three risk behaviors included in this study (*n*=9,461).

Parent Study (Study 1)—Among 2,460 (83.6%) of Rhode Island parents recruited (Prochaska et al., 2004), 2435 participants were included in this study.

Patient Study (Study 2)—Among 5,407 Rhode Island health insurance patients recruited (Prochaska et al., 2005), 5170 participants were included in this study.

Worksite Study (Study 3)—Of the baseline sample of 1,906 employees from Southeastern New England worksites (Linnan et al., 2002; Velicer et al., 2004), a total of 1,856 participants were included in this study.

Treatment

The treatment group was mailed tailored intervention materials at baseline, 6 months, and 12 months including TTM-tailored feedback reports for all behaviors that they were at risk for and an integrated stage-matched multiple behavior self-help manual (Velicer et al., 1993). The manual also contained exercises to assist participants in applying change principles across multiple behaviors, such as increasing the pros of change in the early stages.

Measures

Subjects in both groups were assessed on common variables and reassessed at 12 and 24 months. The main measure for behavior change was the percentage in each group that progressed from pre-Action stages (Precontemplation, Contemplation, and Preparation) at baseline to the Action or Maintenance stages at 12 or 24 months. This common metric is equivalent to progressing from not being at public health criteria at baseline (e.g., smoking) to being at criteria at follow-up (e.g., point prevalence cessation (Action) or prolonged abstinence (Maintenance)).

Procedure

For all three behavior pairs, coaction was assessed at 12 and 24 months on complete cases who at baseline were at risk for both behaviors.

Analysis

A series of logistic regression analyses were conducted using SPSS v18 at the 12 and 24 month time points. These analyses resulted in a series of ORs with 95% confidence intervals and *p*-values. Rates of missingness were equivalent between studies and therefore missing data analysis was not completed on this pooled data set. Preliminary analyses were conducted with ‘study’ assignment in the models to ensure that it was appropriate to pool the data for subsequent analyses. Differences were not found by study; therefore all data analysis is reported with the pooled sample. Given the number of pairs of behaviors to be analyzed, the linear step-up procedure was employed to control for the overall type I error rate for multiple significance tests at α=.05 (Benjamini and Hochberg, 1995; Keselman et al,

2011). Individual coaction odds ratios for behavior pairs were combined to obtain aggregate ORs for treatment and control groups at 12 and 24 months using standard meta-analytic techniques (Lipsey and Wilson, 2001).

Results

Table 1 provides demographics and stage distributions for the treatment and control group participants who were at risk for 2+ of the three risk behaviors at baseline. The majority were married, non-Hispanic Caucasian females with a mean age of 44.9 (SD=10.7).

Table 2 presents the percentage of participants in treatment and control groups that progressed to Action/Maintenance at 12 and 24 months. Proportions are presented for both those participants who changed on the second behavior and those who failed to change on the second behavior. The table includes data for 3 dyads of behaviors: (i) sun protection and diet; (ii) smoking and diet; and (iii) smoking and sun protection. For the first dyad, sun protection and diet, results show that the treatment condition had changed at a greater rate on sun protection regardless of whether they changed on diet. Also, the treatment group demonstrated significant coaction at both 12 and 24 months, with ORs=1.71 and 2.17, respectively. In the control condition, there was no significant coaction at 12 or 24 months with ORs=1.28 and 1.23, respectively. For the second dyad, smoking and diet, results showed that the treatment condition had higher percentages of participants than the control group changing on smoking regardless of whether they changed on diet. While there were no significant ORs for either the treatment or control group, on an absolute basis, the treatment ORs were higher than the control ORs. For the final dyad, smoking and sun protection, the treatment condition had higher ORs on an absolute basis compared to control at both 12 and 24 months.

Across the three behavior pairs at 12 and 24 months, there were six sets of ORs for both the treatment and control groups. Comparing on all six sets of ORs, the treatment ORs were greater on an absolute basis. ORs were combined across the three pairs of behaviors using meta-analytic procedures separately for treatment and control groups at both 12 and 24 months. The combined ORs were significant for the treatment group: 12 month OR=1.63 [95% confidence interval=1.24, 2.13]; 24 month OR=1.77 [1.39, 2.25]. The combined ORs were not significant for the control group: 12 month OR=1.19 [0.87, 1.63]; 24 month OR=1.09 [0.81, 1.46]. Effect sizes for the difference between treatment group and control group ORs were large at both 12 and 24 months, although the confidence intervals were wide due to the small number of behavior pairs being compared. At 12 months, $d = 1.21$ [−0.53, 2.95] and at 24 months, $d = 2.05$ [0.08, 4.03].

Discussion

The results of this study were consistent with hypotheses based on previous research (Johnson et al., 2008; Mauriello et al., 2010; Velicer et al., 2011). All of the treatment group coaction ORs were higher on an absolute basis than the control ORs. Combining across results of this study and three previous studies (Johnson et al., 2008; Mauriello et al., 2010; Velicer et al., 2011), there were 29 out of 30 comparisons of coaction ORs higher for the treatment group. There were, however, fewer significant coaction ORs in this study (33.3%) than in the previous three studies on energy balance behavior pairs: 77.8% (Mauriello et al., 2010), 77.8% (Velicer et al., 2011), and 88.9% (Johnson et al., 2008). In this study, the sample sizes for comparisons involving smoking were substantially smaller than for the other comparisons. Statistically combining ORs across behavior pairs in this study using meta-analytic techniques resulted in substantially larger ORs for treatment at both 12 and 24 months.

Taken together, these results suggest that changes in pairs of behaviors are more related within individuals receiving treatment and more independent in control groups. Based on self-efficacy theory (Bandura, 1977) or motivational interviewing theory (Miller and Rose, 2009), it would seem to be easier to explain more coaction in treatment groups than to explain the lack of coaction in the control groups. Hypotheses like increased self-efficacy and motivation would suggest that generalization or transfer of successful change from one behavior to another should occur whether the success was assisted by treatment or not (Fleig et al., 2011; Lippke et al., 2012). The combined ORs for the control group (1.19 and 1.09 for 12 and 24 months, respectively) suggest little or no coaction occurred without treatment. An alternative hypothesis is that this TTM-tailored multiple behavior change treatment, may be teaching principles of behavior change that can be generalized across behaviors. Such generalization of principles was explicitly taught in the stage-matched manuals included in this study and the adult weight management study (Johnson et al., 2008). Such generalization of principles was not explicitly taught in the two adolescent weight management studies where no manuals were included (Mauriello et al., 2010; Velicer et al., 2011); however, TTM-tailored feedback was provided and could have communicated similar principles even without manuals.

An important avenue for future research is to understand why coaction is consistently higher in treatment than in control. The finding of a smaller percentage of significant ORs in this study (33%) compared to the adult weight management study and adolescent studies raises the question of whether some behaviors may change together more readily than others, specifically those with a common theme (energy balance). The present study involved addictive, energy balance and appearance-related behaviors. Changes in such different types of behaviors may be less strongly related to each other, because they would be changed to prevent different cancers rather than being changed to achieve a common goal, like weight management or cardiovascular health.

Another interpretation is that smoking was one of the behaviors in these analyses that produced consistently non-significant ORs. Smoking has often been viewed as one of the most difficult behaviors to change. Participants working towards smoking cessation may be less likely to take on the challenge of changing a second behavior with or without the help of treatment. Larger studies that include and do not include smoking in the pair may answer questions raised here.

Future research should identify mediators and moderators of coaction. The literature to date includes TTM-tailored treatment as a consistent factor related to behavior change (Blissmer et al., 2010; Krebs et al., 2010; Noar et al., 2007), but treatment enhanced coaction may vary by types of behaviors being treated and different types of populations. Significant mediators could be applied to increase treatment coaction. The more coaction comes under the influence of treatment programs, the more synergy we are likely to produce when simultaneously intervening on multiple behaviors.

Limitations

This study is limited to analyses on only three behavior pairs. These findings, however, were consistent with those found in pairs of energy balance behaviors. This study included only one type of treatment, namely TTM-tailored CTIs. Future research will need to determine the consistency and magnitude of coaction produced by different types of treatments. This study included only adults from in and near Rhode Island; therefore the study populations for these analyses are not a representative sample and therefore cannot be generalized to other populations. In general, findings were consistent with similar outcomes from adolescents and overweight/obese adults from other parts of the U.S. In addition, this sample was mostly white, middle-aged and married participants who were followed up successfully

over time. Populations with more diverse demographic characteristics and those lost to follow-up should be examined in future research. Results in this preliminary study are unadjusted findings and the next step will be to account for other possible mediating variables. In addition, future research should compare coaction across a broad range of types of behaviors, treatments and populations to develop a more systematic understanding of this unique multiple behavior phenomenon that could be the source of synergistic rather than separate behavior changes.

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References

Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev. 1977; 84:191–215. [PubMed: 847061]

Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J R Stat Soc. 1995; 57:289–300.

Berrigan D, Dodd K, Troiano RP, Krebs-Smith SM, Barbash RB. Patterns of health behavior in U.S. adults. Prev Med. 2003; 36:615–623. [PubMed: 12689807]

Blissmer B, Prochaska JO, Velicer WF, Redding CA, Rossi JS, Greene GW, Paiva A, Robbins M. Common Factors Predicting Long-Term Changes in Multiple Health Behaviors. J Health Psychol. 2010; 15(2):205–214. [PubMed: 20207664]

deVries H, Riet JVT, Spigt M, et al. Clusters of lifestyle behaviors: results from the Dutch SMILE study. Prev Med. 2008; 46:203–208. [PubMed: 17904212]

Fine LJ, Philogene S, Graming R, Goups EJ, Sinha S. Prevalence of multipule chronic disease risk factors: 2001 National Health Interview Survey. Am J Prev Med. 2004; 27:18–24. [PubMed: 15275670]

Fleig L, Lippke S, Pomp S, Schwarzer R. Exercise maintenance after rehabilitation: how experience can make a difference. Psychol Sport Exerc. 2011; 12:293–299.

Johnson SS, Paiva AL, Cummins CO, et al. Transtheoretical model-based multiple behavior intervention for weight management: effectiveness on a population basis. Prev Med. 2008; 46:238–246. [PubMed: 18055007]

Keller S, Maddock JE, Hannover W, Thyrian JR, Basler HD. Multiple health risk behaviors in German first year university students. Prev Med. 2008; 46:189–195. [PubMed: 18242666]

Keselman HJ, Miller CW, Holland B. Many tests of significance: new methods for controlling type I errors. Psychol Methods. 2011; 16:420–431. [PubMed: 22040371]

Krebs P, Prochaska JO, Rossi JS. A meta-analysis of computer-tailored interventions for health behavior change. Prev Med. 2010; 51:214–221. [PubMed: 20558196]

Linnan LA, Emmons KM, Klar N, Fava JL, LaForge RG, Abrams DB. Challenges to improving the impact of worksite cancer prevention programs: comparing reach, enrollment, and attrition using active versus passive recruitment strategies. Ann Behav Med. 2002; 24:157–166. [PubMed: 12054321]

Lippke S, Nigg CR, Maddock JE. Health-Promoting and Health-Risk Behaviors: Theory-Driven Analyses of Multiple Health Behavior Change in Three International Samples. Int J Behav Med. 2012; 19:1–13. [PubMed: 21234735]

Lipsey, MW.; Wilson, DB. Practical meta-analysis. Sage; Thousand Oaks, CA: 2001.

Mauriello LM, Ciavatta MM, Paiva AL, et al. Results of a multi-media multiple behavior obesity prevention program for adolescents. Prev Med. 2010; 51:451–456. [PubMed: 20800079]

Miller WR, Rose GS. Toward a theory of motivational interviewing. Am Psychol. 2009; 64:527–537. [PubMed: 19739882]

Noar SM, Benac C, Harris M. Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. Psychol Bull. 2007; 133:673–693. [PubMed: 17592961]

Prochaska JO. Multiple Health Behavior Research represents the future of preventive medicine. Prev Med. 2008; 46:281–285. [PubMed: 18319100]

Prochaska JO, Velicer WF, Rossi JS, et al. Multiple risk expert systems interventions: impact of simultaneous stage-matched expert system interventions for smoking, high-fat diet, and sun exposure ina population of parents. Health Psychol. 2004; 23:503–516. [PubMed: 15367070]

Prochaska JO, Velicer WF, Redding C, et al. Stage-based expert systems to guide a population of primary care patients to quit smoking, eat healthier, prevent skin cancer, and receive regular mammograms. Prev Med. 2005; 41:406–416. [PubMed: 15896835]

Sanchez A, Norman G, Sallis JF, Calfas KJ, Rock C, Patrick K. Patterns and correlates of multiple risk behaviors in overweight women. Prev Med. 2008; 46:196–202. [PubMed: 18022220]

Velicer WF, Prochaska JO, Bellis JM, et al. An expert system intervention for smoking cessation. Addict Behav. 1993; 18:269–290. [PubMed: 8342440]

Velicer WF, Prochaska JO, Redding CA. Efficacy of expert system interventions for employees to decrease smoking, dietary fat, and sun exposure. Int J Behav Med. 2004; 11:277.

Velicer WF, Redding CA, Paiva A, et al. Project BEST: tailored interventions for multiple risk factor prevention for adolescents. Ann Behav Med. 2011; 41

Table 1

Demographics and stage distribution of the control, treatment and total sample[*#].

		Control (*n* = 4800)		**Treatment (*n* = 4661)**		**Total (*n* = 9461)**	
		n	**%**	***n***	**%**	***n***	**%**
Study	Parent	1238	25.8%	1197	25.7%	2435	25.7%
	Patient	2620	54.6%	2550	54.7%	5170	54.6%
	Worksite	942	19.6%	914	19.6%	1856	19.6%
Gender	Male	1596	34.6%	1545	34.6%	3141	34.6%
	Female	3017	65.4%	2921	65.4%	5938	65.4%
Marital status	Married	3265	70.9%	3176	71.3%	6441	71.1%
	Not Married, living w/Partner	163	3.5%	157	3.5%	320	3.5%
	Not Married	460	10.0%	462	10.4%	922	10.2%
	Separated	89	1.9%	90	2.0%	179	2.0%
	Divorced	480	10.4%	452	10.1%	932	10.3%
	Widowed	149	3.2%	119	2.7%	268	3.0%
Ethnicity	American Indian, Alaskan	21	0.5%	20	0.4%	41	0.5%
	Asian, Pacific Islander	40	0.9%	34	0.8%	74	0.8%
	Black, Non-Hispanic	74	1.6%	82	1.8%	156	1.7%
	Hispanic	46	1.0%	45	1.0%	91	1.0%
	White	4319	93.7%	4184	93.8%	8503	93.7%
	Other/Combination	109	2.4%	96	2.2%	205	2.3%
		Mean	SD	Mean	SD	Mean	SD
	Age	44.07	10.7	43.74	10.7	43.90	10.7
		Control		Treatment		Total	
		n	%	*n*	%	*n*	%
Baseline stage—smoking	Precontemplation	413	35.8%	398	35.9%	811	35.8%
	Contemplation	484	41.9%	499	45.0%	983	43.4%
	Preparation	258	22.3%	211	19.0%	469	20.7%
Baseline stage—sun protection	Precontemplation	1220	32.5%	1113	32.1%	2333	32.3%

		Control (*n* = 4800)		Treatment (*n* = 4661)		Total (*n* = 9461)	
		n	**%**	***n***	**%**	***n***	**%**
	Contemplation	923	24.6%	794	22.9%	1717	23.8%
	Preparation	1608	42.9%	1556	44.9%	3164	43.9%
Baseline stage—diet	Precontemplation	1777	52.4%	1645	51.7%	3422	52.1%
	Contemplation	485	14.3%	493	15.5%	978	14.9%
	Preparation	1128	33.3%	1043	32.8%	2171	33.0%

[*] Total sample sizes may differ for each demographic variable due to missing data.

[#] Recruited in 1999 in the United States.

Table 2

Behavior dyads—proportions within groups who changed on one or both behaviors and coaction odds ratios[a] at 12 and 24 months[#].

Sun protection and diet	**12 Months**		**24 Months**	
	Treatment (*n*=1407)	**Control (*n*=1926)**	**Treatment (*n*=1310)**	**Control (*n*=1764)**
Proportion changed on sun protection given change on diet	0.24 [0.19, 0.29]	0.14 [0.10, 0.18]	0.35 [0.29, 0.40]	0.15 [0.10, 0.19]
Proportion changed on sun protection given no change on diet	0.16 [0.14, 0.18]	0.12 [0.10, 0.13]	0.20 [0.17, 0.22]	0.12 [0.10, 0.14]
Coaction odds ratio[a]	**1.71[*] [1.23, 2.36]**	**1.28 [0.88, 1.87]**	**2.17[*] [1.62, 2.90]**	**1.23 [0.85, 1.77]**
Smoking and diet	Treatment (*n*=412)	Control (*n*=597)	Treatment (*n*=360)	Control (*n*=539)
Proportion changed on smoking given change on diet	0.20 [0.09, 0.31]	0.13 [0.05, 0.22]	0.26 [0.16, 0.37]	0.17 [0.09, 0.26]
Proportion changed on smoking given no change on diet	0.14 [0.10, 0.18]	0.12 [0.09, 0.14]	0.22 [0.17, 0.26]	0.18 [0.14, 0.21]
Coaction odds ratio[a]	**1.54 [0.74, 3.17]**	**1.17 [0.55, 2.48]**	**1.28 [0.69, 2.37]**	**0.94 [0.50, 1.80]**
Smoking and sun protection	Treatment (*n*=440)	Control (*n*=576)	Treatment (*n*=388)	Control (*n*=520)
Proportion changed on smoking given change on sun protection	0.20 [0.10, 0.30]	0.09 [0.02, 0.16]	0.24 [0.14, 0.33]	0.14 [0.06, 0.23]
Proportion changed on s no change on sun protection moking given	0.15 [0.12, 0.19]	0.11 [0.08, 0.14]	0.23 [0.19, 0.28]	0.18 [0.14, 0.21]
Coaction odds ratio[a]	**1.40 [0.71, 2.73]**	**0.81 [0.34, 1.96]**	**1.01 [0.55, 1.85]**	**0.80 [0.38, 1.69]**

[*] $p<.001$.

[a] Odds of change on second behavior given change on a first behavior.

[#] Recruited in 1999 in the United States.