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Neural correlates of message tailoring and self-relatedness in smoking cessation programming

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Abstract

BACKGROUND—Smoking leads to illnesses including addiction, cancer, and cardiovascular and respiratory diseases. Different intervention programs have become available. In the past decade, providing tailored smoking cessation messages has been shown to be more effective in inducing smoking cessation than one-size-fits-all interventions. However, little is known about the brain responses of smokers when they receive tailored smoking cessation messages.

METHODS—A neuroimaging study using blocked and event-related designs examined neural activity in 24 smokers exposed to high-tailored and low-tailored smoking cessation messages. RESULTS: In both blocked and event-related conditions, rostral medial prefrontal cortex and precuneus/posterior cingulate were engaged more during the processing of high-tailored smoking cessation messages than low-tailored smoking cessation messages.

CONCLUSION—The activation patterns of smokers to tailored cessation messages show involvement of brain areas commonly implicated in self-related processing. Results seem to add support to the suggested role of self-relevance in tailored cessation programs, where previous studies have shown a potential mediating role of self-relevance on smoking abstinence. The findings are relevant to understanding the cognitive mechanisms underlying tailored message processing and may point to new directions for testing response to health communications programming.

Keywords

smoking cessation; fMRI; nicotine; tailoring; self; addiction

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Disclosures

Drs. Chua, Liberzon, and Welsh reported no biomedical financial interests or potential conflicts of interest. Dr. Strecher is Chairman, Founder and Shareholder of HealthMedia, Inc., a company that develops and licenses computer-tailored health promotion, disease prevention, and disease management tools. Dr. Strecher has also consulted for pharmaceutical companies that market computer-tailored smoking cessation programs.

INTRODUCTION

Nicotine addiction, the second major cause of death in the world, is responsible for about five million deaths each year (1). Intervention programs for smokers have become widely available. For over a decade, published randomized trials of tailored message interventions largely have demonstrated an overall positive impact when compared to generic, one-size-fits-all interventions, which appear to have little or no effect on cessation (2–5). A Cochrane meta-analysis (2) found an odds ratio of 1.42 (CI=1.26–1.61) for the average improvement of behavior when comparing tailored with standard or no materials in seventeen trials.

Messages tailored to specific needs and interests of the smoker are usually perceived as more self-relevant (5–6). In turn, perceived relevance appears to mediate the effects of tailored smoking cessation materials on subsequent abstinence (7). One study (8) found that tailoring on personalization and individual feedback evoked significantly more quitting activity four months after receipt of the intervention.

In neuroimaging studies, processing of self-related information is associated with activation of rostral medial prefrontal cortex (rMPFC), including rostral anterior cingulate, which are implicated when attributing traits to self and relating stimuli to self (9–11), and with precuneus/posterior cingulate region, which has been associated with the retrieval of episodic autobiographical memories (12), and reflecting on own traits (13) and intentions (14).

Given the suggested mediating role of personal relevance in the effect of tailoring on health behavior change, we hypothesize that processing high-tailored smoking cessation messages engages rMPFC and precuneus/posterior cingulate more than processing linguistically comparable but low-tailored smoking cessation messages. A mixed blocked and event-related design using fMRI was used to contrast high-tailored and low-tailored smoking cessation messages in 24 smokers expressing desire to quit.

METHODS AND MATERIALS

This is a within-subjects design. All participants received high- and low-tailored blocked messages, as well as high-tailored (“smokes 20 cigarettes a day”, “smokes when talking on the phone”), low-tailored (“smokes a lot of cigarettes”, “smokes during daily routines”) and generic smoking cessation event-related statements (“quitting is not easy”, “stress is a part of all of our lives”). See Supplement.

Figure 1 presents the paradigm. Blocked conditions were always followed by event-related conditions. Each run started with a 10s fixation screen, followed by a blocked condition of high- or low-tailored smoking cessation message. Each blocked condition lasted approximately 65s, followed by 20s fixation. In the event-related condition, there were 14 short statements taken from the previous blocked condition (7 high- or low-tailored and 7 generic cessation statements or 8 high- or low-tailored and 6 generic cessation statements). Each lasted approximately 3.5s. A fixation screen (jittered 4, 6 or 8s) followed each event-related trial. The messages were presented as an audio track but also shown on the screen. Participants listened to each message and pressed a button to acknowledge hearing the message. The presentation of generic and high- or low-tailored statements was also randomized within each event-related condition. The entire task lasted 32 minutes, with four runs each lasting 8 minutes. After the scan, participants rated each message on a 7-point scale their agreement to “I found it to be written personally for me” (5).

RESULTS

Post-scan Ratings Data

We examined participants' ratings of high-tailored, low-tailored, and generic smoking cessation statements in the event-related conditions in terms of perception of personally written for them. Consistent with past research (3), we found a main effect of the degree of tailoring on the subjective ratings [$F(2,44)=6.66$, $P<0.005$]. Participants rated high-tailored smoking cessation statements as more personally written for them than low-tailored smoking cessation statements, *Ms* 5.68 (*SD*=0.84) vs. 5.15 (*SD*=1.57) respectively, [planned contrast $t(22)=2.95$, $P < .01$].

fMRI Data

First, we contrasted both high- and low-tailored smoking cessation statements with generic cessation statements to assess overall effect of tailoring, and found that the rMPFC and precuneus/posterior cingulate regions were engaged when processing the tailored statements (See Figure 2 and Table 1). We then proceeded to the main analysis that contrasted high- and low-tailored messages to each other. As predicted, high-tailored messages produced greater activity in rMPFC and precuneus/posterior cingulate regions than low-tailored messages in both blocked and event-related conditions.

We also contrasted the high- and low-tailored messages relative to rest in blocked and event-related conditions. The findings indicate that in the blocked conditions, both high- and low-tailored smoking cessation messages increased rMPFC and precuneus/posterior cingulate activation relative to rest. In the event-related conditions, there was deactivation, as compared to baseline, of rMPFC and precuneus/posterior cingulate during processing of tailored smoking cessation statements, as often observed in "default network" regions (15–16). The direction of the effect is similar in both blocked and event-related conditions with greater signal in rMPFC and precuneus/posterior cingulate during high-tailored messages than low-tailored messages.

DISCUSSION

Tailored smoking cessation statements overall engaged rMPFC and precuneus/posterior cingulate, relative to generic smoking cessation statements. High-tailored messages also showed greater activity in the same areas relative to low-tailored messages, in both the blocked and event-related conditions. Participants subjectively rated the high-tailored smoking cessation messages as being more personally written for them.

Although rMPFC & precuneus/posterior cingulate activations may be involved in other psychological processes, the behavioral and fMRI findings together seem to add support to the previous findings suggesting the role of self-relevance in tailored message processing (5–8). High-tailored messages make references to a smoker's specific life events (e.g., smoking while driving); thus, participants are likely to remember personal traits and episodic situations, in accord with the suggested role of rMPFC and precuneus/posterior cingulate regions in autobiographical memories (12,17) and evaluating self-traits (9–10). Moreover, the messages may trigger the smokers to evaluate their intentions and hopes in relation to quitting smoking. We found bilateral temporal pole activations in our blocked condition, which have been shown to activate together with rMPFC and precuneus/posterior cingulate when people think about intentions (13–14). Indeed, reviews about the "self" suggest that the self is a well-developed and often used construct. When the self is activated it provides an integrative framework that promotes elaboration, organization of encoded information, enhanced memory, and helps people choose which motivational and behavioral representations would guide behavior (18–19). Increased attention has been documented

individually tailored health communication message than nontailored health communication program, using event-related potentials (5). The present study contributes to the growing body of work examining potential processes involved in tailored communications.

In the current study, we observed deactivation in rMPFC and precuneus/posterior cingulate when participants process tailored smoking cessation statements in the event-related condition, with less deactivation when processing high tailored messages. Similar to our findings on high-tailored smoking cessation statements, less deactivation in the regions was found with more robust self-related tasks than less self-related tasks (9). Interestingly, processing of blocked messages did not show deactivation in the regions. It is possible that fixation periods during the event-related conditions allowed the return to higher baseline/rest activity, whereas the blocked conditions could not have allowed this. This is consistent with previous findings (15–16) showing that decreases in these regions are typically observed during specific tasks that included a passive state, like simple fixation.

There were some limitations in the current study. First, the current study did not test the effect of tailored messages and self-relevance on health behavior change. Previous studies have established the relationship between tailoring, self-relatedness, and behavioral change (4–5), and future studies should examine the link between brain activation patterns and behavioral changes. Second, we did not collect emotional measures or other direct measures of self-relatedness apart from the general “personally written for me” item. In other words, the current study lacks other behavioral correlates that might further explain the activation patterns. In future studies, additional measures may help to further interpret the activation patterns found. Third, in the experimental design, the event-related conditions followed respective blocked conditions (e.g., low-tailored event-related condition always followed a low-tailored blocked condition). To minimize order effects, presentations of smoking cessation statements (high- or low-tailored or generic) were randomized within the event-related conditions; however, some spill-over effects from the blocked conditions still could have been present. Fourth, while having a priori regions of interest, we still used a relatively low threshold to determine significance (uncorrected .005, $K \geq 5$). Fifth, the messages were presented audio-visually, rather than through a single presentation mode. It is unclear how dual mode presentations affected the brain activation results. Lastly, although we matched for the number of details in the high- and low-tailored messages, it is possible that differences in amount of detail still existed that may have contributed to the activations.

In summary, our study combined a cognitive neuroscience approach and health communications methods to investigate how smokers respond to tailored cessation messages. It is known that tailored message interventions are more likely to lead to changes in health-related behaviors, including smoking abstinence. It is also known that these changes may be mediated by perceptions of message relevance. The current study demonstrated that there is indeed differential neural processing of the high-tailored messages. The specific mechanisms of this encoding process have yet to be determined, though discovery of these mechanisms should yield stronger intervention programming.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. World Health Organization. Tobacco Free Initiative Primer. Switzerland: World Health Organization; 2004.
2. Lancaster T, Stead LF. Self-help interventions for smoking cessation. Cochrane Database Syst Rev. 2005; 3:CD001118. [PubMed: 16034855]
3. Noar SM, Benac CN, Harris MS. Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. Psychol Bull. 2007; 133(4):673–693. [PubMed: 17592961]
4. Ruiter RAC, Kessels LTE, Jansma BM, Brug J. Increased attention for computer-tailored health communications: An event-related potential study. Health Psychol. 2006; 25(3):300–306. [PubMed: 16719601]
5. Strecher VJ. Computer-tailored smoking cessation materials: A review and discussion. Patient Educ Couns. 1999; 36(2):107–117. [PubMed: 10223016]
6. Brug J, Steenhuis I, van Assema P, de Vries H. The impact of a computer-tailored nutrition intervention. Prev Med. 1996; 25:236–242. [PubMed: 8781000]
7. Strecher VJ, Shiffman S, West R. Moderators and mediators of a web-based computer-tailored smoking cessation program among nicotine patch users. Nicotine Tob Res. 2006; 8(1):S95–101. [PubMed: 17491176]
8. Dijkstra A. Working mechanisms of computer-tailored health education: Evidence from smoking cessation. Health Educ Res. 2005; 20:527–539. [PubMed: 15701665]
9. Kelly WM, Macrae CN, Wyland CL, Caglar S, Inati S, Heatherton TF. Finding the self? An event-related fMRI study. J Cogn Neurosci. 2002; 145:785–794.
10. Ochsner KN, Beer JS, Robertson ER, Cooper JC, Gabrieli JD, Kihlstrom JF, et al. The neural correlates of direct and reflected self-knowledge. NeuroImage. 2005; 28:797–814. [PubMed: 16290016]
11. Phan KL, Taylor SF, Welsh RC, Ho SH, Britton JC, Liberzon I. Neural correlates of individual ratings of emotional salience: A trial-related fMRI study. NeuroImage. 2004; 21:768–780. [PubMed: 14980580]
12. Levine B, Turner GR, Tisserand D, Hevenor SJ, Graham SJ, McIntosh AR. The functional neuroanatomy of episodic and semantic autobiographical remembering: A prospective functional MRI Study. J Cogn Neurosci. 2004; 16(9):1633–1646. [PubMed: 15601525]
13. Johnson SC, Baxter LC, Wilder LS, Pipe JG, Heiserman JE, Prigatano GP. Neural correlates of self-reflection. Brain. 2002; 125:1808–1814. [PubMed: 12135971]
14. Den Ouden HEM, Frith U, Frith C, Blakemore S-J. Thinking about intentions. NeuroImage. 2005; 28:787–796. [PubMed: 15964210]
15. Gusnard DA, Akbudak E, Shulman GL, Raichle ME. Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain function. Proc Natl Acad Sci U S A. 2001; 98:4259–4264. [PubMed: 11259662]
16. Gusnard DA, Raichle ME. Searching for a baseline: Functional imaging and the resting human brain. Nat Rev Neurosci. 2001; 2:685–694. [PubMed: 11584306]
17. Cavanna AE, Trimble MR. The precuneus: A review of its functional anatomy and behavioural correlates. Brain. 2006; 129:564–583. [PubMed: 16399806]
18. Wheeler SC, DeMarree KG, Petty RE. Understanding the role of the self in prime-to- behavior effects: The active-self account. Pers Soc Psychol Rev. 2007; 11:234–261. [PubMed: 18453463]
19. Symons CS, Johnson BT. The self-reference effect in memory: A meta-analysis. Psychol Bull. 1997; 121(3):371–394. [PubMed: 9136641]

Figure 1.

fMRI Paradigm. Each run had 1 blocked trial of high-tailored smoking cessation messages, 14 event-related trials of combined high-tailored cessation statements and generic cessation statements, 1 blocked trial of low-tailored smoking cessation messages, and 14 event-related trials of combined low-tailored cessation statements and generic cessation statements. Event-related statements were taken from the blocked trials. There were 4 runs. Overall, each participant received 4 high-tailored blocked messages, 4 low-tailored blocked messages. They also were presented 30 high-tailored, 30 low-tailored, and 28 generic cessation statements as event-related trials.

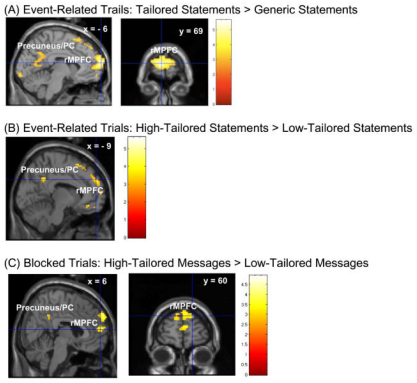

Figure 2.

(A) High- and low-tailored smoking cessation statements, relative to generic smoking cessation statements, activated rMPFC and precuneus/posterior cingulate. The same areas were also activated when contrasting high-tailored smoking cessation messages to low-tailored smoking cessation messages, both in the (B) blocked conditions and (C) event-related conditions. Random-effects SPM *t* map, $p < 0.005$, uncorrected, $[k] \geq 5$ voxel threshold.

Table 1

Peak Activations of Tailored Smoking Cessation Statements, relative to Generic Smoking Cessation Statements, in (a) the Event-Related Trials, and High-Tailored Smoking Cessation Messages, relative to Low-Tailored Smoking Cessation Messages, in (b) Event-Related Trials, and (c) Blocked Trials.

(a) Event-Related Trials:

High- + Low-Tailored Smoking Cessation Statements > Generic Smoking Cessation Statements

Region	*x, y, z*[a]	*Z*[b]	*k*[c]
rMPFC			
L, Superior Frontal Gyrus (BA 10)	−6, 69, 15	4.44	818
Precuneus/Posterior Cingulate (BA30)	0, −66, 9	3.72	257
Middle Temporal Gyrus	−57, −66, 15	4.32	303
Inferior Frontal Gyrus (BA 45)	−51, 18, 15	3.99	115
Lingual Gyrus (BA 18)	−3, −96, −9	3.77	68

(b) Event-Related Trials: High-Tailored > Low-Tailored Smoking Cessation Statements

Region	*(x, y, z)*[a]	*Z*[b]	*k*[c]
rMPFC			
L, Superior Frontal Gyrus (BA 8)	−15, 33, 48	3.56	50
L, Middle Frontal Gyrus (BA 11)	−6, 39, −12	3.44	42
L, Superior Frontal Gyrus (BA 9)	−9, 54, 33	3.40	40
L, Middle Frontal Gyrus (BA 10)	−12, 63, 12	2.75	6
Precuneus/Posterior Cingulate (BA31/7)	−12, −51, 36	3.30	31
Middle Temporal Gyrus	−57, −63, 24	4.42	354
Precentral Gyrus (BA4)	−45, 9, 45	3.93	198

(c) Blocked Trials: High-Tailored > Low-Tailored Smoking Cessation Messages

Region	*x, y, z*[a]	*Z*[b]	*k*[c]
rMPFC			
R, Superior Frontal Gyrus (BA9)	18, 60, 33	3.37	82
L, Superior Frontal Gyrus (BA9)	−18, 54, 33	3.10	41
R, Middle Frontal Gyrus (BA10)	6, 57, 12	3.20	73
Precuneus/Posterior Cingulate (BA7)	3, −45, 30	2.90	14
Sublenticular Extended Amygdala	−12, 12, −3	3.01	8
L, Temporal Pole (BA38)	−36, 18, −24	4.04	26
R, Temporal Pole (BA38)	42, 18, −21	2.83	10

[a] Stereotactic coordinates from MNI atlas, left/right(x), anterior/posterior (y), and superior/inferior (z), respectively, R = right, L = left

[b] Z score, significant at uncorrected p of 0.005.

[c] Spatial extent in cluster size, threshold ≥ 5 voxels.