Embodied cognition and skilled health behaviour

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The present research examines health persuasion from an embodied cognition perspective by proposing that engaging the motor system during presentation of a health message will lead individuals to become more skilled at performing the prescribed behaviour. Participants watched a video on the importance of flossing while either imaging themselves flossing or imaging themselves flossing while minimally engaging the motor system (i.e. touching a piece of floss). Females (but not males) who touched an individual floss while watching the video demonstrated better flossing skills 1 week later. Over time, participants (both males and females) who engaged the motor system also developed more accessible attitudes and had a stronger relationship between their perceived flossing efficacy and actual flossing skill. Implications for the theories of embodied cognition and health interventions are discussed.

Keywords: health persuasion; embodied cognition; motor; self-efficacy; behavioural skill

Introduction

For health behaviours such as using condoms or flossing teeth to yield health benefits, they not only have to be performed consistently but also correctly. Incorrect use of a condom can lead to slippage, breakage or leakage, resulting in greater susceptibility to pregnancy and sexually transmitted diseases (Centers for Disease Control, 2009). Improper flossing allows plaque-causing bacteria to remain between the teeth and along the gum line, thereby attenuating the effectiveness of flossing in preventing periodontal (gum) disease (American Dental Association, 2010). The present study examines whether skill at performing a health behaviour can be improved by engaging the motor system during health persuasion. We build upon recent findings suggesting that supplementing a health message with a motor activity leads to greater likelihood of performing the prescribed behaviour (Sherman, Gangi, & White, 2010).

Despite the large motor component of many health behaviours, the motor system and the embodied cognition approach have not received much attention within models of health persuasion, such as the theory of planned behaviour (Fishbein & Ajzen, 1975; see for example, Hillhouse, Stair, & Adler, 1996) or the health belief
model (Rosenstock, 1974; see for example Brewer et al., 2007). Embodied cognition is the idea that psychological processes are shaped by bodily, kinesthetic interactions with the environment (Barsalou, 1999; Briñol & Petty, 2008; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005). Research has demonstrated that the physical body is integrally tied to persuasion processes such as attitude formation and change (Cacioppo, Priester, & Berntson, 1993) and memory and comprehension (Glenberg, Gutierrez, Levin, Japanich, & Kaschak, 2004; see Barsalou, 1999; Briñol & Petty, 2008; Niedenthal et al., 2005 for reviews). Since health behaviour change requires attitude change (i.e. thinking a health behaviour is important to perform) and memory enhancement (i.e. remembering to perform the health behaviour), these findings suggest that the motor system has potential utility in facilitating health behaviour change.

Supporting this idea, recent research has demonstrated that engaging the motor system with a minimal, health-relevant behaviour during presentation of a health message can increase the likelihood of performing the prescribed behaviour (Sherman et al., 2010). In these studies, participants watched a health video while either imaging (i.e. forming an image of) themselves performing the behaviour or imaging themselves performing the behaviour while minimally engaging the motor system. In one study, participants (females but not males) who touched a piece of floss while watching a video on the importance of flossing demonstrated 60% more flossing in the subsequent week (from 3.05 flosses per week to 4.88). In a second study, participants (both males and females) who walked in place while watching an exercise video exercised 30% more in the subsequent week (from 59.7 minutes per day to 75.7). In both studies, participants who engaged their motor system had intentions that were more predictive of their behaviour than those who merely imaged themselves performing the behaviour.

We build upon these initial findings by testing whether motor manipulations lead to increased skill in performing a prescribed behaviour over a relatively long period of time. An individual’s ability to perform a health behaviour correctly is an important factor in deriving the benefits from the health behaviour. Similar to the previous research, participants watched a video on flossing while either imaging themselves flossing or imaging themselves flossing and engaging their motor system. To operationalise skill at performing the health behaviour, coders, including a dental hygienist, rated participants’ flossing skills 1 week later.

How could mere motor manipulations lead to increased skill at performing a behaviour? Mental imagery, which is the ‘ability to form pictures in the mind’ (Heremans et al., 2009, p.50), has been shown to enhance the skills of athletes and musicians (Lotze & Halsband, 2006; Rogers, 2006). The more vivid and developed the imagery is, the better the performance on relevant tasks (Heremans et al., 2009), and there are several reasons to believe that motor manipulations could facilitate highly accessible imagery. In Fazio’s (1986) attitude-to-behaviour process model, he theorized that direct physical interactions with attitude-objects increase attitude accessibility which, in turn, can influence relevant behaviour. People who have a direct, physical interaction with objects have quicker reaction times to the questions about their relevant attitudes than participants with more indirect experience (Fazio, Chen, McDonel, & Sherman, 1982). Furthermore, Barsalou (1999) argues that information processed through multiple modalities – cognitive, sensory and motor – is represented more vividly and thus is more accessible because all of these modalities become partially reactivated when recalling the information.
Therefore, health messages that appeal to both the cognitive and motor system may result in more accessible attitudes.

If it is the case that health messages which appeal to the motor system increase the accessibility of the information, then this could account for the finding that motor manipulations increased consistency between intentions and behaviour (Sherman et al., 2010). In our prior research, participants who engaged the motor system had significant and strong correlations between their intentions and behaviour, unlike participants who merely imaged themselves flossing (Sherman et al., 2010). Intentions are typically more predictive of behaviour when they incorporate highly vivid and developed mental imagery (Knäuper, Roseman, Johnson, & Krantz, 2009). Therefore, motor manipulations may have fostered more vivid imagery of the video demonstrations, which enabled participants to carry out behaviours to the extent they believed they could, resulting in higher consistency between intentions and frequency, efficacy and behavioural performance. To extend prior findings, we measured participants’ flossing self-efficacy, their perceived ability to floss consistently and correctly, and examined its ability to predict actual flossing skill 1 week later.

Flossing as a model health behaviour

The present research uses flossing as a model health behaviour to test these hypotheses. Daily flossing, which possesses a large motor component, has been shown to prevent periodontal disease, tooth decay and tooth loss (Schonfeld, 1985), and is necessary to prevent the rapid accumulation of plaque that can lead to long-term health problems such as coronary heart disease, stroke and pre-term birth (Dassanayake, 1998). Nevertheless, the American Dental Association (2009) reports that less than half of the US adult population flosses their teeth regularly, and adherence to dental health recommendations is often low. Of those who do floss, many do not do it properly. For example, it is estimated that one-third of adults who floss regularly do not floss all of their teeth (Ronis, Lang, Farghaly, & Ekdahl, 1994).

Beyond the important health implications of this behaviour, dental flossing provides several methodological advantages. First, while most of our college-age participants know that daily flossing is recommended, they are also aware that most people do not floss daily, and so they do not have excessive concerns about evaluation apprehension. Second, flossing is a behaviour that can be done in the laboratory yet privately, and thus, we were able to make videos of participants flossing their teeth and have an expert (a dental hygienist) code the videotapes. Finally, previous research suggests that the amount of flossing can be influenced by manipulated social psychological factors (Sherman, Updegraff, & Mann, 2008; Sherman et al., 2010).

Hypotheses

In summary, the present research tested the following hypotheses: Adding a motor manipulation to a health message will (1) increase skill at performing the health behaviour (flossing), (2) lead to more accessible attitudes towards the behaviour and (3) increase the correlation between efficacy beliefs and actual skill.
Method

Participants and design

Participants who indicated during pre-test that they were infrequent flossers were contacted via e-mail and asked to participate in a two-session study (1 week apart) on evaluating health educational materials for which they would be given either course credit or $5.00 per session. Eighty-three participants completed the first session, and four did not come back for the second session, leaving a final sample of 79 participants (16 males, 63 females, mean age = 18.3 years), who were randomly assigned to either the imagery condition or the motor + imagery condition.

Procedure

Participants watched a video titled ‘Flossing Tips with Amy Guthrie, DDS’. In the video, a dentist emphasises the role of flossing in preventing gum disease and provides information, including graphic pictures, about the disease. She also demonstrates proper flossing techniques such as how to wrap the floss around the fingers, how to get the floss between the teeth and how to ensure that every tooth is reached, and recommends that people floss daily. See Appendix 1. for excerpts from the video.

Prior to the video, participants received sealed instructions (keeping experimenters unaware of condition). Participants in the imagery condition were asked to imagine themselves flossing their teeth while watching the video whereas participants in the motor + imagery condition were asked to imagine themselves flossing their teeth and at the same time to touch the dental floss in the enclosed packet (‘keep the dental floss in your hands, and touch it with your fingers (do not actually floss)’).

Next, participants indicated their flossing self-efficacy on eight yes/no items (e.g. ‘I can floss every day’ and ‘I can floss even if it hurts’). Feelings towards flossing were measured using binary items (harmful/beneficial, pleasant/unpleasant, good/bad, worthless/valuable, and enjoyable/unenjoyable). Participants were shown a pair of words on the computer screen and asked to hit the number key that corresponded to the word which best represented how they felt about flossing (one word in the pair was numbered 1 while the other was numbered 2). The binary items allowed participants to respond quickly so that reaction time data could be collected as an index of attitude accessibility (Fazio, 1990). The amount of time it took participants to hit a number key was collected using MediaLab and DirectRT software. Then, the experimenter gave participants 10 individual flosses and instructed them to use the provided flosses the next 10 times they flossed. Participants were reminded about session two, 1 week hence.

The day before session two, participants received a reminder e-mail with instructions to return their unused flosses; they would be given 50 cents for each unused floss in this reverse-incentive system. At the second session, participants returned their unused flosses and were compensated for them. Participants completed the same measures of self-efficacy and feelings toward flossing as was completed in the first session. Then they were given an individual dental floss (along with hand sanitizer) and asked to floss their teeth while being videotaped. Six participants ($N = 2$ in imagination condition, $N = 4$ in motor + imagination condition) refused to floss on film. Those who agreed ($N = 73$) were shown the video
camera and how to turn the screen towards them so that they could see themselves floss during the taping. They were instructed to floss for as long as they desired.

**Coding of flossing videotapes**
The videotapes were coded by two raters (who were unaware of condition assignment) for the number of teeth flossed ($\alpha = 0.93$). This measure captures one of the important points in the video – flossing thoroughly. Of the 73 videos, three were unable to be coded by the raters, leaving a total of 70 for this dependent measure$^2$. To create a more holistic measure of flossing skill, a dental hygienist, who was unaware of condition assignment, rated the videos for how comfortable participants were with flossing, how thoroughly they flossed, how systematically they flossed, how effortful was their flossing (all on a scale from 1 *not at all* to 5 *very*), and the overall quality of their flossing (from 1 *poor* to 5 *excellent*). The scale items had high reliability ($\alpha = 0.92$), and so we created a composite of flossing skill. The hygienist was able to code all 73 videos.

**Results**

**Health behaviour**
There were two behavioural operationalisations of flossing skill. First, we examined the number of teeth that participants flossed in the second experimental session. The coders’ ratings were averaged and subjected to a one-way analysis of variance (ANOVA). The manipulation had a significant effect in the predicted direction, as those in the motor + imagery condition ($M = 18.68, SD = 6.71$) flossed significantly more of their teeth than those in the imagery condition ($M = 14.99, SD = 5.81$), $F(1, 70) = 6.23, p = 0.015, \eta^2_p = 0.08$ (Figure 1a).

Second, we examined the dental hygienist ratings with an ANOVA comparing the two conditions. Again, the manipulation had a significant effect in the predicted direction, as those in the motor + imagery condition ($M = 3.90, SD = 0.94$) flossed better according to the expert coder than those in the imagery condition ($M = 3.28, SD = 1.02$), $F(1, 71) = 7.20, p = 0.009, \eta^2_p = 0.09$ (Figure 1b). In sum, across both objective behaviour and subjective expert opinion, participants who engaged their motor systems while watching the video flossed with greater skill, thoroughness and efficacy than those who merely imaged themselves engaging in the behaviour.

When sex was entered as a factor in a 2 (condition: motor + imagery vs. imagery) × 2 (sex: male vs. female) ANOVA, a significant sex × condition interaction emerged for number of teeth flossed, $F(1, 66) = 4.30, p = 0.042, \eta^2_p = 0.07$, and dental hygienist rating, $F(1, 69) = 4.02, p = 0.049, \eta^2_p = 0.06$. For females ($N = 54$), the results were in the predicted direction, as those in the motor + imagery condition ($M = 19.35, SD = 6.04$) flossed significantly more of their teeth than those in the imagery condition ($M = 14.24, SD = 6.48$), $F(1, 66) = 9.22, p = 0.003$. Those in the motor + imagery condition ($M = 4.11, SD = 0.80$) also flossed better according to the expert than those in the imagery condition ($M = 3.25, SD = 0.94$), $F(1, 69) = 11.48, p = 0.001$. For the men ($N = 16$), there was no significant difference in the number of teeth flossed between those in the motor + imagery condition ($M = 16.31, SD = 5.01$) and those in the imagery condition ($M = 18.50, SD = 6.61$), $F(1, 66) = 0.50, p = 0.48$. Similarly, for men there was no difference in dental hygienist ratings between those
in the motor + imagery condition ($M = 3.16$, $SD = 1.10$), $F(1, 69) = 0.22$, $p = 0.64$ and those imagery condition ($M = 3.39$, $SD = 1.33$). No other significant sex $\times$ condition interactions were found for the other dependent measures. We return to a discussion of sex differences in the ‘Discussion’ section.

We also examined the number of flosses that participants returned at the second session. However, there were multiple problems with this measure in this sample of participants. Seven participants reported that they did not receive the e-mail prior to the session. Furthermore, 12 participants did not bring back any flosses, suggesting that they either forgot them or flossed 10 times. Because we thought it was implausible that they flossed 10 times over the previous week, and much more likely that they just forgot or lost their floss, we examined their responses to a post-test questionnaire. We asked them whether they agreed with the statement (at Time 2) that they flossed every day this past week; the mean was 3.08 on a 5-point scale anchored at 1 (strongly disagree) and 5 (strongly agree), suggesting that indeed, the majority if not all of these 12 participants did not floss 10 times over the past week. In sum, it appeared as though we could not accurately gauge the flossing behaviour for 24% of our sample.
Nevertheless, after discarding the 12 participants who returned zero flosses, a 2 (condition: motor + imagery vs. imagery) \times 2 (sex: male vs. female) ANOVA revealed that the results were in the predicted direction, although non-significant. Those in the motor + imaging condition flossed more times ($M = 4.06$, $SD = 2.38$) than those in the imaging condition ($M = 2.98$, $SD = 3.37$), $F(1, 56) = 1.75$, $p = 0.19$. There were no main effects of sex, $F(1, 56) = 0.14$, $p = 0.71$, and no interactions between sex and condition, $F(1, 56) = 1.46$, $p = 0.23$.

**Attitude accessibility**

Participants’ reaction times to five binary measures tapping into attitudes and thoughts about flossing were collected at both sessions. We were interested in whether motor manipulations increase accessibility immediately or over time. The scores were averaged each time for the measures of attitude accessibility and subjected to a one-way ANOVA. At the first session, there was no main effect of condition, as those in the motor + imagery condition ($M = 3442$ ms, $SD = 715$) did not differ from those in the imagery condition ($M = 3417$, $SD = 776$), $F(1, 77) = 0.023$, $p = 0.880$.

At session two, 1 week later, those in the motor + imagery condition had more accessible attitudes towards flossing, with faster reaction times ($M = 2865$, $SD = 581$) than those in the imagery condition ($M = 3208$, $SD = 903$), $F(1, 77) = 4.05$, $p = 0.048$, $\eta_p^2 = 0.05$. Over time, the participants who had engaged the motor system during the flossing video came to have more accessible attitudes about flossing.

Actual content of attitudes was assessed by the sum of the five binary items, with higher numbers indicating more positive feelings towards flossing. A one-way ANOVA did not yield a main effect of condition for either Time 1 [$F(1, 77) = 0.11$, $p = 0.75$] or Time 2 [$F(1, 77) = 0.02$, $p = 0.89$]. Therefore, the motor manipulations influenced the accessibility, but not the content, of attitudes.

**Self-efficacy**

For the self-efficacy measure, we summed up the number of ‘Yes’ responses to the eight efficacy questions, with higher scores signifying greater self-efficacy. We looked at this variable at both sessions to investigate whether motor manipulations exert an effect immediately or gradually over time. One-way ANOVAs did not yield a significant effect of condition on efficacy at session one or two ($Fs < 1$, $ps > 0.7$).

To test the hypothesis that motor manipulations increase the consistency between perceived and actual behavioural skill, we conducted a hierarchical linear regression analysis (Aiken & West, 1991) to see if condition moderated the relationship between self-efficacy and flossing skill. At Step 1, we entered condition (0, 1 for imagery and motor + imagery conditions) and self-efficacy (mean-centered) as predictors. The interaction was entered at Step 3. A measure of overall flossing skill was used as the outcome variable. It was created by standardising the number of teeth flossed and the dental hygienist ratings and averaging the two values.

In the analyses using self-efficacy at session one, the model was significant at Step 1 ($R^2 = 0.13$, $F(2, 70) = 5.35$, $p = 0.007$) as the main effect of condition was significant, $\beta = 0.32$, $t(70) = 2.87$, $p = 0.005$. Self-efficacy, however, was not a significant predictor of flossing skill, $\beta = 0.16$, $t(70) = 1.39$, $p = 0.17$. At Step 2, the
interaction was marginally significant ($\beta = 0.27, t(69) = 1.75, p = 0.09$; Step 2: $\Delta R^2 = 0.04, F(3, 69) = 4.68, p = 0.005$).

In the analyses using self-efficacy at session two, the model was significant at Step 1 ($R^2 = 0.14, F(2, 70) = 5.57, p = 0.006$) as the main effect of condition was significant, $\beta = 0.32, t(70) = 2.92, p = 0.005$. Self-efficacy, however, was not a significant predictor of flossing skill, $\beta = 0.17, t(70) = 1.53, p = 0.13$. At Step 2, the interaction was significant ($\beta = 0.40, t(69) = 2.58, p = 0.012$; Step 2: $\Delta R^2 = 0.08, F(3, 69) = 6.23, p = 0.001$). As predicted, there was a significant relationship between self-efficacy and skill in the motor + imagery condition, $\beta = 0.44, t(69) = 2.93, p = 0.005$. By contrast, in the imagery condition, self-efficacy did not significantly predict behaviour, $\beta = -0.12, t(69) = -0.75, p = 0.46$ (Figure 2). Therefore, participants who engaged their motor systems during the health message had flossing efficacy beliefs that were more predictive of their actual skill at flossing.

**Discussion**

The current research examined health persuasion using the embodied cognition framework and found evidence that incorporating a minimal motor manipulation into a health message can lead to increased skill at performing the prescribed behaviour. Participants who touched a piece of dental floss and imaged themselves flossing were more skilled at flossing than those who simply watched the video and imaged themselves flossing. When taken together with previous research (Sherman et al., 2010), these results suggest that motor manipulations can be effective tools in health persuasion.

We also found evidence that engaging the motor system during presentation of a health message can lead to increased accessibility of the attitudes conveyed in the message. Valenced words about flossing were responded to more quickly by participants who engaged their motor system than participants who only imaged themselves flossing. Consistent with previous research, highly accessible imagery can
strengthen the ability to perform skilled behaviours that possess a motor component (Heremans et al., 2009; Lotze & Halsband, 2006; Rogers, 2006). Furthermore, accessible imagery helps individuals form attitudes, beliefs and intentions that are more predictive of behaviour (Kna¨uper et al., 2009). When the motor system was engaged during the health message, self-efficacy beliefs were more concordant with actual flossing ability 1 week later.

These findings provide preliminary support that embodied representations are, by their nature, more accessible. The embodied cognition approach proposes that information representation can involve multiple systems – cognitive, affective, sensory and motor (Niedenthal et al., 2005). If multiple modalities are appealed to during the acquisition of information, then recall of the information will involve partial reactivation of these multiple modalities (Barsalou, 1999; Winkielman, Niedenthal, & Oberman, 2008). The result, as our findings suggest, is that the information is represented and recalled in a more accessible way. In the present study, when participants initially responded to the attitude and self-efficacy questions directly after the watching the video, the information was equally accessible for everyone (given the short elapse in time). As time passed, however, those who engaged their motor systems may have re-experienced the video more vividly, as any cues to flossing, such as the individual flosses they were given, awakened and enlivened their sensorimotor modalities. Thus their attitudes became more accessible over time, and participants’ skill at performing was concordant with their beliefs.

Limitations
In the present study, the effects of motor manipulations on flossing skill were found only for females. This finding is consistent with previous findings that a persuasive attempt to promote flossing which incorporates a motor activity is effective for females but not males (Sherman et al., 2010). According to the transtheoretical model (Prochaska, DiClemente, & Norcross, 1992), an intervention can only be successful if the recipient is in the appropriate stage of change. The same study (Sherman et al., 2010) found that female participants were more ready to change their behaviour, as indicated by their greater intentions to floss, than male participants. Prior research has found that male adolescents are less ready to change their oral health behaviour than female adolescents (Buchanan & Coulson, 2007). When a health behaviour was examined where there were no sex differences in intention or readiness to change (i.e. exercise), motor manipulations were effective in changing behaviour for both males and females (Sherman et al., 2010). Thus there is no reason to believe that the utility of motor manipulations in increasing skill at performing health behaviour is restricted to females. A second limitation in the present study is that there were multiple problems associated with the measure of flossing frequency (returning the unused flosses). Future research may benefit from the inclusion of a daily flossing diary where participants can record their behaviour as was done with exercise in previous research (Sherman et al., 2010).

Final thoughts
Despite the obvious motor component of health behaviours, most interventions to promote health behaviour have not incorporated the motor system. Theories of
health behaviour (e.g. health belief model, theory of reasoned action) typically focus on changing cognitions as a means of changing behaviour and have not specified the role of the motor system per se in their models. The present research suggests that minimally engaging the motor system can increase the effectiveness of a health message in producing longer-term health behaviour change. Information obtained from health messages that get the body involved may exceed what can be vicariously extracted from expert demonstration alone. Motor manipulations may allow health messages to permeate the musculature, enabling people to skillfully execute prescribed behaviours and improve their health.

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Notes
1. Infrequent flossers included those who reported that they had never flossed in the past month as well as those who reported flossing only once or twice in the past month.
2. The three videos were unable to be coded for the number of teeth flossed because the videotape ended in the middle of the session (N = 2) or the participant had braces and was not able to floss every tooth (N = 1). Nevertheless, the dental hygienist thought there was sufficient information to code these videos.
3. The incidence of flossing behaviour cannot account for the effect of motor condition on behavioural skill. Flossing behaviour was not significantly correlated with skill, r(56) = 0.13, p = 0.34 for number of teeth flossed and r(56) = 0.06, p = 0.66 for dental hygienist ratings.
4. Attitude accessibility was not significantly correlated with either flossing behaviour, r(56) = -0.07, p = 0.52, or behavioural skill (combined index), r(73) = -0.18, p = 0.32.

References


Appendix 1. Excerpts from ‘Flossing Tips with Amy Guthrie, DDS’

‘Ok, so the importance of flossing is that it cleans between the teeth where the toothbrush doesn’t reach. So if you don’t floss, you’re only cleaning the sides of the teeth and that’s like washing your car and doing only washing the sides and not the front and the back. So if you don’t floss your teeth then what happens is that the bacteria and the plaque irritates the gum tissue. And the gums will recede in order go away from the bacteria so that is why it is important to floss’.

‘The Plaque take 24–36 hours before it can do damage so that is why it is important to do it everyday. So, I’m going to show you how to floss your teeth... Start with about 18 inches. Wrap it around your middle fingers of both hands and then use your thumbs and index fingers to direct the floss where you want to go. Start in between your teeth zig zag it in and out till it slides up under need. Wrap it around the side of the two teeth so it wraps around the gum and wrap it the other direction under the gum’.

‘(Dentist showing model of teeth) Gingivitis can progress into periodontitis... what that means is that the bone is involved. You can see that the gums have receded even further... The gums are inflamed in this picture the bone looks alright here but you can see the top of the bone has been eaten away by the bacteria. The gum tissue is very puffy and irregularly shaped and there is a lot more inflammation, and the black stuff here is the tarter build up. What the flossing does is remove the plaque before it has an opportunity to calcify and turn into tartar’.