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**Evidence That Process Simulations Reduce Anxiety in Patients Receiving Dental  
Treatment: Randomized Exploratory Trial**

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**Evidence That Process Simulations Reduce Anxiety in Patients Receiving Dental  
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Process simulations – mental simulations that ask people to imagine the process of completing a task – have been shown to decrease anxiety in students facing hypothetical or psychological threats in the short term. The aim of the present study was to see whether process simulations could reduce anxiety in a sample of the general population attending a dental practice, and whether these effects could be sustained throughout treatment.

Participants ( $N = 75$ ) were randomized to an experimental condition where they were asked to simulate mentally the process of seeing the dentist, or to a control condition where they were asked to simulate mentally the outcome of seeing the dentist. Findings showed that participants in the experimental condition were significantly less anxious both before and after their consultations. Self-efficacy and self-esteem remained unchanged. This study suggests that process simulation is one active ingredient in anxiety treatment programs and further research is required to enhance its effects.

**KEYWORDS:** process simulation, imagery, state anxiety, self-efficacy, self-esteem, dental

## **Evidence That Process Simulations Reduce Anxiety in Patients Receiving Dental Treatment: Randomized Exploratory Trial**

The UK National Institute for Health and Clinical Excellence (NICE) recommends that adults should have their teeth checked at least every two years, and more often in the case of adults with specific teeth, gum and mouth complaints (NICE, 2004). However, the Adult Dental Health Survey ( $N = 6,204$ ) showed that in 1998, just 59% of the dentate adult population regularly saw a dentist, and 30% only visited the dentist when they were experiencing trouble with their teeth (Office of National Statistics, 2000). Anxiety was one of the main issues that arose from the survey: 32% of all respondents to the Adult Dental Health Survey reported always feeling anxious about going to the dentist, a proportion that rose to 46% among those who only visited the dentist when they were experiencing trouble with their teeth (Nuttall, Bradnock, White, Morris, & Nunn, 2001). The implication is that interventions to overcome dental anxiety could have wide-reaching effects on oral public health.

Moreover, recent evidence suggests that pre-treatment anxiety increases the chances of developing post-traumatic stress symptoms following dental procedures (e.g. de Jongh, Olf, van Hoolwerff, Aartman, Broekman, Lindauer, & Boer, 2008). To date, however, interventions designed to help overcome dental anxiety have utilized a range of techniques including oral premedication, relaxation therapy, cognitive therapy, hypnotherapy, self-hypnosis training, group therapy, and individual desensitization with some success (e.g. Litt, Kalinowski, & Shafer, 1999; Lundgren, Carlsson, & Berggren, 2006; Moore, Abrahamsen, & Brodsgaard, 1996; Thom, Sartory, & Jöhren, 2000). However, because these interventions are typically targeted at people with extreme dental anxiety (as opposed to the general population), they tend to be time consuming and require the presence of a health professional. Perhaps more importantly, because such interventions typically contain many “active”

ingredients, it has been difficult to tease apart the unique effects of a single component and thereby enhance the effectiveness of the interventions. The aim of the present study is to examine the effects of mental simulation on dental anxiety in the general population.

### *Mental Simulations*

Clinicians, coaches and laboratory-based scientists have used mental simulations to facilitate the performance of a range of behaviors, and they have been used as part of interventions designed to help overcome dental anxiety (e.g. Thom et al., 2000). Pham and Taylor (1999) make a distinction between outcome simulations and process simulations (Taylor, Pham, Rivkin, & Armor, 1998). Outcome simulations involve envisioning the desired outcome – for example, someone wanting to lose weight might imagine how they would look having achieved the desired weight loss. In contrast, process simulations involve mentally simulating the process of achieving the goal – for the person trying to lose weight, this might involve imagining signing up to exercise classes, imagining removing fatty snacks from the diet and/or imagining increasing fruit and vegetable consumption. The evidence supports the idea that process simulations are more effective than outcome simulations in changing people's behavior: Pham and Taylor (1999) showed that students who used process simulations achieved significantly higher exam grades than did students using outcome simulations, and Armitage and Reidy (2008) found that process simulations significantly increased students' motivation to donate blood in contrast with outcome simulations. Crucially, both these studies showed that the process manipulations worked by increasing motivation and reducing anxiety, consistent with the idea that process simulations augment problem-solving activities through increased planning and emotional regulation (e.g. Taylor & Schneider, 1989). An alternative explanation offered by Taylor et al. (1998) for the beneficial effects of mental simulations is that they provide information about how to potentially achieve a goal and thus increase self-efficacy (“confidence in one's own ability”).

There is, however, conflicting evidence regarding this explanation (e.g. Armitage and Reidy, 2008; Pham & Taylor, 1999). Given that self-efficacy both manages anxiety in dental contexts (e.g. Kent, 1987) and can be increased through process simulations (Bandura, 1977), it would be valuable to examine further the potential effects of process simulations on self-efficacy.

Interestingly much of the focus of the impact of mental simulations on emotion regulation has been on negative affect such as anxiety (e.g. Pham & Taylor, 1999). There is, however, some evidence to suggest that simulations also impact upon positive affect (e.g. self-esteem; Rivkin & Taylor, 1999). Self-esteem is regarded as playing a vital role in response to threatening situations and it would be valuable to see whether process simulations increase people's feelings of self-worth (Steele, 1988). More specifically, it is plausible that while experiencing a physical threat such as dental treatment, mentally simulating the process of achieving a goal works in a self-affirming manner, thereby boosting self-esteem (see Steele, 1988).

For the purposes of the present study, however, we were most interested in the effects of process simulation on anxiety and in whether the technique would work in a field setting with patients as opposed to laboratory conditions with undergraduate students (Armitage & Reidy, 2008; Pham & Taylor, 1999). We also wanted to see whether the process simulations would work in the face of a proximal and physical threat, namely, a dental appointment, as opposed to a hypothetical threat (Armitage & Reidy, 2008) or a psychological threat (Pham & Taylor, 1999). It is predicted that, consistent with laboratory research, process simulations will significantly reduce anxiety and that these effects will be sustained throughout the course of the treatment. Although previous research has found mixed effects of process simulations on self-efficacy, the weight of evidence would lead to the prediction that process simulations should increase self-efficacy (e.g. Bandura, 1977). Similarly, because self-esteem is regarded

as playing an important role in the ways in which people respond to threatening situations (e.g. Steele, 1988), it would be valuable to see whether process simulations increase people's feelings of self-worth.

## **Method**

### **Participants**

Participants were recruited from a dental practice in a city in the North of England. One hundred and four potential participants were approached while awaiting treatment or consultation with one of the three practicing dentists (Figure 1). The sample for whom background data were available ( $N = 103$ , 1 individual declined outright) consisted of 67 women and 36 men with an average age of 52 years, ranging between 24 and 80 years. Four participants (3.9%) described themselves as "Asian" and 99 (96.1%) as "White". The occupations of participants ranged from "unemployed" to "company directors", although the most frequently cited occupations were "retired" ( $n = 25$ , 24.3%) and "housewife" ( $n = 14$ , 13.6%). Thus, the sample was not representative in terms of gender or occupation, but ethnicity was close to the English population, where 90.9% are white. When the researcher explained the nature of the study, 28 declined to participate in the visualization exercise (but completed the background measures described above), 1 individual declined to provide any information.

### **Design and Procedure**

The study was given ethical approval by the appropriate Internal Review Board. Participants were randomly allocated to the experimental (process simulation,  $n = 36$ ) or control (outcome simulation,  $n = 39$ ) condition. This was achieved by pre-sorting the questionnaires into a random order on the basis of coin tosses. In order to maximize ecological validity, the experiment was run in the waiting room of the dental practice, where

the participants completed questionnaire packs on their own while they were waiting to see the dental practitioner.

The first page of the study packs gave instructions regarding consent and ethics, as well as instructions for completing the measures. The only difference between the experimental and control conditions was the material that appeared on the second page, namely, the process or outcome simulation manipulations. The researcher was therefore not aware as to which conditions participants had been allocated. The researcher remained onsite in order to answer any questions that were raised, but the researcher remained at a distance in order to let participants complete the questionnaires on their own. When their consultation with the dentist finished, participants completed a brief follow-up measure before being debriefed. Participants' Time 1 and Time 2 questionnaires were matched with unique code numbers.

## **Materials**

**Absorption.** Prior to the simulation manipulations, an abridged version of Tellegen and Atkinson's (1974) absorption scale was used to control for individual differences in people's ability to create mental simulations. The items include, "Sometimes thoughts and images come to me without the slightest effort on my part" and "I can be deeply moved by a sunset" measured on 4-point *never* (0) to *always* (3) scales. The measure was completed at Time 1 only, prior to the simulation manipulations.

**Simulation manipulations.** The simulation manipulations were almost identical to those used by Pham and Taylor (1999), with minimal adaptations being made to frame them with respect to visiting the dentist. To minimize experimenter involvement, all instructions associated with the manipulations were written on the second page of the questionnaire. On the second page of the questionnaire, participants received one of two paragraphs, depending on whether they had been randomly allocated to the control (outcome simulation) or



experimental (process simulation) condition. They were instructed to read the paragraph, rehearse it with their eyes closed, and then write down any thoughts in the space provided.

The control (*outcome simulation*) group received the following paragraph:

“Please empty your mind and visualise yourself after seeing the dentist. From now until you go in, vividly imagine how you will be after seeing the dentist. It is very important that you see yourself actually having seen the dentist and keep that picture in your mind”;

the experimental (*process simulation*) group received the following paragraph:

“Please empty your mind and visualise yourself preparing to see the dentist. From now until you go in, vividly imagine how you will prepare yourself to see the dentist. It is very important that you see yourself actually preparing and keep that picture in your mind”.

Both groups were asked to close their eyes and rehearse the paragraph in their mind until the researcher asked them to stop. Participants were allowed 2 minutes from the beginning of the study to read these instructions and complete the visualization task. Participants then completed the dependent measures described in the following section.

*State anxiety* was measured after the simulation manipulations and following the dental consultation using Marteau and Bekker's (1992) short form of the Spielberger state-trait anxiety inventory. The measure consists of six items that participants rated on 4-point scales labeled *not at all*, *somewhat*, *moderately*, and *very much*. The items are: “I feel calm” (reverse-scored), “I am tense”, “I feel upset”, “I am relaxed” (reverse-scored), “I feel content” (reverse-scored), and “I am worried”. The mean of the items was used to form a scale. Cronbach's  $\alpha$  indicated that the state anxiety scale possessed adequate internal reliability at both Time 1 ( $\alpha = .89$ ) and Time 2 ( $\alpha = .68$ ).

*Self-esteem* was measured after the simulation manipulations and following the dental consultation using Robins, Hendin, and Trzesniewski's (2001) single-item self-esteem scale, "I have high self-esteem" measured on a 5-point *not very true of me to very true of me* (5) Likert scale. Test-retest reliability for this measure in the present study was high,  $r = .90$ .

*Self-efficacy* was measured after the simulation manipulations and following the dental consultation using Schwarzer and Jerusalem's (1995) scale. Participants were presented with ten statements about their performance in specific situations (e.g. "If I am in trouble, I can usually think of a solution" and "I am confident that I could deal efficiently with unexpected events") and asked to respond on 4-point scales whether they *never* (0) or *always* (3) behaved like this. Cronbach's  $\alpha$  indicated that the self-efficacy scale possessed very good internal reliability at both Time 1 ( $\alpha = .89$ ) and Time 2 ( $\alpha = .95$ ). Test-retest reliability was high,  $r = .85$ .

## Results

### Attrition Analysis

Twenty-seven potential participants who declined to participate were willing to provide data on their age, gender, and how often they had visited the dentist in a typical year (1 potential participant declined to participate outright), and so these were compared with participants who subsequently completed the study ( $n = 75$ ). Thus MANOVA was used with *completion* (completers versus non-completers) as the independent variable, and age, gender and prior visits to the dentist as the dependent variables. The multivariate test was significant,  $F(3, 99) = 2.76, p = .05, \eta_p^2 = .08$ , along with one of the univariate tests: Older potential participants ( $M = 57.22, SD = 13.43$ ) were less likely than younger potential participants ( $M = 50.21, SD = 15.05$ ) to take full part in the study,  $F(1, 101) = 4.56, p = .03, \eta_p^2 = .04, d = .48$ . Thus, on average, the final sample consisted of younger people than generally attended the practice. We will return to this issue in the Discussion.

### Randomization Check

Success of the randomization procedure was checked using MANOVA. *Condition*, with two levels (control versus experimental) was the independent variable and age, gender, and number of prior visits to the dentist were the dependent variables. The omnibus test,  $F(3, 72) = 0.87, p = .46, \eta_p^2 = .03$ , and all the univariate tests were nonsignificant meaning that randomization was successful. Thus, there were no grounds for suspecting systematic between-groups differences prior to the manipulations.

### Effects of the Process Manipulation

**Time 1.** MANCOVA was used to test potential differences between *condition* (control versus experimental) on state anxiety, self-esteem and self-efficacy, controlling for the effects of individual differences in imagery ability. The omnibus test,  $F(3, 70) = 2.83, p = .04, \eta_p^2 = .11$ , was statistically significant, as was one of the univariate tests. This showed that anxiety was significantly lower in the experimental as opposed to the control group,  $F(1, 72) = 4.58, p = .04, \eta_p^2 = .06, d = .17$  (Table 1). There were no statistically significant differences between conditions on self-esteem or self-efficacy. In terms of clinical significance, it is notable that 7/36 (19.44%) people in the experimental condition had state anxiety scores lower than the mean-minus-one-standard-deviation state anxiety scores of people in the control condition.

**Time 2.** As expected, within-persons ANOVA showed that state anxiety significantly decreased over time in both groups following the consultation with the dentist,  $F(1, 74) = 28.35, p = .0001, \eta_p^2 = .27, d = .71$ . ANCOVA was used to test potential differences between *condition* (control versus experimental) on state anxiety at Time 2 controlling for time 1 anxiety and the effects of individual differences in imagery ability. The test,  $F(1, 71) = 3.80, p = .01, \eta_p^2 = .14, d = .37$ , was statistically significant meaning state anxiety was significantly lower in the experimental as opposed to the control group (Table 2). In terms of clinical

significance, it is notable that 11/36 (30.55%) people in the experimental condition had state anxiety scores lower than the mean-minus-one-standard-deviation state anxiety scores of people in the control condition.

### **Potential Moderating Effects of Attending for Treatment Versus Regular Check-Up**

Finally, we tested to see whether the results were affected by whether or not people were undergoing treatment as opposed to attending for a regular check-up. Thus, ANCOVA with *condition* (control versus experimental) and *treatment* (check-up versus treatment) as the independent variables, individual differences in imagery ability as the covariate, and state anxiety as the dependent variable was conducted on the Time 1 and Time 2 data. Although people attending for treatment were significantly more anxious at Time 1,  $F(1, 70) = 4.69, p = .03, \eta_p^2 = .06, d = .74$ , there were no significant differences between those who had been for a check-up and those who had been treated at Time 2,  $F(1, 70) = 1.04, p = .31, \eta_p^2 = .01$ . Moreover, there were no condition  $\times$  treatment interactions at either Time 1,  $F(1, 70) = 2.32, p = .13, \eta_p^2 = .03$ , or Time 2,  $F(1, 70) = 0.14, p = .70, \eta_p^2 < .01$ , implying that the manipulation was equivalently effective for those attending for a check-up and those attending for treatment.

## **Discussion**

The aim of the present study was to see whether process simulations could reduce anxiety in a sample of the general population attending a dental practice and so examine one of the active ingredients commonly used as part of treatment packages for dental anxiety (e.g. Thom et al., 2000). The principal findings were that, consistent with previous research, process simulations were effective in clinically and statistically significantly reducing state anxiety (see Armitage & Reidy, 2008; Pham & Taylor, 1999). Moreover, for the first time, the present research showed that the effects were sustained longer than the period immediately following the manipulation and, in terms of clinical significance, the effect of

process simulation on state anxiety was larger following the consultation (11/36, 30.55%, lower than mean-minus-one-standard-deviation state anxiety) than they were before the consultation (7/36, 19.44%, lower than mean-minus-one-standard-deviation state anxiety). The following discussion considers the clinical and theoretical implications of these findings.

### **Clinical Implications**

In contrast with prior laboratory-based research, the present study shows that process simulations can work to reduce anxiety in a field setting where people are under imminent threat of physical discomfort. Perhaps more importantly, the present findings demonstrate that the effects were sustained over a longer period of time than has previously been observed, and – importantly from a clinical point of view – continued post-consultation. In fact, between Time 1 and Time 2, the clinical significance of the findings increased from 7/36 (19.44%) to 11/36 (30.55%) people in the experimental condition with state anxiety scores lower than the mean-minus-one-standard-deviation state anxiety scores of people in the control condition. Thus, the present findings map onto those of Thom et al. (2000), who demonstrated that participants in their psychological treatment condition showed further improvement at follow-up.

Moreover, the present findings isolate one element of treatment for dental anxiety, meaning that further work should focus on enhancing the effects of process simulations specifically. There are three routes for further research. First, the present technique could be refined to examine (for example) dose-response relationships to see whether periods of time shorter than two minutes might exert similar effects and/or whether doubling the length of time to four minutes doubles the effects on state anxiety. Second, although one of the advantages of the present manipulation is that it can be administered unsupervised, it is plausible that its effects could be significantly enhanced with the assistance of a health professional. Third, it is worth highlighting that, consistent with previous research (Armitage

& Reidy, 2008; Pham & Taylor, 1999), the present study employed a general measure of anxiety as opposed to the specific dental anxiety instruments typically used in this domain (Litt et al., 1999; Thom et al., 2000). The implication is that the present technique could be extended to other anxiety-provoking domains and to enhance the effectiveness of anxiety treatment programs more generally.

### **Theoretical Implications**

The present findings show that process simulations work both beyond the undergraduate student population and outside the laboratory, which thereby provides greater confidence in the potential generalizability of earlier studies (cf. Armitage & Reidy, 2008; Pham & Taylor, 1999). The implication is that process simulations might work in a variety of contexts for a variety of purposes. In particular, we provide strong evidence to support the idea that process manipulations facilitate emotional regulation (Taylor & Schneider, 1989). Moreover, the present research demonstrates that these effects are not transitory: Whereas Armitage and Reidy (2008) and Pham and Taylor (1999) showed that state anxiety was only affected by process simulations at baseline, the present study showed that the effects could be sustained beyond a dental consultation.

The findings with respect to self-efficacy and self-esteem were more mixed. Although we anticipated that process simulations might boost people's self-efficacy and self-esteem, the present findings did not support those hypotheses. One possible explanation centers around our measures: Because previous research suggested effects on general (rather than fear-specific) anxiety (Armitage & Reidy, 2008; Pham & Taylor, 1999) and because we were anticipating a variety of self-generated simulations, we chose measures of *generalized* self-efficacy (Schwarzer & Jerusalem, 1995) and *global* self-esteem (Robins et al., 2001). In future, it might be valuable to consider refining the process simulation instructions by asking participants to focus their simulations on generalized or global aspects of the experience.

Nevertheless, it is worth highlighting that: (a) Pham and Taylor (1999) similarly found null effects with respect to the effects of process simulations on self-efficacy; (b) the effects of self-affirmation (Steele, 1988) on self-esteem can best be described as “mixed” (e.g., contrast Armitage & Rowe, in press with Armitage, in press); and that the unique effect of the process simulation on state anxiety strongly suggests that the present findings cannot be attributed to reporting biases.

### **Limitations**

Although the present findings take the research on treating anxiety and process simulations forward in some important respects, it is important to note some potential limitations. First, according to Cohen’s (1992) criteria, the effect sizes can be described as “small” (Time 1) and “small-medium” (Time 2) meaning that mental simulations might best be considered one active ingredient as part of a broader tool to address dental anxiety, rather than a treatment in its own right. Second, a significant minority of participants (29/104, 27.88%) declined to participate in the study, even though they were approached on an individual basis by a researcher and had ample time to participate in pleasant surroundings. People who completed the study were significantly younger than those who declined to participate, and so it would be valuable to explore different strategies to target older people. A third potential limitation concerns the fact that, by definition, participants were already attending a dental surgery and were therefore not representative of people with anxieties about visiting the dentist. However, the fact that we were able to detect significant effects in such a sample implies that the technique is robust and potentially applicable in other populations. Fourth, we only followed people over a relatively short period of time and it would have been useful to see whether the significant effects on anxiety persisted over a longer period, particularly as the clinical gains were enhanced at Time 2. However, we would argue that there are grounds for cautious optimism: Thom et al. (2000) showed that

participants in their psychological treatment condition (which included imagery) experienced further improvements two months post-treatment, implying that the effects on anxiety demonstrated in the present study might well have endured for some time. Fifth, we did not have a baseline measure of anxiety; however, the fact that our randomization check was successful gives us grounds for assuming that both experimental and control group had equivalent levels of anxiety at baseline.

### **Conclusions**

The present study shows that process simulations reduce state anxiety in the short-term, and that they work in people who are not undergraduate students. It has isolated one active ingredient of programs designed to treat dental anxiety and has the potential to be applied not just in clinical settings, but in addressing oral public health more broadly, given that it is a very brief intervention that can be self-directed. Further research is required to look at refining the technique and identifying the other active ingredients of intervention programs that could supplement the effects of mental simulations.



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Table 1

*Effects of the Process Simulation Manipulation at Time 1*

Dependent Variables	Control		Experimental		$F^a$
	$n = 39$		$n = 36$		
	$M$	$SD$	$M$	$SD$	
State anxiety	2.20	0.83	2.06	0.80	4.58*
Self-esteem	3.54	0.97	3.36	1.02	0.58
Self-efficacy	2.30	0.42	2.22	0.42	0.90

*Note.* The  $M$ s and  $SD$ s are “raw” and unadjusted for imagery ability. <sup>a</sup>Univariate  $F$ s testing

Time 1 differences between control and experimental conditions;  $dfs = 1, 72$ .

\* $p < .05$ .

Table 2

*Comparison of State Anxiety for Experimental and Control Groups Between Time 1 and Time*

*2*

Dependent Variables	Time 1		Time 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Control group ( <i>n</i> = 39)	2.20	0.83	1.73	0.46
Experimental group ( <i>n</i> = 36)	2.06	0.80	1.55	0.51

*Note.* The *Ms* and *SDs* are “raw” and unadjusted for imagery ability and time 1 anxiety.

Figure 1

*Flow Diagram of Participant Progress Through the Phases of the Trial*

