AFFECTIVE MULTIMODAL INTEGRATION OF VISUAL AND TACTILE TEXTURES

Brian HENSON*, Stephen LILLFORD

School of Mechanical Engineering, University of Leeds, United Kingdom

ABSTRACT

An experiment is reported that demonstrates that affective responses to visual and tactile stimuli, at least within the context of this experiment, are integrated by weighted averaging. Other research has shown that people integrate multimodal information according to different mechanisms, such as additive, super-additive and by maximum likelihood estimation. This experiment was carried out to determine the integration mechanism for visual and tactile textures, which were required to build a computational model predicting affective responses to visual and tactile textures. Twelve plaques made of laminate board with four visual textures and three tactile textures in all combinations were made. Twenty six participants rated the combined stimuli semantic differential scales against six words: *natural, simple, rough, warm, like* and *elegant*. Participants also rated the visual textures separately without touching them, and the tactile textures without seeing them. Analysis of variance was used to determine whether the scores of the stimuli combinations were independent. The results show no evidence of interaction between visual and tactile stimuli for all the words except *natural*; people's responses to the visual textures do not generally depend on the tactile textures they are presented with. By considering the scores of combined stimuli to scores of stimuli only touched or only seen, it is shown that people's integration of visual and tactile stimuli in this context is most likely by weighted averaging. We speculate that the deviation from the weighted average model for the word *natural* is due to congruency effects.

Keywords: *multimodal effect, touch, vision*

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* **Corresponding author**: School of Mechanical Engineering, University of Leeds, Leeds, LS2 9JT, United Kingdom. b.henson@leeds.ac.uk

1. INTRODUCTION

One of the possible criticisms of affective or kansei engineering is that it is often used in a reductionist way. Different elements of a product design are tested separately and it is assumed that recombining the elements will produce a congruent whole. Thus, consumers' emotional experience of products depends on the combination of messages they receive. The cues they receive include, amongst others, visual ones such as branding and color, and tactile cues such as tactile texture. Messages from each of the cues should be complementary to ensure a coherent brand message. This paper tests the assumption that elements of stimuli can be tested separately, and reports an investigation into a method to determine the way in which people combine the effects of visual and tactile stimuli.

There has been much previous research into how people integrate information from different senses. However, this has concentrated mainly on perception, such as whether visual cues can improve tactile discrimination, rather than on elements' influence on overall affect. For example, Zampini, Guest and Spence [1] researched the combination of auditory and tactile; and Zellner and Whitten [2] investigated visual and olfactory stimuli. In the visual and tactile domains, Guest and Spence [3] have shown that combining visual and tactile stimuli does not enhance perception of surface texture. They cite previous work (such as Jones & O'Neil [4]) that suggests that visual and tactile inputs lead to weighted averaging of the information from the different senses. Guest and Spence conclude that visual and tactile inputs act as independent sources of information which can both contribute to the decision process. Others have obtained similar results [5]. However, the nature of the averaging that occurred in these studies was not fully characterized.

In the area of affective integration of the senses, Schifferstein [6] used self-report questionnaires to investigate which senses dominate consumers' interaction with products. The relative importance of the senses was found to depend heavily on the particular product, for example on whether the product was a vase or a television. Schifferstein's approach depends on the ability of subjects accurately to report their experiences of using products.

A hypothesis of the research reported in this paper is that people combine their affective responses to different elements of a product using simple algebraic relationships, such as weighted averaging. If a person's affective response to a stimulus is related to their perception of the stimulus, then previous research suggests that combining visual and tactile stimuli will result in an affective response which is a weighted average of the responses to the two stimuli separately, and that the visual cues should dominate. Such relationships have been demonstrated in a range of judgment tasks such as rating the desirability of dates based on photographs and written descriptions [7], although it is not the only mechanism possible. Others have shown that in the estimation of length involving noisy visual and haptic information, people adapt their integration model using maximum likelihood integration to minimize the variance in their final judgment [8].

In the experiment reported here, twelve tiles made of laminate boards with four visual textures and three tactile textures in all combinations were made [9]. Twenty-six participants were asked to indicate their responses to the combined stimuli on a twenty-one point semantic differential scales against the words *natural, simple, rough, warm, like* and *elegant.* The experiment was carried out to determine the integration mechanism for visual and tactile textures, which was required to build a computational model predicting affective responses to visual and tactile textures as part of a larger EC research project (SynTex, NEST043157). Participants also rated the visual textures separately without touching them, and the tactile textures without seeing them. Analysis of variance was used to determine whether the scores of the stimuli combinations were independent.

The experimental approach used was to develop a factorial design and use a system of scaling pioneered by [7]. In this approach, a set of stimuli (in the case of this research, images) which evoke high, medium and low responses against some uni-dimensional construct, are combined in all possible ways with other stimuli (in this case, tactile textures), which also elicit high, medium and low responses against the construct. Respondents then rate each of the stimulus combinations against the construct. The results are set out in a matrix (Table 1). If the values of each of the stimulus combinations are graphed on the ordinate axis against a regularly spaced abscissa, then the resulting lines between the values for each row are sometimes parallel. This can only happen when the response scale is linear, the responses to the different sorts of stimuli are independent, and people combine the effects of the stimuli using a weighted average or a sum. The approach is similar the kansei method QT1. QT1, however, assumes a model of integration (the affect are combined according to a weighted sum), rather than testing which model applies in each case.

Table 1: Table 1. Example of factorial design for stimulus interaction experiment [7].

Stimuli 1 / Stimuli 2	H_1	M_1	L_1	
H_2	Response H_1H_2	Response M_1H_2	Response L_1H_2	Average H_2
M_2	Response H_1M_2	Response M_1M_2	Response L_1M_2	Average M_2
L_2	Response H_1L_2	Response M_1L_2	Response L_1L_2	Average L_2
	Average H_1	Average M_1	Average L_1	

2. METHODOLOGY

2.1. Stimuli

The stimuli used in this experiment were 22 100mm × 100mm plaques made of laminate board material (Figure 1). Twelve of the boards (boards 3, 4, 5, 6, 7, 9, 12, 13, 14, 15, 18 and 19 in Figure 1) formed a full-factorial design, systematically combining four visual and three tactile textures. The tactile textures are referred to as *bumped, rough* and *dimpled* in this paper. They were chosen because they felt different from each other when touched. The visual textures are referred to as *pine*, *walnut, textile* and *checkered*, and they were chosen because they subjectively looked different from each other.

In addition to these twelve plaques, ten other stimuli were used. One plaque of each visual texture (plaques 2, 10, 20 and 22 in Figure 1) were mounted on a wall, just below eye level when the respondent was seated, and with the direction of light shining directly onto the plaques, so that visual cues of the tactile texture were minimized. One plaque with each of the three tactile textures (plaques 11, 16 and 17) were placed in cabinets behind curtains, where they could be touched, but not seen. Three other plaques (1, 8, 21) with different visual and tactile combination were included, to be both seen and touched, to add variety and mask the purpose of the experiment from respondents.

2.2. Collection of Semantic Differential Data

Semantic differential questionnaires were prepared using the following adjectives: *Cold – Warm, Smooth – Rough, Elegant – Not Elegant, Simple – Complex, Natural – Artificial, Dislike – Like.* The words were presented on a twenty-one point scale in random order and in random polarity. A twenty-one point scale was used because it is similar to those used in many experiments reported by experimental psychologists [7].

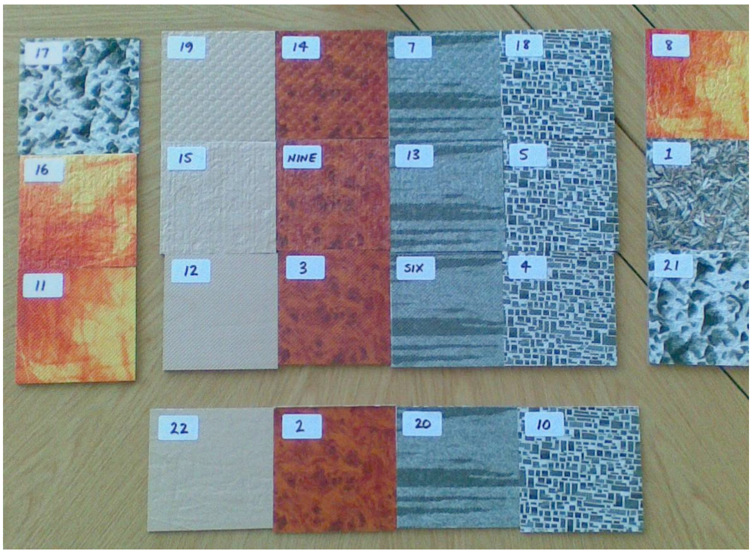

Figure 1: Figure 1: Stimuli used to determine multimodal integration model.

Thirty participants of mixed gender and ages were recruited to complete the questionnaire. The questionnaires were administered context-free in a controlled environment in an affective engineering evaluation room. The respondents were presented with each stimulus in a random order, told to lay them flat on the table and to touch with the tip of the second finger in a way that seemed most natural and comfortable. Participants were instructed to look at but not touch the plaques that were mounted on the wall, and to touch but not look at the plaques in the box. Questionnaires were administered on two consecutive days. The first day was used for training the participants using plaques different from the ones used on the second day, and only data from the second day were used. Participants were not told of the reason for being asked to complete the exercise on consecutive days.

The data were analyzed using analysis of variance using SPSS version 14. Data were analyzed using box plots to identify outlying responses.

3. RESULTS

The box plot analysis of the data revealed four outliers, and their data were removed from the analysis.

The average scores of each of the twelve plaques evaluated using both vision and touch against each of the six adjectives are shown in Figure 2. If there are no interaction effects between visual and tactile stimuli, then the lines in each graph should be parallel. Figure 3 shows the average scores against two of the adjectives, *rough* and *warm*, for each of the combined visual and tactile stimuli, for the touch only stimulus and for the vision only stimulus. If in each case the integration model is a weighted average, then the line for the combined visual and tactile stimulus should be a constant proportion between the lines for the visual only and touch only responses.

Repeated multivariate anova was used to test for significant interactions between the vision and touch sensory modes. For each of the words *simple, rough, warm, like* and *elegant,* there was no evidence of interaction between the visual and tactile textures. In other words, people's affective ratings of the tactile textures were not affected by the visual textures they were presented with, and vice versa. Many significant interaction effects were found between the visual and tactile textures for the word *natural*.

Participants rated the tactile textures significantly differently against the words *elegant*, *natural*, *complex*, and *rough*. The tactile textures *bumps* and *dimples* were significantly different against the word *like*. Participants rated the visual textures significantly differently against the words *complex* and *warm*. Two of the visual textures, *bumps* and *dimples*, were rated significantly differently by participants against the word *like*. The visual textures were not rated significantly differently against the words *rough, elegant,* and *natural*. Tactile textures were not rated significantly differently against the word *warm*.

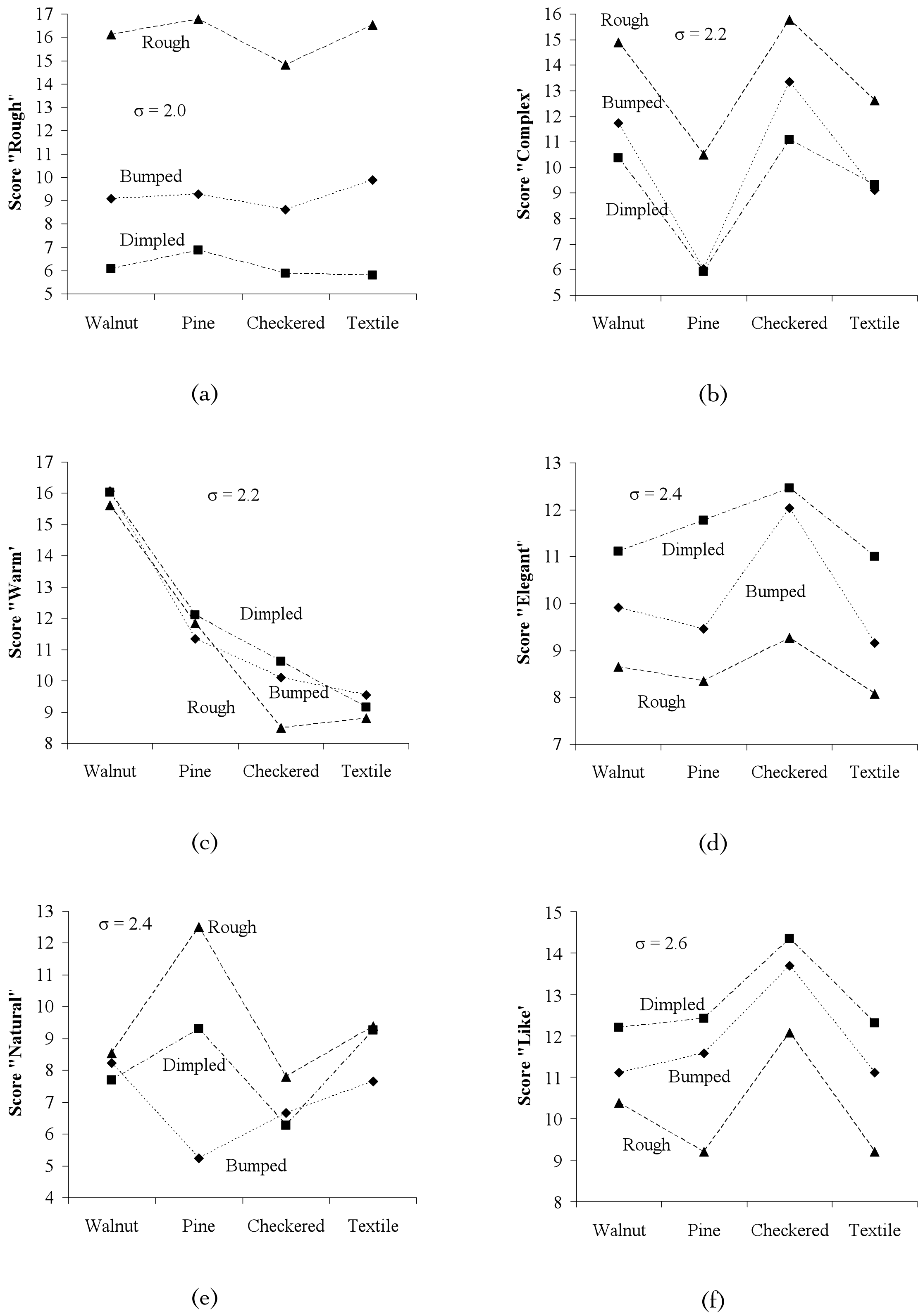

Figure 2: Average ratings of the plaques evaluated by both vision and touch against each of the six adjectives (a) *rough* (b) *complex* (c) *warm* (d) *elegant* (e) *natural* (f) *like*. If there are no interaction effects, the lines should be parallel.

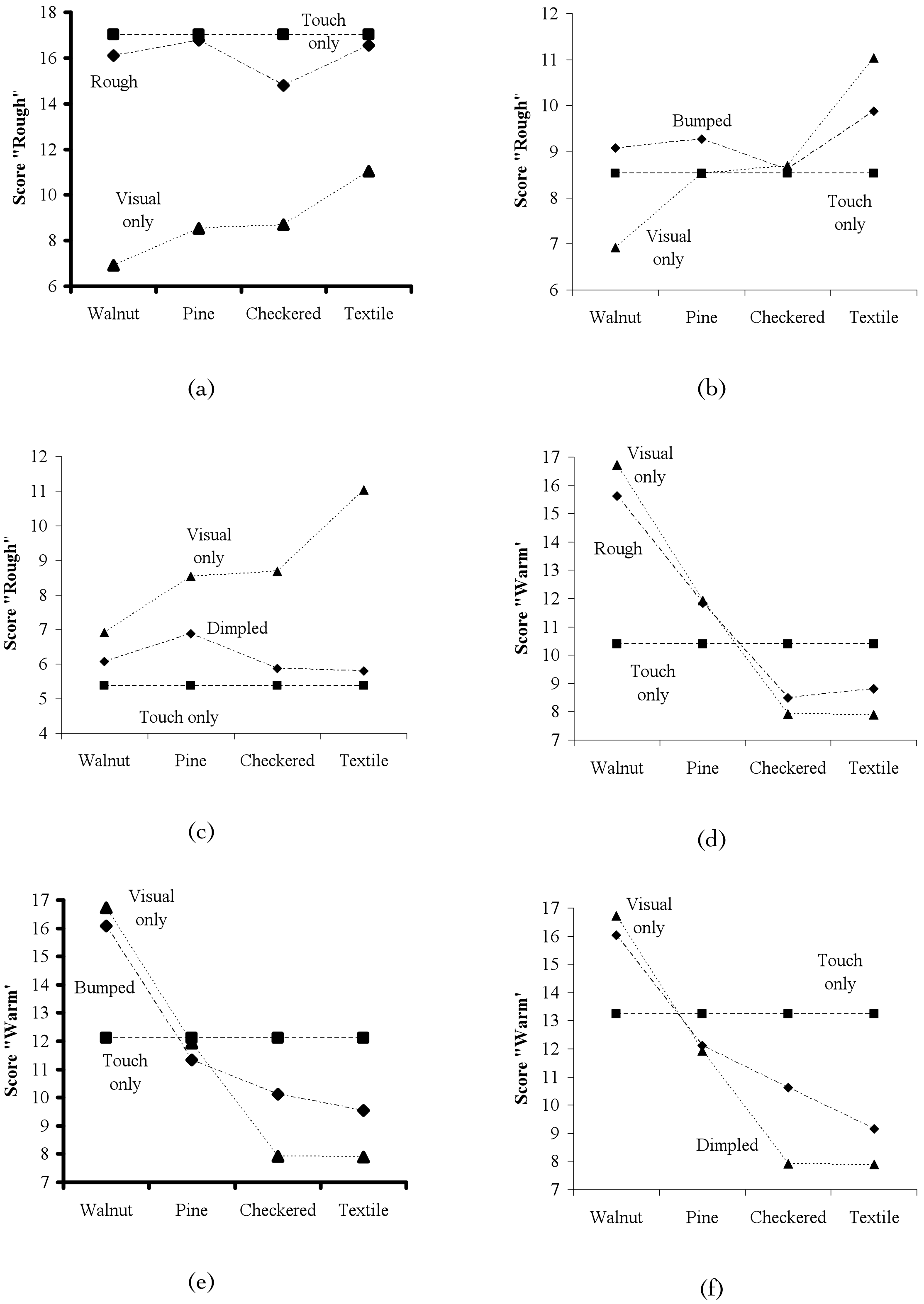

Figure 3: Average scores against the word *rough* for (a) the plaques with the *rough* surface, (b) *bumped* and (c), *dimpled* surface; and against *warm* for (d) *rough*, (e) *bumped* and (f), *dimpled* surface.

4. DISCUSSION

The lack of a significant interaction effect (Figure 2) between the visual and tactile textures for most of the adjectives supports the hypothesis that the visual and tactile stimuli in this case are combined by weighted averaging or adding. The responses to the combined stimuli against each of the words (e.g. Figure 3) are between the values of the responses to separately looking at or touching the plaque. This indicates that the responses to the combined stimuli are a weighted average of the responses to the visual and tactile stimuli separately. This outcome concurs with previous research [3, 4, 5], but more precisely identifies the integration model and extends the application from the perceptual to the affective domains.

Previous researches suggest that responses to combined stimuli should be dominated by the visual cues. The results here suggest that which mode dominates depends on the word against which the stimuli are being assessed. The closeness of the lines for the responses of the combined stimuli to the lines for the responses to the touch only stimuli in Figure 3 (a), (b) and (c) suggests that responses to the word *rough* are dominated by tactile cues. And the closeness of the lines for the responses of the combined stimuli to the lines for the responses to the visual only stimuli in Figure 3 (d), (e) and (f) suggests that responses to the word *warm* are dominated by visual cues. Further evidence for this assertion is participants' inability to significantly distinguish between the visual textures against *rough* and between the tactile textures against *warm*.

The results of this experiment show no evidence that maximum likelihood integration was used to integrate multimodal affective information. In the previous research reporting the use of this integration mechanism [8], people were asked to estimate the heights based on noisy visual and haptic cues. We speculate that either the nature of the integration task was fundamentally different to that explored here (i.e. integration to estimate of a single objective property is not the same as integration to determine an affect), or that maximum likelihood estimation is used when the cues from different modes cannot clearly be determined.

In this experiment, responses against the word *natural* departed from the weighted average model. As the participants had apparently no difficulty in significantly distinguishing the tactile textures against *natural*, departure from the model could be because of the difficulty people experienced in rating inherently unnatural visual textures. It could instead or also be because the visual and tactile textures were incongruent, which violated any feelings of naturalness.

5. CONCLUSIONS

An experiment has been reported that demonstrates that affective responses to visual and tactile stimuli, at least within the context of this experiment, are most likely integrated by weighted averaging. The results show no evidence of interaction between visual and tactile stimuli for all the words used except *natural*; people's affective responses to the visual textures do not generally depend on the tactile textures they are presented with. We speculate that the deviation from the weighted average model for the word *natural* is due to congruency effects.

The demonstration of a weighted average integration model concurs with previous research, but goes further, by more precisely identifying the integration model. This work extended the application of multimodal integration theory from the perceptual to the affective domains.

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