THE EFFECTS OF LANGUAGE ON PERCEIVED SOFTNESS

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ABSTRACT

THE EFFECTS OF LANGUAGE ON PERCIEVED SOFTNESS

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Perceived haptic softness of materials has been studied as a single dimension; however, it has recently been shown that it has multiple dimensions. Research on bimodal perception demonstrated the effect of sound frequency on perceived shapes, where people associate higher frequency sounds with angular shapes and lower frequency sounds with round shapes, known as the Bouba/Kiki effect. In this thesis the effects of onomatopoeic words, the words that mimic the sound they describe (e.g., *şırıl şırıl, çatır çutur*, etc.), were investigated on perceived material softness to test whether similar associations between onomatopoeic words and perceived softness also exist. Experiments were carried out using the onomatopoeic words in the written and the spoken form, and the materials in the video form. The two experiments using written and spoken onomatopoeic words report four softness related dimensions. The online experiment using written onomatopoeic words and material videos showed no significant results for the interaction effect of onomatopoeic words and materials. However, using spoken onomatopoeic words, the interaction effect was found to be significant for most of the pairings. Experiment with written onomatopoeic words conducted in a laboratory environment showed significant results for the effects of onomatopoeic words on perceived softness. There was no significant difference observed between the written and spoken modalities of onomatopoeic words, except for the main adjective Gelatinous. Hence, the obtained

results are in line with previously reported findings, and support the hypothesis that onomatopoeic words have an effect on the perceived softness of materials.

Keywords: Softness Perception, Haptic Perception, Material Perception, Onomatopoeia, Sound-Symbolism

ÖZ

DİLİN YUMUŞAKLIK ALGISINA ETKİSİ

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Malzemelerin algılanan dokunsal yumuşaklığı çoğunlukla tek bir boyut olarak incelenmiştir ancak son zamanlarda algılanan yumuşaklığın çok boyutlu olduğu gösterilmiştir. Önceki araştırmalar, ses frekansının, insanların daha yüksek frekanslı sesleri açısal (köşeli) şekillerle ve daha düşük frekanslı sesleri yuvarlak şekillerle ilişkilendirdiğini göstermiştir, bu etki literatürde Kiki-Bouba etkisi olarak bilinir. Bu tezde, tarif ettikleri sesi taklit eden kelimeler olan yansıma kelimelerin (örneğin şırıl şırıl, çatır çutur, vb.) algılanan materyal yumuşaklığı üzerindeki etkileri araştırılarak yansımalı kelimeler ile algılanan yumuşaklık arasında da benzer çağrışımlar olup olmadığı test edilmiştir. Yansıma kelimeler yazılı ve sözlü formda, materyaller ise video formunda kullanılmıştır. Yazılı ve sözlü yansıma sözcükleri kullanan iki deneyde yumuşaklıkla ilgili ortak dört boyut raporlanmıştır. Yazılı yansıma sözcükleri ve materyallerin videolarını kullanan online deney, yansıma sözcüklerin ve materyallerin etkileşimine ilişkin anlamlı sonuçların bulunduğu hipotezini desteklememiştir. Bununla birlikte, sözlü yansıma sözcüklerin kullanıldığı farklı bir deneyde, etkileşim etkisinin çoğu koşul için anlamlı olduğu bulunmuştur. Yazılı yansıma kelimelerin kullanıldığı deney laboratuvar ortamında tekrarlandığında, araştırılan koşulların çoğu için anlamlı etki elde edilmiştir. Ayrıca, yansıma kelimelerin yazılı veya sözlü olarak sunulması arasında ana sıfat grubu olan Jölemsi haricinde anlamlı bir fark bulunamamıştır. Dolayısıyla, elde edilen sonuçlar daha önce bildirilen

bulgularla uyumludur ve yansıma sözcüklerin malzemelerin algılanan yumuşaklığı üzerinde bir etkisi olduğu hipotezini desteklemektedir.
Anahtar Kelimeler: Yumuşaklık Algısı, Dokunsal Algı, Materyal Algısı, Yansıma Kelime, Ses Sembolizmi

To my beloved grandparents, who have been my greatest supporters ever. I wish you could see this day. This one is for you.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Perception is one of the most widely researched areas in cognitive psychology. The field has improved immensely with the advancements in physiological measuring tools as well as visualization devices. A popular area of research, the literature in visual perception has always been more prevalent than any other sensory modality, such as touch (Katz, 1925/1989). A previously less popular topic of research, haptic perception has recently gained growing interest with more studies being conducted in the field with novel methods. However, as much as these advancements have contributed to the field, the basics and the fundamentals of haptic perception, and its relation with other perceptual and cognitive components are still open to exploratory inquiries.

Haptic perception is defined as the active exploration of objects by touch. As one of the pioneers in the field, Gibson (1962) emphasized the difference between active and passive touch, stating that active touch involves *exploratory action*, which are the movements performed to explore certain qualities of the object in question, where passive touch involves *performatory action*, which are the movements performed when an object is being relocated or lifted. This distinction between different ways of touching has led the literature on haptic perception to improve significantly, where many studies were beginning to be conducted. Until recently, however, most of the studies have focused on the haptic perception of stiff materials such as wood, stone, glass, and alike (DiFranco et al. 1997; Avanzini and Crosato 2006), and included soft materials in studies for texture perception such as fabrics (e.g., velvet and cotton), and in some cases liquids (e.g., water and oils) (Picard et al., 2003; Soufflet, Calonnier, & Dacremont 2004; Tanaka, Tanaka, & Chonan, 2006; Guest et al., 2011).

However, the inclusion of soft materials was not in order to study softness on its own, but rather to be able to contrast the 'hard' materials with a single category.

When studying softness perception, softness has been considered as a single dimension and as an equivalent of compliance (Lederman & Klatzky, 1987; Drewing et al., 2017), and was defined as the degree of a material's deformability, meaning how likely a material is to change its form when applied pressure ranging from mild to harsh (Di Luca, 2014). One of the most extensive studies in textile material dimensions was conducted by Okamoto et al. (2013). In a review of 18 studies using a variety of materials including fabrics, papers, fluids, car seats, and hard materials, they reported five general dimensions for tactile texture perception: Hardness/Softness, Warmness, Fine Roughness, Macro Roughness, and Friction. Similarly, in a review of tactual perception of material properties, Tiest (2010) reported four categories based on the commonalities found in several studies: Roughness, Compliance, Coldness, and Slipperiness. Their distinction between categories again included the softness, but only as a contrast to hardness in a single category. However, this description remains too vague to include all the objects that are currently only identified in the 'soft' category. If we imagine running our fingers through sand, or squeezing a rubber ball, or stroking our hands over fur, we would experience all these materials as being soft. However, it is detectable when we explore these materials that there are certain characteristics that differentiate them from each other, e.g., the experience of touching sand is very different than touching a soft rabbit fur; and this can theoretically suggest the existence of subcategories under the general dimension of 'softness'.

This thesis explores the effects of language on softness perception of materials. It is therefore important to understand some central concepts. First, exploratory procedures will be introduced as they are used in the material videos in three of the experiments. Second, studying haptic perception with the use of visual materials will be discussed. Third, perception of sound generating materials will be discussed as it will relate to the other type of stimuli, onomatopoeic words, that is used in the experiments. And lastly, these should be considered within the domain of language

since language is an important factor in how we perceive the world around us. The concepts of sound-symbolism and the studies conducted using onomatopoeic words will therefore be subsequently discussed.

1.1. Perception of Materials

This section will focus on the perception of materials and specifically discuss the studies focusing on softness perception.

1.1.1. Exploratory Procedures (EPs)

An important term to explain here is what is called 'exploratory procedures' (EPs) in haptic perception literature. Exploratory procedures are the stereotyped hand movement patterns that have certain defining characteristics (Lederman & Klatzky, 1987). EPs are not defined by the area of the hand involved in the exploratory action, but rather the action itself. If we consider estimating the roughness of an object, regardless of using either palm or fingertips, a certain amount of pressure will be applied. There are several predefined EPs when it comes to studying material perception, these are useful in determining certain characteristics about the object such as their shape and weight. The main EPs that are detailly described by Lederman and Klatzky (1987) are lateral motion, pressure, static contact, unsupported holding, enclosure, contour following, function test, part motion test (Figure 1.1). However, this is not a comprehensive list of EPs that are used to explore objects, and the type of EP used changes based on which information is needed about the material. For instance, applying pressure could be used to determine how rough the object is, static contact provides information about the temperature of the object, unsupported holding could inform about the weight, and contour following provides information about the shape of the object. The EPs that are relevant when studying soft materials are applying pressure, rubbing, rotating, stirring, running through fingers (e.g., with sand), pulling, tapping, and stroking.

Recently, there have been studies conducted using EPs to study whether there are distinct softness categories that are more descriptive to be found within the materials generally classified only as 'soft'. Dövencioğlu et al. (2018, 2019, 2022) has shown that softness perception consists of multiple dimensions. Their study (Dövencioğlu et al., 2022) was conducted with 50 materials corresponding to 5 different categories (elastic, textile, deformable, granulate, and non-soft). They used a list of 31 adjectives that relate to softness and roughness aspects of touch, which was adapted to Turkish from a comprehensive haptic lexicon from Guest et al. (2011). The results showed the existence of five dimensions for material perception: Compliance, Viscosity, Surface Softness, Granularity, and Roughness (control). This was one of the first studies to identify such a distinction between the formerly known soft objects. One of the reasons for this is arguably the fact that their study included a wider range of materials which could be labeled as 'soft' but which differ from each other in certain aspects. Another interesting result for this study was related to EPs that the participants used when exploring the materials haptically. They were able to successfully predict the perceptual dimension a material likely belongs to using the EP patterns that were performed, suggesting that the EP patterns change based on the material properties as well as the task at hand.

In a subsequent study, Cavdan, Doerschner, & Drewing (2019) investigated how different perceptual dimensions of softness affect the haptic exploration procedures and found five dimensions as a result: Granularity, Furriness, Visco-Elasticity, Deformability and Roughness. Their results showed that participants tended to adapt their EPs both to the material being explored and to the softness dimension. They found when participants were asked to make judgements about a material's roughness, a common EP was rubbing; and when they were asked about material's deformability, applying pressure was the most frequently used EP. The results of these studies taken together provide support for the multidimensionality of softness, as opposed to the approach of previous studies.

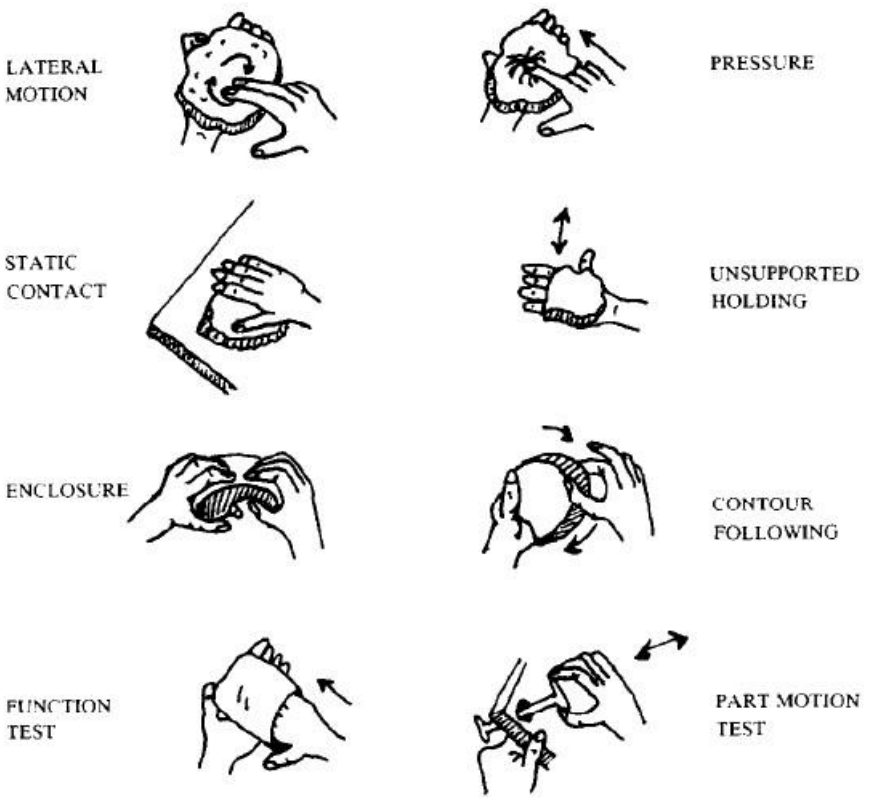


Figure 1.1. An illustration of exploratory procedures adapted from Lederman & Klatzky (1987).

1.1.2. Studying Haptic Perception with Visual Stimuli

Where some studies used visual stimuli to explore tactile perception dimensions (Dövencioğlu et al., 2019, 2022; Cavdan et al., 2019; Picada, 2006; Yoshida, 1968), Okamoto et al. (2013) examined whether there were particular differences between haptic and visual modalities for tactile texture perception. They found that the two modalities were similar on surface properties, with the exception of some distinct dimensions such as glossiness to exist only for visual perception, and such as temperature to exist only for tactile perception. Similarly, in a study conducted with the same set of 84 materials for both visual and haptic judgement, Baumgartner et al. (2013) showed that visual space was similar to haptic space for material perception. Therefore, it is common to use visual stimuli to study haptic perception,

and we could expect to see similar dimensions extracted through one modality to be observed in the other modality. Moreover, a study by Drewing (2009) found that vision alone was sufficient enough for participants to determine the softness of the stimuli being presented. In this study, they found that when participants watched another person's fingers exploring the object in front of them, they were able to infer the deformability of the object successfully.

When studying visual perception of materials, it is also important to select the stimuli in a way that would convey the most amount of information about the material to the perceiver. There are studies that use images to achieve this, however there has also been a discussion about whether videos would be more informative about material properties. Wijntjes et al. (2019) tackled this question by using fabrics as stimuli that were either visually perceived in the image or video form, or were tactilely explored. In the visual similarity task, they were unable to find a significant correspondence of the videos or images to haptic judgements. However, in an additional study, where a group of participants explored the material haptically and another group was tasked to observe this process and made evaluations about their haptic similarity, they found that the two groups were significantly different. They conclude that as much closer to reality the videos have, as much similarity to the haptic judgements can be observed. Cavdan et al. (2021) carried out a study where they investigated whether material properties would be assessed similarly in haptic and visual conditions, whether they would correspond to similar perceptual spaces. They had 19 materials to be explored either visually and haptically and collected ratings about material properties on adjectives. They also differentiated between two visual conditions: images and videos of materials. They reported three dimensions for the visual condition with images: surface softness/deformability, granularity, and viscosity. For the visual condition with videos, they reported four dimensions: surface softness, granularity, viscosity, and deformability. Finally, the haptic condition resulted with five dimensions, including the dimensions that were gathered for the video condition and an additional dimension of roughness. Conducting a correlation between these three modularities revealed that the haptic space was more similar to visual space with videos, suggesting they correspond to similar information with

regards to material properties. These studies taken together suggest the feasibility of using visual stimuli to study haptic perception, and that using material videos instead of material images could be more informative about the material properties.

1.1.3. Perception of Sound Generating Materials

Although the present study does not specifically focus on sound perception, it is important to introduce some key aspects of the area before discussing topics related to language. An important aspect of material perception has to do with perceiving sound generating objects. There are many studies in how we perceive the mechanical properties of sound-generating objects, as listeners are able to estimate the properties of everyday non-vocal, non-musical sound sources based solely on acoustic information (Vanderveer, 1979). Gaver (1993) outlined a taxonomy of everyday sound events and categorized the non-vocal sounds into three categories which depended on the state of matter of the sound generating material: (I) solid sound sources (e.g., knocking, clapping, tapping), (II) liquid sound sources (e.g., flowing water, (III) gaseous/aero-dynamic sound sources (wind blowing, explosions). Similar to haptic perception, the field of sound perception has been dominated with studies focusing on the sound perception of stiff solid materials, generally using impact sounds (e.g., objects being hit by a hammer). When studying material properties of stiff sounding objects, it was found that participant responses were influenced by both the sound decay and the frequency (Wildes and Richards, 1988). Overall, the studies on identifying the materials based on impact sounds reveal a nearly perfect distinction between gross categorical differences, e.g., identifying metal or glass (McAdams et al., 2004; McAdams et al., 2010). Moreover, when asked to determine the hardness/softness of the objects based on sounds, Giordano et al. (2010) found that listeners were able to estimate the hardness of sounding objects independently of the size of the objects.

There are also studies focusing on the auditory perception of deformable materials (textiles) and liquids. There is a lack of studies investigating the auditory perception of material properties of textiles, the existing studies focus on hand-feel of textiles

and the pleasantness ratings. Cho et al. (2005), by using frictional sounds of warp-knitted fabrics, found that measures of roughness were strongly correlated with the perceived pleasantness of sounds made by fabrics. For the studies conducted with liquids, Jansson (1993) found that participants were able to estimate the amount of liquid in a container in the haptic, auditory, and visual modalities. Additionally, Jansson (2006) used a trimodal setting with auditory-haptic-visual condition and found that participants were able to estimate the amount of liquid, especially in the condition where they were able to shake the container and not just lift it. Interestingly, in a study conducted by Velasco et al. (2014), they found that participants were able to identify whether the temperature of the poured water was hot or cold for each of the four containers (glass, plastic, ceramic, and paper). These studies together show that listeners are able to differentiate between material types, identify the roughness of stiff materials, give pleasantness ratings for textiles, and estimate the amount and temperature of liquids using the sound perception. The ability to identify all these material properties based on sounds relates to this study as we will further introduce the onomatopoeic words, which are words representing the sound that an object makes.

1.2. Sound-Symbolism

Since the materials and the methods that were used in this thesis involve linguistic components, which are later linked to the haptic perception of various objects, understanding the literature on sound symbolism is of utmost importance. For example; a review by Lupyan et al. (2020) on the effects of language on visual perception found that language has incremental effect on recognition, discrimination, and detection of objects, colors, and other visual stimuli we encounter daily. A related area of research includes the studies with sound symbolism. Sound symbolism refers to the concept that phonetic properties of speech sounds carry semantic information (Hinton, Nichols, & Ohala, 2006). Within the framework of linguistics, sound symbolism has been studied with phonemes, and results show that vowels and consonants such as /i/ and /k/ with higher frequency relate to small and sharp referents, whereas vowels and consonant such as /u/ and /b/ with lower frequency

relate to large and heavy referents (Hinton et al., 1994). There are many studies for the perception of material properties within the context of sound-shape or sound-size associations. Literature shows that higher frequency sounds are generally associated with angular shapes and lower frequency sounds with round shapes (Klatzky et al., 2000; Avanzini and Rocchesso, 2001; Giordano and McAdams, 2006).

There are a number of studies on sound-symbolism, which start with the early work of Sapir (1929) and Köhler (1929). Sapir conducted a study where 500 participants tested across multiple experiments associated pseudowords containing the vowel 'a' (as in 'mal') with larger shapes and pseudowords containing the vowel 'i' (as in 'mil') with smaller objects. This result was replicated in a later study conducted by Tarte and Barritt (1971). Köhler conducted a similar study where the pseudoword 'maluma' was associated with round shapes, and 'takete' was associated with angular shapes. Later, the same idea found its name as the 'Bouba/Kiki Effect', deriving from the study of Ramachandran and Hubbard (2001). In their experiment, they used two shapes; a round shape and a spiky shape, to be associated with the pseudowords 'bouba' or 'kiki'. Their result showed that participants more often than not associated the pseudoword 'bouba' with round shapes and 'kiki' with spiky shapes. Their results have been demonstrated with other studies across cultures and with different stimuli used for words and/or shapes (Westbury, 2005; Parise & Spence, 2012), and the overall results suggest this effect to be universal.

One study conducted with 25 languages to test the bouba/kiki effect showed this effect to be robust across cultures and different writing systems, however failed to report a significant effect within the speakers of Turkish language (Ćwiek et al., 2021). Their results show that Romanian, Mandarin Chinese, and Turkish speakers had lower than %50 matches for the expected matching of pseudoword bouba with round shapes and the pseudoword kiki with spiky shapes. The authors provide possible reasons for this, suggesting it might be due to a lack of specific phonemes in these languages. In the case of Romanian, they argue that these pseudowords might have stronger associations for sound-alike words. Specifically, the word for 'wound' in Romanian is buba, possibly having a strong existing association with sharp

pain. Nevertheless, although the effect needs more evidence for specific languages, it remains as robust across multiple languages. Furthermore, a study by Ozturk, Krehm, and Vouloumanos (2013) demonstrated the said effect with 4-month-old infants, where they were able to distinguish between congruent and incongruent sound-shape mappings. Their results further show that neither vowels nor consonants alone were sufficient enough for the mappings for 4-month-old infants, whereas either vowels or consonants alone sufficed for the adult sample. Their results suggest that sound-shape associations may precede language learning, and might also be helpful in assisting with language learning by the existence of an already established sound-shape mappings.

Establishing the universality of the effect was a great turning point for the studies in sound-symbolism, however it is still important to understand how this effect occurs. There have been controversial arguments on whether this effect is observable only on an explicit decisional level, questioning whether it arises as a result of a decision-making process or whether the effect can be found in a lower perceptual level. Pieffer-Smadja & Cohen (2019) were able to demonstrate the said effect with an Implicit Association Task (IAT), where participants are asked to make quick judgements about the presented stimuli, suggesting the effect occurs on a perceptual level rather than a decisional level. This distinction is important, if the effect occurs on a perceptual level, then it might indicate further support for the idea of sound-symbolism and the phonetic properties of speech sounds carrying information about how we perceive the world around us.

The discussion between whether this effect is resulted by the phonetic properties of speech sounds or the visual characteristics of letters has led researchers to study this in greater depth. There are strong arguments for both these views. Cuskley, Simner, and Kirby (2015) studied effects of sound symbolism with both written and spoken pseudowords and reported the effect for both modalities to be significant. One explanation for this is that hearing a pseudoword automatically activates the mental representations of its written form, therefore relying more on the visual characteristics of the letters. However, there are also arguments on the contrary. It

is argued that curvy letters such as /d/, /g/, /s/ and /f/ may be associated with round shapes as their similarities with the voiced plosives and voiceless fricatives. On the other hand, angular letters such as /k/, /t/ and /z/ might be associated with angular shapes as their similarities to voiceless plosives and voiced fricatives. These suggest that these associations are a reflection of an intrinsic phonetic properties of the corresponding sounds. Aiming to identify the differences between these modalities, Carolis et al. (2018) conducted a study comparing phonetic forms, visual shapes, and the letter fonts within the Bouba/Kiki paradigm. Their results showed that when spiky frames and angular fonts were displayed together, the participant responses were faster, suggesting the influence of visual interaction effects. In another study, Graven & Desebrock (2019) investigated the effects of visual imagery on Bouba/Kiki effect. In their experiment they presented the words in the auditory modality, and asked participants to match with the corresponding images with blind, blindfold, and visual conditions. Their results suggested that all experimental groups created mental images of the most characteristic shape features of bouba and kiki. This study is also an example for using auditory words to collect visual related judgements.

The majority of the studies investigating this focused on the visual modality in term of material perception, and there is very little research on the associations between tactile and other sensory stimuli. A recent example for such studies is by Fryer et al. (2014). In their study, they successfully demonstrated the Bouba/Kiki effect in haptic and auditory modalities, where participants associated the name 'Bouba' with rounded shapes and 'Kiki' with spiky shapes after they were asked to touch the objects. Moreover, Etzi et al. (2016) studied the relationship between pseudowords and the tactile attributes of everyday materials. Their results showed that participants matched the words 'Kiki', 'Ruki' and 'Takete' with materials that were rated rougher (i.e., sandpaper, abrasive sponge), compared to smoother materials (i.e., satin, cotton, tinfoil) which were matched with 'Bouba' and 'Lula'.

The studies mentioned so far have studied the Bouba/Kiki effect using pseudowords that do not have any specified meaning. These studies could be summarized as letters such as /b/ and /o/ are often associated with round shapes, and letters as /k/ and

/t/ are often associated with angular shapes. However, this is not the extent of the studies in the subject of sound-symbolism. A great portion of the studies in this area use onomatopoeic words, which unlike other words in languages, are non-arbitrary words.

1.2.1. Onomatopoeic Words

Languages are considered to be arbitrary, which means that the meanings associated to the words in language systems derive from cultural conventions. Most words do not facilitate any semantic meaning by solely examining their form. However, there is a specific exception to the arbitrariness of language: a subset of words that display iconic characteristics. These words are referred to as 'onomatopoeias', which are the words that mimic the sound they describe (e.g., bang, oink, chirp in English, and şırıl, patır, çatır in Turkish). These words are formed with direct iconic associations with the sounds the meaning of the words refer to. For example; 'şırıl şırıl' means 'water flowing continuously and by noisily' in Turkish, and the word is formed by the reflection of the actual sound of a water flow.

The concept of sound-symbolism has been studied in many different frameworks, and an important and a relevant one here is the early language learning. To test whether sound symbolism hypothesis extends to onomatopoeia, a study by Laing (2017) investigated the effects of sound symbolism on early language learning with the use of non-arbitrary words that are onomatopoeias with 10-month-old infants. Their result showed that on a picture-mapping task, infants were better able to match the target images to their labels in the onomatopoeic word condition as compared to in the conventional word condition. This result reveals the influences of sound-symbolism in language learning, as was previously seen with studies using pseudowords.

In order to understand the extent of sound-symbolism to our perception of materials, there have been a number of studies investigating the relationship between onomatopoeic words and material perception properties. A considerable portion of

these studies are within the Japanese language, since Japanese has the highest number of onomatopoeic words as compared to other languages (a dictionary by Yamaguchi (2015) lists 2000 Japanese onomatopoeias). Doizaki, Watanabe and Sakamoto (2017) conducted a study to propose a system to automatically estimate multidimensional ratings of touch from a Japanese sound-symbolic word. Three experiments they conducted show that several material ratings can be estimated using sound-symbolic words. Later on, Sakamoto and Watanabe (2017) conducted a study using materials associated with Japanese onomatopoeia to study tactile perception dimensions. They collected a list of sound-symbolic onomatopoeia, and selected the materials to be included in the study based on these onomatopoeic words. Using 26 adjective pairings with the semantic differentiation method, where the adjectives on either side of the scale are exact opposites, they collected ratings while participants could actively run their fingers on the surface of the materials that were presented in a closed box. Their results show six dimensions: Affective evaluation and Friction, Compliance, Surface, Volume, Temperature, and Naturalness.

Hanada (2016) used Japanese onomatopoeias to explore perceptual dimensions of visual material properties by using the free-calling method, where participants were asked to name an onomatopoeia that they feel is suitable to describe the material that is presented to them, and obtained three meaningful perceptual dimensions: wetness/stickiness, fluffiness/softness, and smoothness-roughness/gloss-dullness. Their dimensions include three of the main five that was described by Okamoto (2013) earlier in this chapter. Furthermore, Hanada (2019) used the same free-calling method for studying food/texture dimensions and obtained 15 meaningful dimensions. Wakamatsu et al. (2017) investigated the texture-sound symbolism with 1,946 material images where participants depicted their impression with onomatopoeias and found a correlation between certain textures and IPA (International Phonetic Alphabet) formations of onomatopoeias. To test the universality of the effect, they conducted another experiment with Japanese, Korean, and English participants, where they had to judge texture-sound pairings. Their results provided examples for a universal texture-sound symbolism for word and

sound pairs. In a study investigating the recognition mechanism of a certain Japanese onomatopoeia (sara-sara) related to cosmetic powders showed that sara-sara was strongly correlated with a slippery feel of a material (Kato et al., 2021).

Although the studies that focus on the effects of onomatopoeia in material perception are important, a significant part of this area is to understand how this effect occurs. Since onomatopoeic words are sound-symbolic words, a number of studies have tackled this by focusing on the phonetic properties of the words and by understanding how they play a role. A study by Fujisawa, Iwamiya & Takada (2004) researched the auditory imageries that were associated with Japanese onomatopoeic words that were presented auditorily. Using the semantic differential method, they asked the participants to rate the expressions of auditory imagery evoked by the typical and non-typical onomatopoeic words. The distinction between typical and non-typical onomatopoeic words were that typical onomatopoeic words followed certain phonological and morphological rules, where the non-typical words did not. They conducted a principal component analysis on the collected ratings and ended up with three components: beauty, potency, and sharpness. However, a more interesting result of this study was the relationship between phonetic properties of the onomatopoeic words and the gathered components. Using rank order correlation coefficients and calculating the correlations between phonetic parameters of language and the principal component scores of typical and non-typical onomatopoeic words, they found that onomatopoeic words with voiced consonants were more likely associated with a 'dirty' impression. Similar to the research on sound-symbolism, they reported that onomatopoeic words that included the vowel /i/ were associated with a 'sharp' impression, and words that included the vowel /u/ or /o/ were associated with a 'dull' impression. This result provides further support for sound-symbolism by using onomatopoeias as the stimuli.

The literature in sound-symbolism yields very important results in terms of aiding our understanding of multisensory material perception. However, the majority of these studies do not create a distinction between material types, and/or use the hardness/softness contrast as mentioned before. Therefore, it is a promising area of

research to understand how these phenomena explain the perception of soft materials specifically.

As the written language and spoken language have clear distinctions from one another, one being a visual modality and the other an auditory modality, it is therefore important to understand the similarities and dissimilarities of the two modalities in terms of material perception. Previous research on sound-symbolism mentioned above use both these forms of words. Exploring the effects of language, and specifically of onomatopoeic words, on perception of soft materials is crucial and will cover a significant gap in existing literature.

Finally, a phonetic analysis will be carried out on the onomatopoeic words as part of the thesis; therefore, it is crucial to briefly discuss the linguistic properties of Turkish phonemes. A phoneme refers to the smallest class of sound in any language. For Turkish, each individual letter constitutes a phoneme. Turkish alphabet consists of 29 letters, and there are 8 vowels in it: /a/, /e/, /ı/, /i/, /o/, /ö/, /u/, and /u/. The remaining 21 letters are consonants and they can be classified into separate categories with criteria based on phonetic properties of these phonemes. There are 3 common categories that will be discussed here: 1) the positioning of the vocal cords; 2) place of articulation; and 3) manners of articulation (Dursunoğlu, 2017).

For their positioning of the vocal cords, the consonants have been separated into two categories as i) hard (voiceless) consonants, and ii) soft (voiced) consonants. Voiceless consonants are: /ç/f/h/k/p/s/ş/t/. Voiced consonants are: /b/c/d/g/ğ/j/l/m/n/r/v/y/z/. For the place of articulation, there are seven subcategories: labial, labio-dental, post-alveolar, alveo-palatal, prevelar, velar, glottal. And finally, for the manners of articulation, there are two subcategories: continuous and discontinuous (plosive). Continuous consonants are further divided into two categories as fluid and fricative.

Taken together, there are 20 parameters in Turkish to be considered when moving forward with a phonological analysis. These are: 8 vowels, 2 positioning of vocal cords, 7 places of articulation, and 3 manners of articulation.

1.3. Aim and Hypothesis

There are no studies to date that examine the effect of Turkish onomatopoeic words on tactile material perception of softness. The onomatopoeic words constitute a valuable portion of the Turkish language, similar to the Japanese language (Zulfikar, 1995). This similarity in terms of the frequency of the use of such words presents a promising gap for an initial study on the effect of language on haptic perception. Hence, it is plausible to suggest similar associations between sound-symbolic words and the tactile perceptual space. Another ground on which the current study has been proposed is the opportunity to use a previously formed adjective list that was originally designed to study clusters within soft materials. This allowed the combination of a previously defined set of words and perceived softness to be systematically studied. This adjective list was adapted to Turkish by Dövencioğlu et al. (2019 & 2022) from Guest et al. (2011)'s comprehensive list of 262 touch-related adjectives. The adjectives were first eliminated based on being emotional and non-sensual, and then the adjectives that were too similar to each other were eliminated. The resulting list consisted of 31 adjectives that were specific to studying softness and roughness aspects of touch. Therefore, this adjective list is highly suitable when studying clusters of dimensions within soft materials.

In this study, the relationship between Turkish onomatopoeic words and materials were investigated in terms of their correspondent pairing in five experiments. The research question that the thesis aims to answer is whether there is an effect of language, specifically onomatopoeic words, on the perceived softness of materials. The two main hypotheses regarding the set of experiments were as follows: (1) Onomatopoeic words will display a similar softness dimension distribution to that observed with materials. (2) Onomatopoeic words will have an effect on material

softness perception. The studies will incorporate onomatopoeic words in two different forms: Written (Study 1, Experiment 1, and Experiment 3) and spoken (Study 3 and Experiment 2). The hypotheses were investigated using both the written and the spoken forms of onomatopoeic words.

In line with the previous research, the following results are hypothesized: First, the dimensions collected from using the onomatopoeic words in Study 1 and Study 3 will be similar to that of previously obtained softness dimensions. This hypothesis is based on the works of Hanada (2016), who reported three distinct dimensions using Japanese onomatopoeic words, that were: wetness/stickiness, fluffiness/softness, and smoothness-roughness/gloss-dullness. The same logic applies to the current study in that similar dimensions are hypothesized to be obtained for the Turkish onomatopoeic words. Study 1 (with written onomatopoeic words) and Study 3 (with spoken onomatopoeic words) will serve to test this hypothesis. Second, in line with the previous studies within haptic perception (Dövencioğlu et al., 2018, 2019, 2022; Cavdan et al., 2019), the number of dimensions gathered from using material videos in Study 2 are expected to be at least five, which are as follows: Deformability, Viscosity, Hairiness, Granularity, Roughness (control). Study 2 will be conducted to test this hypothesis. Study 1, 2, and 3 are critical in order to conduct the experiments 1,2 and 3 and to test the second hypothesis. These studies will be evaluated on their own, and the results gathered from these studies will create the basis and the manipulation conditions for the experiments. Third, regarding the second hypothesis, the onomatopoeic words and materials are hypothesized to be matched on the basis of congruency. Here, congruency refers to having received similar scores within the same softness dimension, whereas incongruency refers to having received opposite scores (e.g., an onomatopoeic word that receives a high score matched with a material that receives a low score within the same softness dimension). It is further hypothesized that the congruent condition will receive higher scores for the respective adjectives, and that the incongruent condition will receive lower scores for the respective adjectives. The confirmation of these hypotheses will provide support for the idea that onomatopoeic words have an effect on perceived softness of materials. Contrarily, the lack of a significant relation between onomatopoeic words

and materials will suggest that the two processes are independent of each other, and that their contribution to softness perception occurs in different ways. Experiment 1, 2, and 3 will be conducted to test this hypothesis. All studies in this thesis are approved by the METU Human Subjects Ethics Committee (Appendix A).

CHAPTER 2

EFFECTS OF WRITTEN ONOMATOPOEIC WORDS ON PERCEIVED SOFTNESS

This chapter will focus on the experiments using written onomatopoeic words, where Chapter 3 contains a relevant study done with spoken onomatopoeic words. First in Study 1 and 2, softness dimensions for written Turkish onomatopoeic words and material videos as stimuli, respectively, were extracted from the ratings of softness related adjectives. Then, Experiment 1 was conducted to investigate whether written onomatopoeic words have an effect on how material softness is perceived.

Study 1 and Study 2, as well as Experiment 1 were originally designed to be conducted in a laboratory environment. However, due to the timeline coinciding with the global COVID-19 pandemic, the experiments were adapted to be conducted online on Qualtrics, which is a widely used software for behavioral experiments.

For Study 1, it is hypothesized that onomatopoeic words will display a similar softness dimension distribution to that previously observed with materials. Meaning, softness dimensions that relate to a material's stickiness, softness/fluffiness, and smoothness/roughness, as reported by Hanada (2016), is expected to be extracted using the Principal Component Analysis.

For Study 2, it is hypothesized that the softness dimensions will be at least five, and they will be similar to those previously reported (Dövencioğlu et al., 2019; 2022; Cavdan et al., 2019). In line with the findings of these studies, it is expected to extract the following dimensions from the Principal Component Analysis: Deformability, viscosity, granularity, surface softness, and roughness.

For Experiment 1, it is hypothesized that the onomatopoeic words will have an effect on the perceived softness of materials. To test this hypothesis, the results of Study 1 and Study 2 will be used, and stimuli will be selected according to obtained softness dimensions. Experiment 1 will use both the written onomatopoeic words and the material videos, where the two will be matched to be either in a congruent condition (both high or low rated), a control condition (both rated in mid-levels), or in an incongruent condition (one rated high while the other is low). ANOVA will be used to test the collected data, where a significant interaction between onomatopoeic words and materials will constitute the "congruency" that is explained, and this result will be in support of our hypothesis.

2.1. Study 1: Softness Dimensions from Written Onomatopoeic Words

In this experiment we wanted to extract softness dimensions from written onomatopoeic words, using 47 Turkish onomatopoeic words and 31 material-related adjectives.

2.1.1. Method

2.1.1.1. Participants

Participants were recruited through SONA, the research participation system of Middle East Technical University. Participants gave consent to participate by signing the informed consent form (Appendix B) and received course credits for participating.

59 participants were recruited for this experiment. 12 of those did not complete the experiment in time, and their partial data were removed from the analysis. From the remaining 47, 8 responses were removed from the analysis based on the duration it took for them to complete the experiment. The duration to complete the experiment was estimated to be around 60 minutes prior to data collection. The average time to complete the experiment, with the 47 participants, was 3.05 hours. The eight

removed participants had the completion times of 53.89 hours, 13.82 hours, 3.36 hours, 3.46 hours, 10.45 hours, 0.3 hours, 2.64 hours, and 5.31 hours respectively. When these responses were removed, the average time to complete the experiment was 1.28 hours, which is close to our estimation based on the number of stimuli. The seven of these responses were removed as they completed the experiment in a long amount of time, suggesting they did not follow the instruction to complete the experiment in a single session. Since the study is conducted online, there is no real way of measuring participants' attention to the stimuli. Taking an unsolicited break between trials might suggest the use of distractors in between the sessions, which renders these responses unreliable. On the contrary, one of these responses was removed because the time to complete the experiment was too short, suggesting the participant might not have given their entire attention to the onomatopoeic words and adjectives that were displayed on screen. Resulting number of participants is 39 (6 Male, M = 21.1, SD = 1.44), all but one was students at Middle East Technical University, and all were native Turkish speakers.

2.1.1.2. Stimuli

2.1.1.2.1. Onomatopoeic Words

There is not a single depository to search for all the onomatopoeic words in Turkish language. Hence, the onomatopoeic words were collected through a literature search of Turkish linguistics books and reviews (Zulfikar, 1995; Özkan, 2010). The resulting list of words was 51. After we gathered a suitable list of onomatopoeic words, each word was checked for their meaning in Turkish in the official Turkish Language Society (TDK) dictionary, and only words with a meaning related to materials that we had in the laboratory were included as experimental stimuli, along with a few words not related to materials being included for control. Then, each word was checked for frequency in TS Corpus, the largest Turkish corpora available (Sezer & Sezer, 2013; Sezer, 2016; Sezer, 2017). This statistic provided the commonality information for the onomatopoeic words. The words that resulted in a frequency of 0 were excluded from the study as for not being common in the language, and for being a potentially

Table 2.1

List of 47 onomatopoeic words used in the study

Onomatopoeic Word (TR)	**Meaning in English**
cart curt	Brag, throw one's mouth off
çat pat	Pop, a little
çatır çatır	The sound of breaking, burning, ripping or squeezing a hard thing crackle
çıt çıt	Snap fastener, gripper
efil efil	Gently, intermittently and slowly (blowing wind, snowing, hair waving)
fıkır fıkır	With a gagging sound
fısır fısır	Whisper about someone or something, murmur
fokur fokur	Bubbling noisily, boiling up
gacır gucur	Squeak, making an ugly and scratchy sound
gıcır gıcır	Crips, brand new
gurul gurul	Rumbling sound
güm güm	With repeated booms
gürül gürül	In a loud, rich voice, with a gurgling sound
haşır huşur	Hard and dry things wring, wheezing, rumbling
hışır hışır	With a rustling sound
horul horul	Sound of loud snoring
kıkır kıkır	Gigglingly
kıpır kıpır	Wriggly, humming, restless, fidgety
kıtır kıtır	Crispy, brittle, crusty
kös kös	Head ahead, in a tired, sad, thoughtful state without looking left or right, pensively
küt küt	With several knocks, thuddingly
kütür kütür	Crisp, fresh, with a crunching sound
lıkır lıkır	With a gurgling sound
lime lime	In small pieces, rags and tatters
lüp lüp	A voice describing the sudden swallowing of something large, gulping
mırıl mırıl	Murmuring
mışıl mışıl	Sleeping peacefully and soundly, with a quiet and deep breath
paldır küldür	Making a rough noise, pell-mell, hasty, herky-jerky
patır patır	By making a strong, loud sound, pitter-patter
pıtır pıtır	With a patter
sapır sapır	In great quantities and continuously
şakır şakır	Pouring, pelting, rattling
şakır şukur	By making a lot of clattery noise
şap şap	Kissing with a screed sound, alum alum
şapur şupur	The sound of "smack-whisk" when kissing or eating
şarıl şarıl	Flowing splashingly, with a splashing sound
şıp şıp	Making a 'flashing' sound, plop
şırıl şırıl	Continuous and loud flowing of water with a pleasant noise
tak tak	The sound that is made during hitting, impact, rat-tat
tangır tungur	Crash bang wallop, bone-shaking, clack
tıkır tıkır	At a rattling pace, tickety-boo
tın tın	Rattlebrained, timbre
tiril tiril	Crisp and clean, gauzy, floaty
vıcık vıcık	Ropy, sludgy, gooey, slushy
zangır zangır	Rattling, trembling
zır zır	Making a weary and continuous sound, knick-knack
zırıl zırıl	Shrieking

unfamiliar word for participants. The words that resulted with a frequency score of 0 and therefore removed from the list were as follows: 'hatır hutur', 'lömbür lömbür', 'tıngır tıngır', 'vın vın', resulting in *a* remaining list consisting of 47 onomatopoeic words.

Table 2.1 shows the complete list of onomatopoeic words used in the study, along with their translations in English. Some of the Turkish onomatopoeic words have English sound-symbolic counterparts (e.g., 'murmur' for 'fısır fısır') however the majority of the onomatopoeic words in the list do not. For this reason, most of the words are explained with their meaning.

2.1.1.2.2. Adjective List

The adjectives used in this study were gathered from a previous study (Dövencioğlu et al., 2019; 2022) that studied the haptic perception of soft materials. The list included 31 adjectives in Turkish that relate to a material's softness/hardness and was specifically adapted to study softness perception. Two of the adjectives on the list have been modified due to them being onomatopoeic words, which were included in the study as main stimuli. The first modified adjective was originally 'tiril tiril' (airy) and modified into 'havadar'. The second adjective was 'vıcık vıcık' (gooey) and was modified into 'cıvık'. The modifications were made so that the adjectives would not lose their meaning in Turkish. The complete list of adjectives and their translations to English can be seen in Table 2.2.

2.1.1.3. Design and Procedure

The experiment included 47 onomatopoeic words and 31 adjectives, resulting in 1457 trials for each participant. The online research platform Qualtrics was used to collect participant responses. The experiment used a block design, where the adjectives were presented to the participants in a single list, allowing them to see all the adjectives for the respective onomatopoeic word. Instructions were added in the beginning for participants to complete the entire experiment in a single session. The

Table 2.2

List of 31 adjectives with their meanings in English

	Adjective (TR)	**Adjective (ENG)**		**Adjective (TR)**	**Adjective (ENG)**
1	*biçimlenebilir*	malleable	17	*nemli*	moisturous
2	*derimsi*	leathery	18	*odunsu*	woody
3	*dokulu*	textured	19	*parlak*	glossy
4	*esnek*	flexible	20	*pul pul*	scaly
5	*esnemez*	inflexible	21	*pürüzlü*	roughened
6	*et gibi*	meaty	22	*sert*	hard/firm
7	*güç uygulanabilir*	compliant	23	*sümüksü*	slimy
8	*hamursu*	doughy	24	*süngerimsi*	spongy
9	*hassas*	delicate	25	*tanecikli*	granular
10	*ipeksi*	silky	26	*havadar*	airy
11	*jölemsi*	gelatinous	27	*toz gibi*	powdery
12	*kabarık*	fluffy	28	*tüylü*	hairy
13	*kabuklu*	scabby	29	*cıvık*	gooey/sludgy
14	*kadifemsi*	velvety	30	*yapışkan*	sticky
15	*kaygan*	slippery	31	*yumuşak*	soft
16	*kum gibi*	sandy			

onomatopoeic word without completing all adjective ratings for the current onomatopoeic word. The order of the onomatopoeic words was randomized for each participant. Moreover, the order of adjectives for each onomatopoeic word was also randomized. This was included as a measure of ensuring the participant responses do not become automatic over time, and each adjective is read before a rating is given. Participants were asked to rate each adjective based on how well they think the match is between the adjective and the onomatopoeic word on a 0 (not at all) to 100 (very) scale. Entire experiment session lasted around 60 minutes.

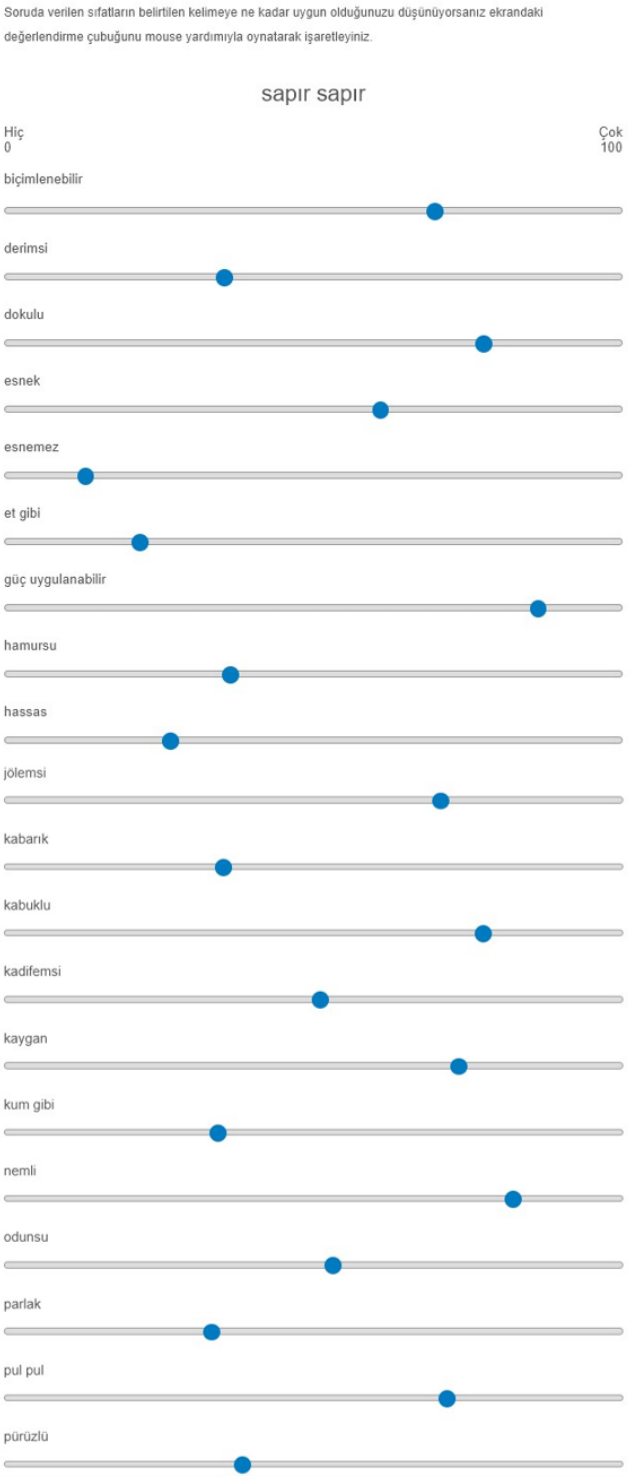


Figure 2.1 Sample screenshot from Study 1 as was on Qualtrics.

2.1.2. Results

2.1.2.1. Principal Component Analysis (PCA)

The experiment data was analyzed using the JAMOVI software (R Core Team 2018; The jamovi project, 2019) and JASP (JASP Team, 2022). The Principal Component Analysis (PCA) was chosen to analyze this data. PCA is a technique that is commonly used for dimensionality reduction (Abdi & Williams, 2010). It aims to create dimensions that maximize interpretability and minimize possible information loss. This study initially had 31 dimensions (corresponding to the 31 adjectives) that were used to explain the data at hand. PCA was selected as the analysis method for this study to see whether the same data could be explained with a reduced number of dimensions, ones that are clusters of adjectives forming distinct dimensions that explain a certain characteristic of softness. Instead of 31 dimensions, it was expected to see the five dimensions reported in the literature (Dövencioğlu et al., 2019; 2022): viscosity, deformability, surface softness, granularity, and roughness (control).

PCA achieves this by first standardizing the data. This step is to ensure that all scales contribute equally to the analysis. This is achieved by subtracting the mean and dividing by the standard deviation for each value in each variable. Then a covariance matrix is computed in order to identify any correlations between variables of the data. Then, eigenvectors and eigenvalues of the covariance matrix are computed to identify the principal component. From a mathematical view, principal components are the ones that represent the direction of data that explain the maximum amount of variance. In other words, these are the lines that would capture the most of the information. Once the first principal component is established, the second principal component is calculated in a similar manner, assuming it remains uncorrelated with the first principal component and represents the next highest variance. The data has the same number of eigenvalues and eigenvectors to that of initial variables (or dimensions; here it is 31) in the data. Eigenvectors are the directions of the axis that carry the most information, and eigenvalues are the coefficients that explain the amount of variance that is carried by each eigenvector. In order to obtain principal

components, eigenvalues are ranked from highest to lowest to get the principal components in the order of significance. The next step is to decide which principal components are important and which ones can be discarded. There are different approaches to this based on the goals of particular studies, however, for Study 1, the criteria selected for PCA was eigenvalue = 1. Meaning, any dimension that resulted in an eigenvalue of less than 1 was discarded, and the remaining dimensions were the principal components.

In total, 1457 ratings were collected from each participant (47 onomatopoeic words x 31 adjectives). To check the suitability of items in the data for PCA, there are several steps that need to be checked. First, Cronbach's alpha levels were calculated for each adjective in order to check for internal consistency. Of the total 31 adjectives, 18 yielded a Cronbach's alpha value over .90, which is considered "excellent", and 13 yielded a value over .80, which is "good" (Gliem & Gliem, 2003). This shows that onomatopoeic words as items had relatively high internal consistency as a group (see Table 2.3 for the complete list of Cronbach alpha levels), and that all the items could be included in PCA.

To move forward with the analysis, the responses were averaged over participants and calculated separately for each adjective and onomatopoeic word. This step is necessary as the PCA requires data to be averaged in order to make the calculations. The resulting data consisted of 47 rows (onomatopoeic words) and 31 columns (adjectives). The averaged responses were entered into PCA. The suitability of the data for PCA was checked using Bartlett's test of sphericity and Keiser-Meyer-Olkin (KMO) criterion. The KMO measure of sampling adequacy yielded a score of .658 which is above the required criteria of .5 for PCA. Bartlett's test of sphericity yielded a significant result, x^2 (465) = 2070,27, p = .000, which suggests that observed correlations are meaningful. Principal components were extracted using Kaiser normalization and varimax rotation. Seven principal components were extracted from the analysis, explaining 88.06% of total variance in the data (Figure 2.3).

Table 2.3

Cronbach alpha values for adjectives used in Study 1

Adjective	**Cronbach Alpha**	**Adjective**	**Cronbach Alpha**	**Adjective**	**Cronbach Alpha**
airy	0.928	hard	0.923	silky	0.879
compliant	0.949	inflexible	0.949	slimy	0.853
delicate	0.923	leathery	0.900	slippery	0.903
doughy	0.877	malleable	0.952	soft	0.892
flexible	0.940	meaty	0.890	spongy	0.916
fluffy	0.899	moisturous	0.911	sticky	0.880
gelatinous	0.907	powdery	0.867	textured	0.954
glossy	0.936	roughened	0.881	velvety	0.910
gooey	0.839	sandy	0.918	woody	0.900
granular	0.895	scabby	0.885		
hairy	0.843	scaly	0.904		

Table 2.4 shows the rotated factor loadings of each adjective in the seven-factor solution. Factor 1 explained 23.01% of variance. Adjectives gelatinous, slimy, sticky, doughy, gooey, soft, elastic and slippery loaded in this factor. This factor was labeled 'Viscosity'. Factor 2 explained 19.2% of variance. Adjectives scabby, compliant, woody, inflexible, hard and roughened were loaded in this factor. The second factor was therefore labeled 'Roughness'. Factor 3 explained 14.51% of variance. Adjectives that loaded on this factor were velvety, silky, hairy, and delicate. This factor seemed to be related to the texture of a material and was labeled 'Surface Softness'. Factor4 explained 10.47% of variance. Adjectives sandy, granular, scaly, and powdery were loaded on this factor. This factor was labeled 'Granularity'. Factor 5 explained 9.45% of variance. Adjectives leathery, meaty, textured, and malleable were loaded on this factor. This factor was labeled 'Texture'. Factor 6 explained 6.45% of the variance. Adjectives slippery, moisturous and glossy loaded in this factor. This factor was labeled 'Glossiness'. Finally Factor 7 explained 4.97% of the variance. This factor was labeled 'Fluffiness' as adjectives fluffy and airy were loaded in this factor. Figure 2.3 shows the percentage explained variance for 7 factors.

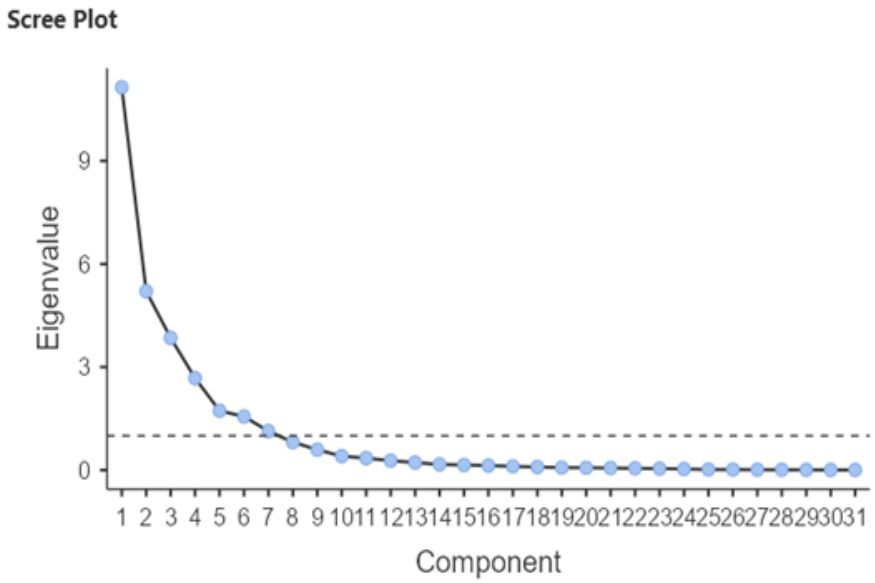


Figure 2.2 Scree plot for PCA of adjectives for Study 1. The x-axis shows all components that could possibly be extracted from the design (31). The y-axis shows the eigenvalues for the components. The dotted line is for eigenvalue = 1, which was the criterion used to extract components.

The adjective ratings of the onomatopoeic words were in correlation with the meanings of the words. For instance, the adjective moisturous had the highest ratings on words 'vıcık vıcık' (very loose, softened, watery consistency), 'şarıl şarıl' (water or rain, abundantly and loudly flowing, falling), 'şırıl şırıl' (water, continuous and loud flowing). Similarly, the adjective woody had high ratings on 'tak tak' (the sound that is made during hitting, impact), 'çatır çatır' (the sound of breaking, burning, ripping or squeezing a hard thing crackles), and 'küt küt' (by making a 'thud' sound over and over) (Appendix C).

Table 2.4

Component Loadings from PCA for Study 1

	Component							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Uniqueness**
gelatinous	0.947							0.0574
slimy	0.942							0.0554
sticky	0.911							0.1262
doughy	0.901				0.333			0.0282
gooey	0.898							0.0277
soft	0.660	-0.322	0.570					0.0735
flexible	0.631	-0.362	0.438					0.0954
slippery	0.625	-0.397				0.614		0.0469
spongy	0.588	-0.331	0.456		0.378			0.1558
moisturous	0.552	-0.469				0.438		0.1481
scabby		0.887						0.0506
compliant		0.877			0.389			0.0582
woody		0.852						0.0668
inflexible	-0.338	0.841	-0.326					0.0472
hard	-0.351	0.834	-0.304					0.0592
roughened		0.767		0.388				0.1197
velvety			0.881					0.0858
silky			0.865					0.0534
hairy			0.792					0.2448
delicate			0.781					0.2935
sandy				0.929				0.0902
granular				0.880				0.1508
scaly				0.860				0.1660
powdery			0.392	0.642				0.2846
leathery					0.872			0.1301
meaty	0.370				0.759			0.2232
textured		0.545			0.642			0.0927
malleable	0.427	0.372			0.605			0.1950
glossy						0.893		0.1172
fluffy							0.860	0.2246
airy			0.556				0.582	0.1366

Note. 'varimax' rotation was used. Loadings below 0.3 were hidden from the table.

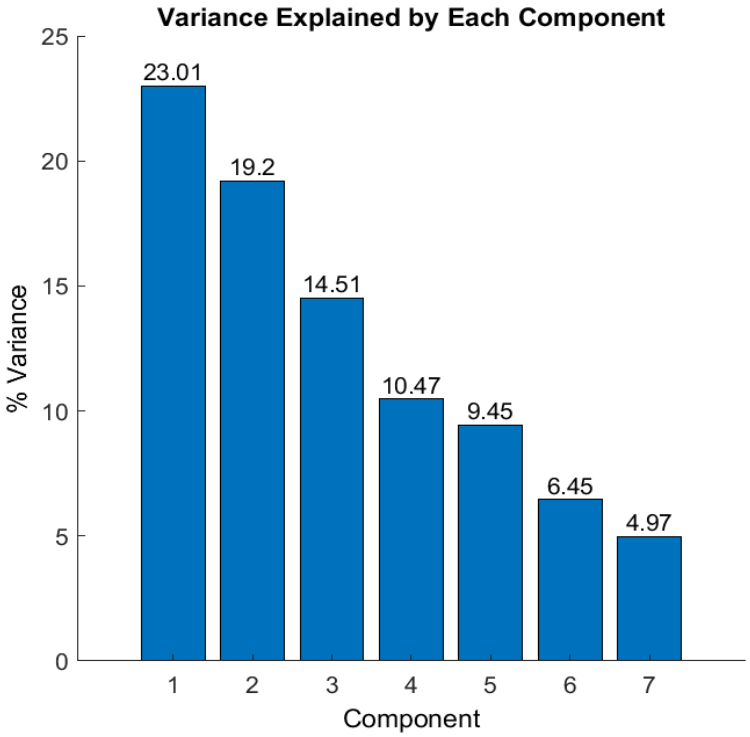


Figure 2.3 % Variance Explained by Each Component for Study 1. X-axis shows the components extracted from the analysis. The y-axis shows the % variance. Exact numbers for percentage are noted at the bar tips.

2.1.2.2. Multidimensional Scaling (MDS) Analysis

Multidimensional scaling can be described as a visual representation of distances between objects or sets of objects. 'Objects' can be anything, depending on what the study is focused on (Kruskal and Wish, 1978). For Study 1, since the point of interest was the onomatopoeic words, the 'objects' here are the onomatopoeic words. MDS creates a plot that visualizes the distance between these words, which tells us about their spatial organization. Words that are more similar are located closer to each other on the graph than the words that are less similar. This is achieved by mapping the pairwise distances among a set of objects into a configuration of points on the abstract cartesian space.

The steps to follow to conduct the MDS is to first assigning a number of points to coordinates in an n-dimensional space, 'n' referring to the number of objects. Then, the next step is calculating the Euclidean distances for all of the pairs of points created. Euclidian distance is the straight-line distance between two points in the Euclidian space and is calculated by using the Pythagorean theorem. This calculation results with a similarity matrix. The next step is to compare the similarity matrix with the original input matrix using the stress function. Stress function here is a measure based on the differences between predicted and actual distances of points. The final step is to adjust to coordinates, when it is necessary, to minimize the stress.

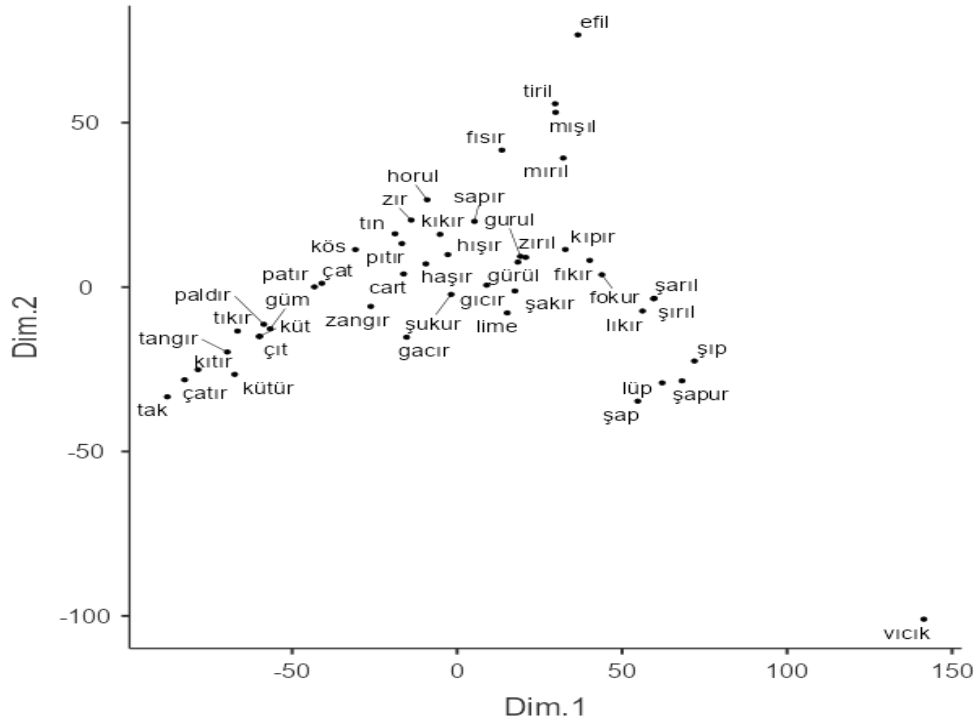


Figure 2.4 MDS plot. The onomatopoeic words that are located closer to each other for clusters.

In order to conduct MDS, the JAMOVI software (R Core Team 2018; The jamovi project, 2019) was used. The MDS solution for Study 1 (Figure 2.4) shows the onomatopoeic word space for written onomatopoeic words. As can be seen in the figure, the written onomatopoeic words do not form clear and distinct clusters. This

finding is contrary to the previous results of PCA where 7 dimensions were extracted for the onomatopoeic word space.

2.1.2.3. Relationship Between PCA Results and the Phonetic Features of Onomatopoeic Words

To investigate the relationship between PCA results of written onomatopoeic words and the phonetic features, Spearman's rank order correlation coefficient scores were obtained between the frequencies of phonetic parameters and the principal component scores of written onomatopoeic words. In order to do this analysis, 20 phonetic parameters were identified based on the 8 vowels in Turkish (/a/, /e/, /ı/, /i/, /o/, /ö/, /u/, /ü/), 2 positioning of vocal cords (voiced and voiceless), 7 places of articulation, and 3 manners of articulation (Table 2.5).

Table 2.5

Categorization of Turkish consonants

Categorization of Phonemes	Subcategories	Consonants
Positioning of Vocal Cords	Voiced	/b/c/d/g/ğ/j/l/m/n/r/v/y/z/
	Voiceless	/ç/f/h/k/p/s/ş/t/
Places of Articulation	Labial	/b/, /m/, /p/
	Labio-dental	/f/, /v/
	Post-alveolar	/d/, /n/, /s/, /t/, /z/
	Alveo-palatal	/c/, /ç/, /j/, /ş/
	Prevelar	/g/, /k/, /l/, /r/, /y/
	Velar	/ğ/
	Glottal	/h/
Manners of Articulation	Continuous - Fluid	/l/, /m/, /n/, /r/, /y/
	Continuous - Fricative	/f/, /ğ/, /h/, /j/, /s/, /ş/, /v/, /z/
	Discontinuous - Plosive	/b/, /c/, /ç/, /d/, /g/, /k/, /p/, /t/

This analysis was adapted from Fujisawa, Iwamiya & Takada (2004) by including the phonetic parameters of Turkish instead of Japanese. Analysis was started by a PCA with onomatopoeic words to obtain the component loading scores. The procedure for

the PCA was the same as detailed above, but this time including onomatopoeic words as the dimensions instead of the adjectives. The results for the PCA can be seen in Table 2.6. The PCA resulted with 7 dimensions.

Next, frequencies of phonetic parameters were calculated for each onomatopoeic word. For example: The onomatopoeic word 'küt küt' has four voiced consonants (two /k/ and two /t/ sounds), and two of the vowel /ü/. Then rank order correlation coefficients were obtained between principal component scores of onomatopoeic words and the frequencies of phonetic parameters for each principal component. The tables for the correlation coefficients of each component can be found in Appendix J.

Table 2.6
Example frequency scoring table for onomatopoeic word 'küt küt'

Onomatopoeic Word	Frequencies				
küt küt	Vowel /a/ 0	Vowel /e/ 0	Vowel /ı/ 0	Vowel /i/ 0	Vowel /o/ 0
	Vowel /ö/ 0	Vowel /u/ 0	Vowel /ü/ 2	Voiceless 4	Voiced 0
	Fluid 0	Fricative 0	Plosive 4	Labial 0	Labio-dental 0
	Post-alveolar 2	Alveo-palatal 0	Prevelar 2	Velar 0	Glottal 0

There was a significant negative correlation between Component 1 loadings of onomatopoeic words and the frequency of the phonetic parameter fricative ($r(39) = -.57$, $p = .003$). There was a positive correlation between the Component 1 loadings of onomatopoeic words and the phonetic parameters of plosive ($r(39) = .45$, $p = .023$), and post-alveolar ($r(39) = .58$, $p = .002$) phonetic parameters. The onomatopoeic words that loaded under Component 1 make up the 'roughness' dimension. These results can be interpreted to state that the onomatopoeic words that contained the consonants /f/, /ğ/, /h/, /j/, /s/, /ş/, /v/, /z/ had a less 'rough' impression since this parameter was negatively correlated. Example words for this are 'vıcık', 'şırıl', and 'hışır'. However, onomatopoeic words that contained plosive consonants /b/, /c/, /ç/, /d/, /g/, /k/, /p/, /t/, such as 'tıkır', and 'kıtır' and the post-

Table 2.7

Principal component loadings for the onomatopoeic words

	Component							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Uniqueness**
küt	0.971							0.037
çat	0.965							0.033
tangır	0.965							0.018
çatır	0.962							0.036
kıtır	0.960							0.038
tıkır	0.955							0.029
tak	0.955							0.037
kütür	0.953							0.043
güm	0.952							0.056
çıt	0.950							0.042
paldır	0.943							0.044
kös	0.932							0.084
zangır	0.918							0.083
tın	0.869							0.141
zır	0.862							0.127
patır	0.861							0.058
cart	0.759				0.434			0.157
kıkır	0.717							0.260
horul	0.712						0.459	0.133
gacır	0.665				0.611			0.059
şarıl		0.969						0.037
şırıl		0.956						0.039
şıp		0.932						0.022
lıkır		0.907						0.095
zırıl		0.872						0.112
şakır		0.830			0.337			0.092
gürül		0.802					0.408	0.087
fokur		0.780					0.445	0.120
şapur		0.745	0.480					0.054
fıkır		0.737					0.427	0.107
şukur	0.590	0.649			0.332			0.096
lüp		0.343	0.848					0.125
şap		0.564	0.726					0.069
lime			0.712					0.337
gurul		0.521	0.659					0.177
vıcık	-0.326	0.515	0.645					0.147
kıpır			0.615	0.444				0.254
mışıl				0.880				0.065
efil				0.818			0.317	0.132
tiril				0.809	0.404			0.077
mırıl				0.807				0.150
fısır		0.330	-0.330	0.688		0.335		0.150
gıcır		0.357			0.780			0.122
hışır	0.413				0.746	0.312		0.109
haşır	0.528		0.306		0.548		0.308	0.149

Table 2.7 continued

Principal component loadings for the onomatopoeic words

	Component							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Uniqueness**
sapır						0.921		0.088
pıtır	0.408					0.852		0.053

Note. 'varimax' rotation was used

alveolar consonants /d/, /n/, /s/, /t/, /z/, such as 'zangır', and 'zır' were associated with a 'rough' impression.

For Component 3, the correlation between the component loadings of onomatopoeic words and the phonetic parameter of fricative was significant, $r(39) = -.68$, $p = .041$. The onomatopoeic words that loaded under Component 3 can be described as making up 'visco-elasticity' dimension. This result suggests that onomatopoeic words that contained the consonants /f/, /ğ/, /h/, /j/, /s/, /ş/, /v/, /z/, such as 'fısır', and 'haşır' had a less 'viscous' or 'elastic' impression.

Lastly, two significant correlations were observed for the Component 7 between the loadings of onomatopoeic words and the phonetic parameters of vowel /o/ ($r(39)= 0.82$, $p = .04$) and prevelar ($r(39) = .82$, $p = .04$). This result indicates that onomatopoeic words that contained the vowel /o/ and the consonants /g/, /k/, /l/, /r/, /y/, such as 'gürül' and 'fokur', had a more 'dynamic' impression.

2.1.3. Discussion

Here the association of onomatopoeic words to perceived softness dimensions were investigated. A PCA was carried out which confirmed the existence of 7 dimensions that explain 88.06% of the variance in the data. The main result of the main study is that 31 adjectives could be described by 7 dimensions. Three of these dimensions were Fluffiness, Texture, and Glossiness. These dimensions, however, did not have many unique adjective loadings for them. Meaning, the adjectives that loaded for

these dimensions were also loaded in for other dimensions, and most of the adjectives had higher loadings for the other dimensions than these. Nevertheless, this finding is new and provide further information about the onomatopoeic word related softness dimensions. The remaining 4 major dimensions were as follows: Viscosity, Surface Softness, Granularity, and Roughness (control). Our results are in parallel with the dimensions shown before (Dövencioğlu et al., 2019;2022; Cavdan et al., 2019) except from Deformability dimension. This dimension was not obtained in the PCA and I believe this is likely due to the lack of Turkish onomatopoeic words that sound like a deforming material.

The results support the hypothesis that onomatopoeic words have a similar dimensional distribution in comparison to previously shown softness material dimensions. These findings constitute the earliest empirical evidence for such effect to be observed with Turkish onomatopoeic words. Further research is conducted to investigate the degree to which this effect can be observed with perceived softness of materials in Experiment 1.

2.2. Study 2 – Softness Dimensions from Material Videos

In Study 2, softness dimensions were extracted from videos of materials, using 40 materials and 29 adjectives related to material qualities.

2.2.1. Method

2.2.1.1. Participants

Participants signed up for the experiment on SONA, the research participation system, and completed the experiment on Qualtrics. Total of 15 participants (2 Male, $M = 23.8$, $SD = 4.5$) participated in the experiment. One participant was left-handed, and all participants had normal or corrected to normal visual acuity. All participants gave consent to participate in the study before they started the experiment, and upon completion they received course credit as compensation. None of the participants

exceeded the average completion time predicted for the experiment, which was estimated to be 50 minutes, therefore data from all 15 participants were included in all analyses.

2.2.1.2. Stimuli

2.2.1.2.1. Materials

A total of 40 materials were used in this study. 32 soft materials were selected to be the main stimuli and 8 hard materials to be were selected to be included as control. For a comprehensive list of all the materials, see Figure 2.5.

In line with the results of previous research material videos were selected as the means to present the materials to participants, since they reveal more information about the materials are more closely correlated with the haptic perceptual space (Cavdan et al., 2021). The videos were recorded on a laboratory setting with a black background. Only the material, the container for the material, and the hand displaying the exploratory movements were visible in the videos. Videos were recorded without sound using Canon EOS M50 situated on a tripod approximately 50 cm away from the material. The ISO setting was set to automatic and natural light was used during the photoshoot. The videos were shot at 50 frames per second on Full HD mode with a resolution of 1920 x 1080 pixels. During the video recording, the researcher displayed each of the 8 EPs that were previously mentioned for 5 seconds. These were pressure, rubbing, rotation, run through, stirring, pulling, tapping, and stroking. Then, the best EPs for each material were selected and 5 second versions of the exploratory videos were recorded using the selected EPs. The best EPs here are defined as the EPs that would present the most salient feature of each material; such as applying pressure for sponge (deformable), rotating for tennis balls (rough), rubbing for velvet (textile), stirring for hand cream (viscous), and running through the fingers for green lentils (granular) (Figure2.6). The final 5 second videos were then compressed to reduce in size while keeping the quality at HD.

Figure 2.5 A complete list of all materials used in Study 2, listed alphabetically.

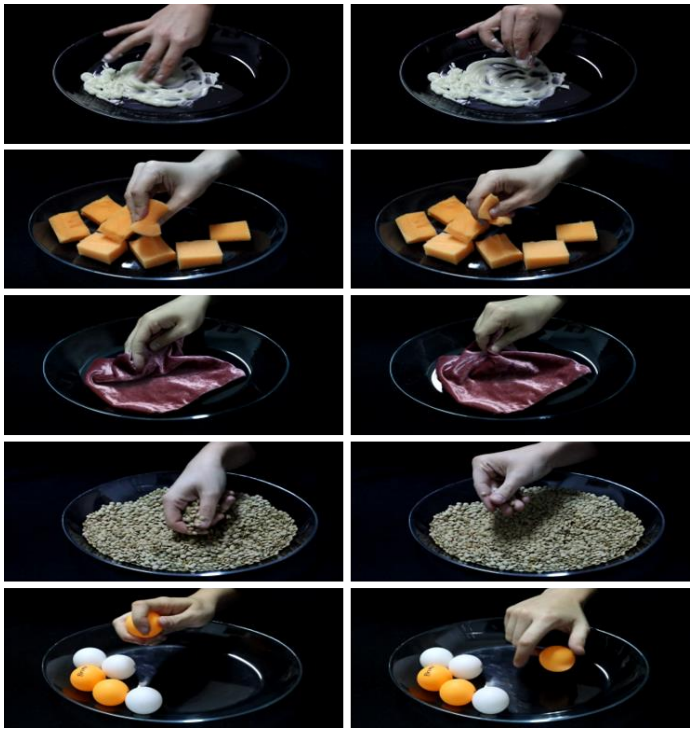


Figure 2.6 Sample video screenshots displaying the exploratory procedures used in Study 2. From the top the materials are hand cream, sponge, velvet, chickpeas, and tennis balls.

2.2.1.2.2. Adjective List

The adjectives used in this study were the same as of Study 1, except for the removal of two adjectives, resulting in 29 total adjectives. Adjective 'meaty' was removed from this experiment as it more closely relates to food, and specifically to meat, which was not included in the material list for this experiment. Adjective 'leathery' was removed because the Turkish translation of the adjective (*derimsi*) is not commonly used in daily language and was therefore not a good indicator to be included in the experiment.

2.2.1.3. Design and Procedure

The experiment consisted of 40 materials and 29 adjectives, resulting in 1160 trials. The experiment was carried out online using the platform Qualtrics. Before the start of the experiment, participants were instructed to first play the video, and then to complete the adjective ratings. They were also informed that they will only be able to play the video once. Similar to Study 1, block design was used where participants had to complete all adjective ratings for one material before moving on to another material. Duration for the experiment was around 50 minutes. Ratings were on a 7-point Likert scale where 1 is None at all and 7 is Very appropriate to the video in trial. Figure 2.7 displays a direct screenshot from the experiment.

One difference that was made for this experiment, and for the following experiments, was the change of the scale that was previously used for Study 1. The scale in Study 1 was between 0 to 100, whereas we changed it to a seven-point Likert scale between 1 and 7. This change was made after receiving feedback about the scale from several professionals in the area. The main point of the argument was that a 101-point scale (0 to 100) could remain too vague for the participants. When the data is examined, it can be seen that participants were lenient towards giving ratings that were very close to either end (0 or 100), but there was not much variability of the ratings observed for the middle sections of the scale. This might relate to the hardness of conceptualization for such a large range, the difference between a rating of 60 and 61 becomes less identified than that between 3 and 4 in a 7-point scale. Similarly, Preston and Colman (2000) showed that given a choice of multiple-point scales, respondents preferred the 101-point scale least commonly, and the 7-, and 9-point scales were generally preferred. Based on this reason, all remaining studies and experiments were conducted with the 1-7 Likert scale.

2.2.2. Results

The principal component analysis was conducted using the software JAMOVI software (R Core Team 2018; The jamovi project, 2019) and JASP (JASP Team, 2022). The same steps as Study 1 were followed: Cronbach's alpha levels were calculated for each adjective to check for internal consistency, this time 9 adjectives yielded an

"excellent" Cronbach's alpha value over .90, and 13 yielded a "good" value over .80 (Gliem & Gliem, 2003). These values suggest that material videos had high internal consistency. However, two of the adjectives yielded values lower than 0.60 indicating low internal consistency. These were the adjectives *airy* and *spongy* (see Table 2.5 for the complete list of Cronbach alpha levels for Study 2).

Table 2.8

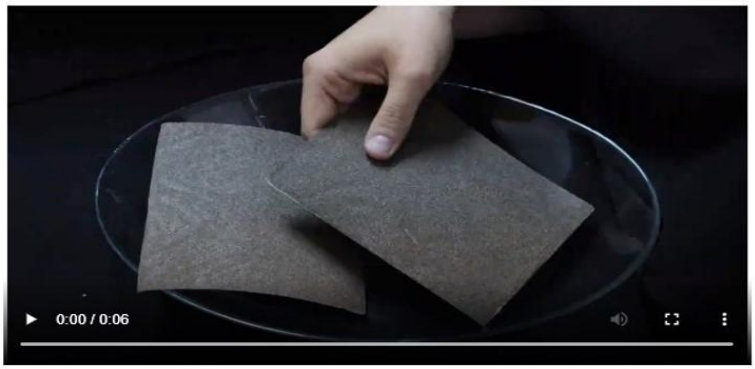
Cronbach alpha values for adjectives used in Study 2

Adjective	**Cronbach Alpha**	**Adjective**	**Cronbach Alpha**	**Adjective**	**Cronbach Alpha**
airy	0.260	hairy	0.815	silky	0.884
compliant	0.938	hard	0.808	slimy	0.800
delicate	0.934	inflexible	0.899	slippery	0.908
doughy	0.882	malleable	0.920	soft	0.871
flexible	0.900	moisturous	0.900	spongy	0.565
fluffy	0.873	powdery	0.693	sticky	0.862
gelatinous	0.652	roughened	0.852	textured	0.946
glossy	0.848	sandy	0.656	velvety	0.904
gooey	0.860	scabby	0.946	woody	0.687
granular	0.723	scaly	0.889		

The analysis was continued by averaging the responses across participants and taking into account the ratings for each adjective and onomatopoeic word separately. The average rating table resulted in 40 rows (materials) and 29 columns (adjectives).

The average responses were used to conduct a PCA. Before starting the analysis, the suitability of the data for PCA was checked with Bartlett's test of sphericity and Keiser-Meyer-Olkin (KMO) criterion. Bartlett's test of sphericity yielded a significant result,

Aşağıdaki sıfatları videodaki malzemeye göre değerlendiriniz.



1 - Hiç, 7 - Çok anlamına gelmektedir.

	1	2	3	4	5	6	7
kabarık	○	○	○	○	○	○	○
nemli	○	○	○	○	○	○	○
kum gibi	○	○	○	○	○	○	○
yumuşak	○	○	○	○	○	○	○
kadifemsi	○	○	○	○	○	○	○
cıvık	○	○	○	○	○	○	○
ipeksi	○	○	○	○	○	○	○
yapışkan	○	○	○	○	○	○	○
kaygan	○	○	○	○	○	○	○
pul pul	○	○	○	○	○	○	○
pürüzlü	○	○	○	○	○	○	○
biçimlenebilir	○	○	○	○	○	○	○
tüylü	○	○	○	○	○	○	○
tanecikli	○	○	○	○	○	○	○
sert	○	○	○	○	○	○	○
havadar	○	○	○	○	○	○	○
güç uygulanabilir	○	○	○	○	○	○	○
hamursu	○	○	○	○	○	○	○
esnek	○	○	○	○	○	○	○
jölemsi	○	○	○	○	○	○	○
hassas	○	○	○	○	○	○	○
toz gibi	○	○	○	○	○	○	○
esnemez	○	○	○	○	○	○	○
kabuklu	○	○	○	○	○	○	○
süngerimsi	○	○	○	○	○	○	○
dokulu	○	○	○	○	○	○	○
sümüksü	○	○	○	○	○	○	○
odunsu	○	○	○	○	○	○	○
parlak	○	○	○	○	○	○	○

Figure 2.7 Sample screenshot from Study 2 on Qualtrics. All 29 adjectives were presented in a single list.

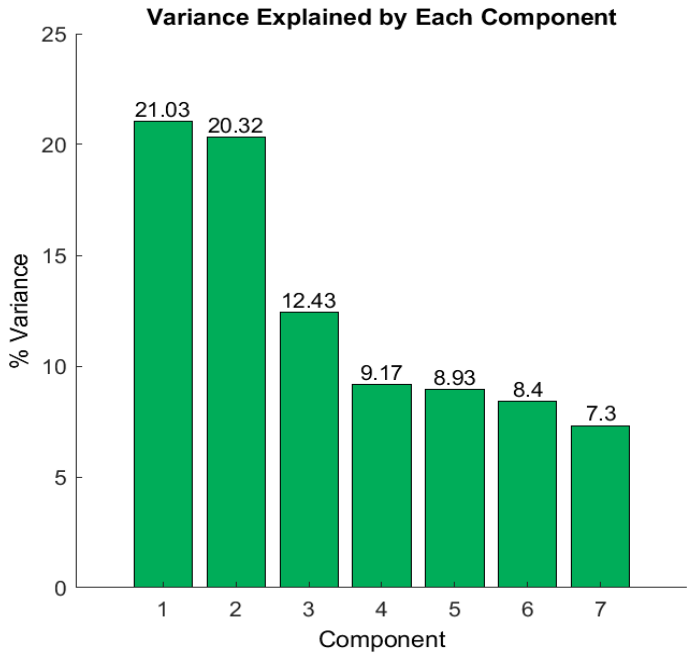


Figure 2.8 % Variance explained by each component for the seven-factor solution for Study 2. The x-axis shows the components extracted from the analysis. The y-axis shows the % variance. The exact percentage number for each component is noted at the bar tips.

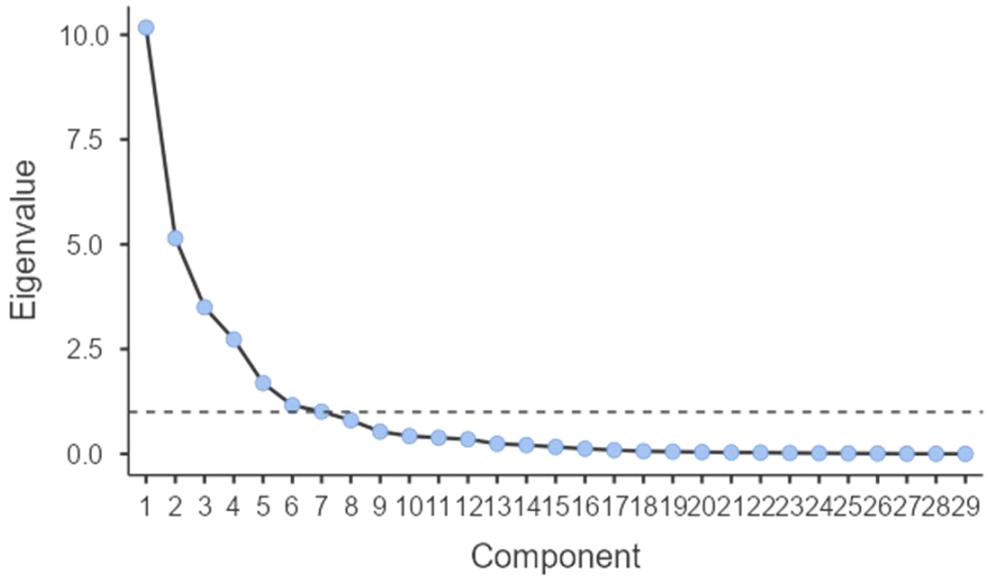


Figure 2.9. Scree plot for Study 2. The x-axis shows all components that could possibly be extracted from the design (31). The y-axis shows the eigenvalues for the components. The dotted line is for eigenvalue = 1, which was the criterion used to extract components.

Table 2.9

Component Loadings of PCA for Study 2

	Component							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Uniqueness**
gooey	0.933							0.041
gelatinous	0.917							0.068
slimy	0.905							0.081
sticky	0.890	0.364						0.054
moisturous	0.870							0.115
slippery	0.800					-0.378	-0.341	0.071
malleable		0.926						0.065
compliant		0.896						0.073
flexible		0.826						0.122
inflexible		-0.819						0.089
doughy	0.347	0.800						0.224
delicate		0.698			0.426			0.136
soft	0.427	0.680		0.379	0.348			0.050
hard	-0.399	-0.631		-0.349	-0.334			0.117
sandy			0.966					0.058
powdery			0.932					0.105
granular			0.890					0.099
scaly			0.726			0.414		0.180
silky				0.897				0.122
velvety				0.883				0.168
hairy				0.678		0.330		0.225
airy					0.835			0.171
fluffy					0.806			0.145
spongy		0.354			0.656			0.308
roughened						0.852		0.098
textured	-0.307					0.851		0.103
woody							0.824	0.152
scabby						0.322	0.736	0.166
glossy	0.578						-0.579	0.180

Note. 'varimax' rotation was used. Loadings below 0.3 were hidden from the table.

x^2 (1546) = 406, p < .001. The KMO measure of sampling adequacy resulted in an overall score of 0.584 which is above the required criteria of .5 to use PCA. These results suggest that the observed correlations were meaningful and the data was

suitable to be used for PCA. Using the same settings as Study 1, principal components were extracted with Kaiser normalization and varimax rotation. Seven principal components were extracted from the analysis that explain % 87,58 of total variance observed in the data.

Table 2.6 depicts the rotated factor loadings of each adjective in the seven-factor solution. Factor I explained 21.03% of variance. Adjectives *gooey, gelatinous*, *slimy*, *sticky*, *moisturous, slippery, doughy, soft, glossy, hard (-),* and *textured (-)* were loaded in this factor. This factor was therefore labeled Viscosity. The second factor explained 20.32% of variance. Adjectives *sticky, malleable, compliant, flexible, inflexible (-), doughy, delicate, soft, hard (-),* and *spongy* were loaded in this factor. The second factor was labeled as Deformability. The third factor explained 12.43% of variance. Adjectives sandy, granular, scaly, and powdery were loaded on this factor. This factor was labeled Granularity.

The fourth factor explained 9.17% of the variance. Adjectives that loaded on this factor were silky, velvety, hairy, soft, and hard *(-).* This factor was labeled Surface Softness. The fifth factor explained 8.93% of variance. Adjectives delicate, soft, hard (-), airy, fluffy, and spongy were loaded on this factor. This factor was labeled Fluffiness. The sixth factor explained 8.4% of the variance. Adjectives slippery (-), scaly, hairy, roughened, textured, and scabby loaded in this factor. This factor was labeled Roughness. The seventh and the final factor explained 7.3% of the variance. Adjectives slippery (-), woody, scabby, and glossy (-) were loaded in this factor. This factor was labeled Scabbiness. Figure 2.8 shows the percentage explained variance for 7 scales and Figure 2.9 shows the scree plot.

Appendix D displays the ratings collected for each material across all the adjectives used in Study 2.

2.2.3. Discussion

In Study 2 the categorization of materials for softness dimensions were investigated. The PCA revealed 7 perceptual softness dimensions which explain 87.58% of the variance in the data. Five of the dimensions were in line with previous research

(Dövencioğlu et al., 2018, 2019, 2022; Cavdan et al., 2019): Viscosity, Deformability, Surface Softness, Granularity, and Roughness (control condition). The remaining two dimensions were Fluffiness and Scabbiness. These dimensions have not been previously reported and constitute a new finding in terms of material dimensions of softness. These results once again provide support for the existence of at least four softness-related dimensions, challenging the previously accepted idea of softness as a single dimension.

The results support our hypothesis that materials have a similar dimensional distribution in comparison to previously shown softness material dimensions. We were able to categorize the materials in relation to the adjective list, and we used these results for stimulus selection for Experiment 1.

2.3. Experiment 1 – The Effects of Written Onomatopoeic Words on Perceived Softness of Material Videos

In this experiment the effect of written onomatopoeic words on perceived softness of material videos were investigated by creating word-video pairings that are congruent or incongruent. In Study 1 and 2, both onomatopoeic words and material videos were used to extract very similar softness-related dimensions. For Experiment 1, it was hypothesized that the onomatopoeic words will have an effect on material softness perception. This hypothesis is driven by previous research conducted with onomatopoeias in other languages, and mainly in Japanese (Hanada, 2016; Hanada, 2019). To test this, the onomatopoeic words and the materials were matched. It is expected that when the onomatopoeic word and material pairings are congruently matched, the ratings for related adjectives should be higher and when they are incongruently matched the ratings for related adjectives should be lower. A significant result for the interaction effect of onomatopoeic word and material (which will constitute the "congruency" condition) from ANOVA will be in support of this hypothesis. This result will suggest that onomatopoeic words have an effect on the perceived softness of materials.

2.3.1. Method

2.3.1.1. Participants

Twenty-seven participants (8 Male, *M* = 24.9, *SD* = 8.17) participated in the study. Similar to Study 1 and 2, all participations were recruited from SONA and the experiment was run on Qualtrics. Six participants were left-handed, and all participants had normal or corrected to normal visual acuity. Participants gave their consent to participate in the study before the experiment started, and upon completion they received course credits.

2.3.1.2. Stimuli

The stimuli to be used in Experiment 1 were selected using the PCA results from Study 1 and 2. Both onomatopoeic words and material videos were used in this experiment, and softness dimensions from the PCA were used to decide the congruency of the onomatopoeic word and material pairings. We only used the components that were evident in both experiments, which resulted in four components: Viscosity, Surface Softness, Granularity, and Roughness (control). Table 2.7 displays the adjectives loaded on both experiments, as well as the common ones selected for Experiment 1. There were five adjectives for Viscosity*: gooey, gelatinous, sticky, moisturous, slippery, glossy*, and *slimy*. There were three adjectives for Surface Softness*: silky, velvety,* and *hairy*. For Granularity, there were four adjectives: *sandy, powdery, granular,* and *scaly*. Lastly, for Roughness there was only one adjective common in both experiments: *roughened*. These adjectives were titled as 'Main Adjectives' to differentiate the main adjectives we used for stimuli selection from the softness related adjectives we use in the rating task.

After selecting the Main Adjectives, I then selected the onomatopoeic words and materials. For each Main Adjective, two onomatopoeic words (high and low rated) and three materials (high, middle, and low rated; corresponding to ratings above 3.5, at 3.5, and lower than 3.5, respectively). Each onomatopoeic word was used only

Table 2.10

Common adjective selection based on adjective loadings on Study 1 and 2

Component	Word Experiment	Material Experiment	Component	Word Experiment	Material Experiment
Viscosity	sticky gooey slimy gelatinous moisturous slippery doughy flexible inflexible (-) soft spongy hard (-) meaty malleable	gooey gelatinous sticky moisturous slippery glossy slimy	*Surface Softness*	flexible inflexible (-) spongy velvety hairy silky airy delicate soft hard (-) powdery (-)	silky velvety hairy
Component	Word Experiment	Material Experiment	Component	Word Experiment	Material Experiment
Granularity	sandy powdery scaly granular roughened	sandy powdery granular scaly	*Roughness*	woody roughened slippery (-) glossy (-)	roughened textured

once, however some of the materials were used more than once regarding their ratings on related Main Adjective. For instance, *wool* was used as a low rated material for Gelatinous, and a high rated material for Hairy.

Onomatopoeic words and materials were then paired to be either in a congruent (both low or both high rated), control (onomatopoeic word high or low rated, material middle rated), or an incongruent (one high rated while the other is low rated condition. For instance, for the Main Adjective Gooey, *vıcık vıcık* (high rated) was congruently paired with hair conditioner, paired as control with kinetic sand, and incongruently paired with tulle. Whereas *kütür kütür* (low rated), was congruently paired with tulle, paired as control with kinetic sand, and incongruently paired with hair conditioner. This configuration resulted in 6 word-video pairs per Main Adjective.

2.3.1.2.1. Adjective List

We used a total of 13 adjectives in the ratings task: gelatinous, slimy, sticky, gooey, slippery, roughened, sandy, granular, powdery, scaly, silky, velvety, and hairy. The adjectives to get ratings on were the same as the Main Adjectives.

2.3.1.3. Design and Procedure

A within-subject design with three independent variables (IV) and a continuous dependent variable was used in this experiment. First IV was Onomatopoeic Word (2 levels: high and low rated in Study 1), the second IV was Materials (3 levels: high, middle, and low rated in Study 2), the third IV was Adjective (13 levels: gelatinous, slimy, sticky, gooey, slippery, roughened, sandy, granular, powdery, scaly, silky, velvety, and hairy). The dependent variable was the ratings obtained for each adjective. Each Main Adjective were regarded as a subset, and for each of them the design was a 2 x 3 x 13 ANOVA.

A similar block design as of Study 1 and 2 was used where participants had to complete all adjective ratings before they could move on to the next stimuli. However, in this experiment, each block consisted of one onomatopoeic word and one material, presented in that order (Figure 2.11). Onomatopoeic words were presented on screen (2 seconds), followed by blank screen (1 second), followed by the video of a material (5 seconds). After watching this sequence once, participants had to complete the ratings for 13 adjectives. Once the ratings were complete, they moved on to the next trial. Before starting the next trial, they first were asked to write the onomatopoeic word that they had seen at the beginning of the sequence. This memory task was included at the end of each trial as a control to ensure participants remembered the onomatopoeic word they saw. There was a total of 78 trials, lasting around 60 minutes to complete the entire experiment.

Table 2.11

Stimuli List used in Experiment 1 based on the Main Adjectives and each adjective selected under the Main Adjectives

VISCOSITY

Gelatinous

Rating	*Word*	*Rating*	*Material*
High	*lüp lüp*	High	shower gel
		Middle	shaving cream
Low	*çatır çatır*	Low	wool

Slimy

Rating	*Word*	*Rating*	*Material*
High	*şapur şupur*	High	honey
		Middle	handcream
Low	*kıtır kıtır*	Low	rubberband

Sticky

Rating	*Word*	*Rating*	*Material*
High	*şap şap*	High	slime
		Middle	playdough
Low	*tıkır tıkır*	Low	sponge

Gooey

Rating	*Word*	*Rating*	*Material*
High	*vıcık vıcık*	High	hair conditioner
		Middle	kinetic sand
Low	*kütür kütür*	Low	tulle

Slippery

Rating	*Word*	*Rating*	*Material*
High	*şarıl şarıl*	High	olive oil
		Middle	metal nuts
Low	*tak tak*	Low	matchstick

GRANULARITY

Sandy

Rating	*Word*	*Rating*	*Material*
High	*fısır fısır*	High	sand
		Middle	green lentils
Low	*tak tak*	Low	cardboard pieces

Powdery

Rating	*Word*	*Rating*	*Material*
High	*efil efil*	High	flour
		Middle	foam
Low	*şapur şupur*	Low	felt

Granular

Rating	*Word*	*Rating*	*Material*
High	*pıtır pıtır*	High	poppy seeds
		Middle	glass balls
Low	*horul horul*	Low	latex

Scaly

Rating	*Word*	*Rating*	*Material*
High	*hışır hışır*	High	sawdust
		Middle	leather
Low	*lıkır lıkır*	Low	woodblocks

SURFACE SOFTNESS

Silky

Rating	*Word*	*Rating*	*Material*
High	*tiril tiril*	High	silk
		Middle	cotton
Low	*zır zır*	Low	rubberband

Velvety

Rating	*Word*	*Rating*	*Material*
High	*mışıl mışıl*	High	velvet
		Middle	fur
Low	*çat çat*	Low	stone

Hairy

Rating	*Word*	*Rating*	*Material*
High	mırıl mırıl	High	wool
		Middle	cotton
Low	kös kös	Low	chickpeas

ROUGHNESS

Roughened

Rating	*Word*	*Rating*	*Material*
High	*çıt çıt*	High	sandpaper
		Middle	fur
Low	*gürül gürül*	Low	water

2.3.2. Results

As for each Main Adjective the stimuli of onomatopoeic word and materials differed, they had to be analyzed separately. We conducted 13 two-way repeated-measure ANOVAs. The data was analyzed using JASP (JASP Team, 2022), with a total of 1014 ratings per participant. I corrected for multiple comparisons with Bonferroni correction 0.05/13α = .003. I expected to see a significant interaction effect between Onomatopoeic Word * Material, as this interaction corresponds to congruency, which was the manipulation in the experiment. Unfavorably, out of all 13 ANOVAs, none of the interactions between Onomatopoeic Word * Material was significant. Table 2.9 shows a comprehensive list of all significant main and interaction effects.

For the main effects, main effect of Onomatopoeic Word was also not significant in any of the 13 ANOVAs. For Gelatinous ($F(1,26) = 1.09$, $p = .03$, $\eta^2_p = .04$), Slimy ($F(1,26) = 1.97$, $p = .17$, $\eta^2_p = .07$), Sticky ($F(1,26) = 1.23$, $p = .27$, $\eta^2_p = .04$), Gooey ($F(1,26) = 4.87$, $p = .036$, $\eta^2_p = .16$), Slippery ($F(1,26) = 0.61$, $p = .04$, $\eta^2_p = .02$), Roughness ($F(1,26) = 1.94$, $p = .17$, $\eta^2_p = .07$), Silky ($F(1,26) = 1.19$, $p = .28$, $\eta^2_p = .04$), Velvety ($F(1,26) = 0.06$, $p = .79$, $\eta^2_p = .003$), Hairy ($F(1,26) = 0.03$, $p = .85$, $\eta^2_p = .001$), Sandy ($F(1,26) = 1.03$, $p = .31$, $\eta^2_p = .03$), Powdery ($F(1,26) = 0.63$, $p = .43$, $\eta^2_p = .02$), Granular ($F(1,26) = 0.36$, $p = .54$, $\eta^2_p = .01$), and Scaly ($F(1,26) = 1.14$, $p = .29$, $\eta^2_p = .04$).

The main effect of Materials was significant for 12 out of the 13 ANOVAs at a level of $p < 0.00$. For Gelatinous ($F(2,56) = 41.4$, $p < .001$, $\eta^2_p = .61$), Slimy ($F(2,56) = 78.1$, $p < .001$, $\eta^2_p = .75$), Sticky ($F(2,56) = 62.1$, $p < .001$, $\eta^2_p = .7$), Gooey ($F(2,56) = 31.3$, $p < .001$, $\eta^2_p = .5$), Slippery ($F(2,56) = 24.2$, $p < .001$, $\eta^2_p = .48$), Roughened ($F(2,56) = 25.5$, $p < .001$, $\eta^2_p = .5$), Silky ($F(2,56) = 5.49$, $p = .007$, $\eta^2_p = .17$), Velvety ($F(2,56) = 30.4$, $p < .001$, $\eta^2_p = .53$), Hairy ($F(2,56) = 6.61$, $p = .003$, $\eta^2_p = .20$), Sandy ($F(2,56) = 68.9$, $p < .001$, $\eta^2_p = .72$), Powdery ($F(2,56) = 22.1$, $p < .001$, $\eta^2_p = .46$), Granular ($F(2,56) = 75$, $p < .001$, $\eta^2_p = .74$), Scaly ($F(2,56) = 30.7$, $p < .001$, $\eta^2_p = .54$).

Table 2.12

ANOVA main effect and interaction results for Experiment 1

	Gelatinous		Slimy		Sticky		Gooey		Slippery	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Word	1.09	0.04	1.97	0.07	1.23	0.04	4.87	0.16	0.62	0.02
Material	41.45*	0.61	78.15*	0.75	62.07*	0.70	31.29*	0.54	24.21*	0.48
Adjective	59.04*	0.69	75.78*	0.74	49.39*	0.65	39.41*	0.52	21.08*	0.45
Word * Material	1.57	0.06	1.49	0.05	4.73	0.15	0.52	0.005	1.29	0.05
Word * Adjective	1.06	0.04	0.59	0.02	1.07	0.04	0.51	0.02	0.46	0.02
Material * Adjective	56.79*	0.68	42.23*	0.62	46.41*	0.64	36.59*	0.58	27.74*	0.52
Word * Material * Adjective	0.52	0.02	0.93	0.03	1.92	0.07	0.77	0.03	0.45	0.02

Note. * denotes significant result. IV Onomatopoeic Word is transcribed as "Word" to create a better fit with the table margins.

The main effect of Adjective was significant for all 13 ANOVAs. For Gelatinous ($F(12,312) = 59$, $p < .001$, $\eta^2_p = .69$), Slimy ($F(12,312) = 75.8$, $p < .001$, $\eta^2_p = .74$), Sticky ($F(12,312) = 49.4$, $p < .001$, $\eta^2_p = .65$), Gooey ($F(12,312) = 39.4$, $p < .001$, $\eta^2_p = .52$), Slippery ($F(12,312) = 21.1$, $p < .001$, $\eta^2_p = .45$), Roughened ($F(12,312) = 31.2$, $p < .001$, $\eta^2_p = .54$), Silky ($F(12,312) = 32.1$, $p < .001$, $\eta^2_p = .55$), Velvety ($F(12,312) = 62.4$, $p < .001$, $\eta^2_p = .7$), Hairy ($F(12,312) = 37.9$, $p < .001$, $\eta^2_p = .59$), Sandy ($F(12,312) = 53.6$, $p < .001$, $\eta^2_p = .67$), Powdery ($F(12,312) = 29$, $p < .001$, $\eta^2_p = .52$), Granular ($F(12,312) = 39.7$, $p < .001$, $\eta^2_p = .59$), and Scaly ($F(12,312) = 31.1$, $p < .001$, $\eta^2_p = .54$).

The interaction between Onomatopoeic Word * Material was not significant for any of the 13 ANOVAs. For Gelatinous ($F(2,52) = 1.57$, $p = .21$, $\eta^2_p = .05$), Slimy ($F(2,52) = 1.49$, $p = .23$, $\eta^2_p = .05$), Sticky ($F(2,52) = 1.06$, $p = .38$, $\eta^2_p = .04$), Gooey ($F(2,52) = 0.12$, $p = .88$, $\eta^2_p = .005$), Slippery ($F(2,52) = 1.29$ $p = .28$, $\eta^2_p = .04$), Roughness ($F(2,52) = 1.22$, $p = .30$, $\eta^2_p = .04$), Silky ($F(2,52) = 0.38$, $p = .68$, $\eta^2_p = .01$), Velvety ($F(2,52) = 7.03$, $p = .002$, $\eta^2_p = .21$), Hairy ($F(2,52) = 0.52$, $p = .59$, $\eta^2_p = .02$), Sandy ($F(2,52) = 0.11$, $p = .89$, $\eta^2_p = .004$), Powdery ($F(2,52) = 3.02$, $p = .05$, $\eta^2_p = .10$), Granular ($F(2,52) = 0.07$, $p = .93$, $\eta^2_p = .003$), and Scaly

($F(2,52) = .04$, $p = .95$, $\eta^2_p = .002$).

Table 2.12 (continued)

ANOVA main effect and interaction results for Experiment 1

	Sandy		Powdery		Granular		Scaly	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Word	1.03	0.04	0.61	0.02	0.368	0.01	1.15	0.04
Material	68.80*	0.73	22.16*	0.46	75.01*	0.74	30.66*	0.54
Adjective	53.57*	0.67	29.04*	0.53	38.66*	0.60	31.15*	0.54
Word * Material	0.12	0.00	3.02	0.10	0.07	0.003	0.05	0.002
Word * Adjective	1.10	0.04	1.36	0.05	1.34	0.05	0.31	0.012
Material * Adjective	41.36*	0.61	30.50*	0.54	37.59*	0.59	14.38*	0.36
Word * Material * Adjective	0.73	0.03	1.32	0.05	2.15	0.08	0.86	0.03

Note. * denotes significant result. IV Onomatopoeic Word is transcribed as "Word" to create a better fit with the table margins

Table 2.12 (continued)

ANOVA main effect and interaction results for Experiment 1

	Silky		Velvety		Hairy		Roughness	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Word	1.20	0.04	0.07	0.02	0.02	0.001	1.03	0.04
Material	5.49	0.17	30.37*	25.52*	25.52*	0.20	68.80*	0.73
Adjective	32.07*	0.55	62.38*	31.17*	31.17*	0.59	53.57*	0.67
Word * Material	0.38	0.01	7.04	1.22	1.22	0.02	0.12	0.00
Word * Adjective	0.66	0.02	1.07	0.40	0.40	0.04	1.10	0.04
Material * Adjective	29.02*	0.53	39.85*	37.03*	37.03*	0.59	41.36*	0.61
Word * Material * Adjective	0.50	0.02	1.43	1.27	1.27	0.01	0.73	0.03

Note. * denotes significant result. IV Onomatopoeic Word is transcribed as "Word" to create a better fit with the table margins

The interaction between Onomatopoeic Word * Adjective was not significant for any of the 13 ANOVAs. For Gelatinous ($F(12,312) = 1.06$, $p = .39$, $\eta^2_p = .03$), Slimy ($F(12,312) = 0.59$, $p = .85$, $\eta^2_p = .02$), Sticky ($F(12,312) = 1.06$, $p = .39$, $\eta^2_p = .03$), Gooey ($F(12,312) = 0.51$, $p = .90$, $\eta^2_p = .02$), Slippery ($F(12,312) = 0.46$, $p =$

.93, η^2_p = .02), Roughness (F(12,312) = 0.39, p = .96, η^2_p = .01), Silky (F(12,312) = 0.66, p = .79, η^2_p = .02), Velvety (F(12,312) = 1.07, p = .38, η^2_p = .04), Hairy (F(12,312) = 1.14, p = .32, η^2_p = .04), Sandy (F(12,312) = 1.09, p = .36, η^2_p = .04), Powdery (F(12,312) = 1.36, p = .18, η^2_p = .05), Granular (F(12,312) = 1.34, p = .19, η^2_p = .05), and Scaly (F(12,312) = 0.31, p = .98, η^2_p = .01).

The interaction effect of Material * Adjective was significant for all 13 ANOVAs. For Gelatinous (F(24,624) = 56.8, p < .001, η^2_p = .68), Slimy (F(24,624) = 42.2, p < .001, η^2_p = .62), Sticky (F(24,624) = 46.4, p < .001, η^2_p = .64), Gooey (F(24,624) = 36.6, p < .001, η^2_p = .58), Slippery (F(24,624) = 27.7, p < .001, η^2_p = .51), Roughness (F(24,624) = 37, p < .001, η^2_p = .58), Silky (F(24,624) = 29, p < .001, η^2_p = .53), Velvety (F(24,624) = 39.9, p < .001, η^2_p = .6), Hairy (F(24,624) = 36.9, p < .001, η^2_p = .59), Sandy (F(24,624) = 41.3, p < .001, η^2_p = .61), Powdery (F(24,624) = 30.5, p < .001, η^2_p = .54), Granular (F(24,624) = 37.5, p < .001, η^2_p = .59), and Scaly (F(24,624) = 14.4, p < .001, η^2_p = .35).

Lastly, the three-way interaction between Onomatopoeic Word * Material * Adjective was not significant for any of the 13 ANOVAs. For Gelatinous (F(24,624) = 0.53, p = .97, η^2_p = .02), Slimy (F(24,624) = 0.93, p = .56, η^2_p = .03), Sticky (F(24,624) = 1.92, p = .044, η^2_p = .06), Gooey (F(24,624) = 0.77, p = .77, η^2_p = .02), Slippery (F(24,624) = 0.45, p = .99, η^2_p = .01), Roughness (F(24,624) = 1.27, p = 0.17, η^2_p = .04), Silky (F(24,624) = 0.5, p = .98, η^2_p = .02), Velvety (F(24,624) = 1.43, p = .08, η^2_p = .05), Hairy (F(24,624) = 0.33, p = .99, η^2_p = .01), Sandy (F(24,624) = 0.73, p = .82, η^2_p = .03), Powdery (F(24,624) = 1.32, p = .14, η^2_p = .04), Granular (F(24,624) = 2.15, p = .034, η^2_p = .07), and Scaly (F(24,624) = 0.86, p = .54, η^2_p = .03).

Appendix E displays the rating differences between conditions across all adjectives, for each of the Main Adjectives.

2.3.3. Discussion

Experiment 1 was conducted to test the hypothesis that onomatopoeic words have an effect on the perceived softness of materials. The effect of congruency was not observed, which would be a significant result for the interaction between Onomatopoeic Word * Material, on any of the 13 ANOVAs conducted. Therefore, I failed to reject the null hypothesis and the hypothesis for this experiment was not supported. This might suggest that the onomatopoeic word and material pairings used in this experiment were not strong enough for such an effect to be observed. Meaning, the pairings created for congruent and incongruent conditions may not be optimal. On the other hand, given that the experiment was conducted online, it is probable that participants did not give their undivided attention to the stimuli displayed on screen.

It is also probable that either onomatopoeic word or the material was more salient for each adjective and therefore participants focused on only one of them when giving their ratings. However, with the current design it is not possible to test this. It might also be related to the onomatopoeic words being presented in a written format, instead of spoken. Because the onomatopoeic words were in the written format, they were presented before the video of the material. The alternative was to display the onomatopoeic word and the video of the material on the same screen. However, that design was avoided to not divide attention to different parts of the screen. To confidently report any significant result associated with the onomatopoeic word and the material, it needs to be ensured that participants pay attention to both stimuli simultaneously. We proposed a similar design of material videos synchronously presented with spoken onomatopoeic words. This study is detailly reported in Chapter 3.

CHAPTER 3

EFFECTS OF SPOKEN ONOMATOPOEIC WORDS ON PERCEIVED SOFTNESS

This chapter focuses on Study 3 where softness related dimensions are extracted from spoken onomatopoeic words, and Experiment 2 where a similar methodological design to Experiment 1 (Chapter 2) was employed and the adjective ratings of materials were manipulated by creating congruent and incongruent conditions with onomatopoeic words and material videos.

3.1. Study 3: Softness Dimensions from Spoken Onomatopoeic Words

This section focuses on an experiment (Study 3) conducted to see whether softness related dimensions could be extracted from spoken onomatopoeic words. The study design is similar to that of Study 1 (Chapter 2), however instead of written onomatopoeic words being displayed on screen, this time the stimuli is presented in spoken form. Another difference added is that Study 3 is conducted in a laboratory setting, instead of being online, which was one of the issues we discussed earlier at the end of Chapter 2.

For this experiment, the hypothesis was that spoken onomatopoeic words will show a similar softness dimension to that observed with materials. The results are expected to be also similar to that of Study 1, where written onomatopoeic words were used.

3.1.1. Method

3.1.1.1 Participants

Similar to previous experiments, participants were recruited through the research participation system SONA. All participants received course credits as compensation for participating in the study. We collected data from 30 participants (*M* = 22.4, *SD* = 2.4, 7 Male, 3 left-handed). Three participants were left-handed, all participants had normal or corrected to normal visual acuity, and no participant reported any auditory disorders that is associated with a loss of hearing. All participants were students at Middle East Technical University, and all were native Turkish speakers.

3.1.1.2. Stimuli

3.1.1.2.1. Onomatopoeic Words

The list of onomatopoeic words to be used in this study was chosen by completing a small pilot study using the onomatopoeic words in Study 1. For the pilot study, we collected data from 21 participants, who were asked to judge how familiar they are with each onomatopoeic word on a scale from 1 (not at all familiar) to 7 (very familiar). We also collected ratings for the same adjective list that was used in Experiment 1 as a way of identifying the suitability of each onomatopoeic word to be used in Study 3. The initial onomatopoeic word list for this pilot study comprised of 47 onomatopoeic words. We selected the cutoff point as 3, meaning any onomatopoeic word receiving an average familiarity rating of less than 3 was eliminated. Furthermore, we eliminated the onomatopoeic words that were semantically distant to the adjective list. The remaining list consisted of 27 onomatopoeic words (Table 3.1).

The onomatopoeic words were presented in audio form. To record the words, the researcher used a CANON EOS M50 camera and RODE noise cancelling microphone add-on. All the recordings were completed by the researcher, a native Turkish speaker, in a sound-isolated room. All recordings were then edited in Audacity software to include a 1 second of silent onset, followed by the onomatopoeic word (~2 seconds), then the amount of silent block necessary to equal total audio duration

to 5 seconds. The recordings were then normalized to -3 dB to ensure all recordings had the same volume.

3.1.1.2.2. Adjective List

The adjectives used in this study are the same ones that we used in Study 2 (Chapter 2), consisting of 29 adjectives. This list excludes the adjectives 'meaty' and 'leathery'

Table 3.1

Onomatopoeic words used in Study 3

çıt çıt	lıkır lıkır	şarıl şarıl
efil efil	lime lime	şıp şıp
gıcır gıcır	mırıl mırıl	şıpır şıpır
haşır huşur	mışıl mışıl	şırıl şırıl
hışır hışır	pıtır pıtır	tak tak
katur kutur	pofur pofur	tangur tungur
kırt kırt	püfür püfür	tıkır tıkır
kıtır kıtır	şap şap	tiril tiril
kütür kütür	şapur şupur	vıcık vıcık

from the original list of 31 adjectives, as they are not common in Turkish language and their meanings are therefore vague and not informative. The remaining list consists of 29 material related adjectives. The complete list of adjectives can be seen in Table 3.2.

3.1.1.3. Design and Procedure

The experiment included 27 onomatopoeic words and 29 adjectives, resulting in 783 trials for each participant. The experiment was coded in MATLAB R2020b and Psychtoolbox-3. The experiment was conducted in the sound-isolated room on an HP ENVY dv6 laptop at the behavioral laboratory of Social Sciences building at Middle

East Technical University. The audio stimuli were presented using Sennheiser SK-507364 HD 206 headphones, and the responses were collected using a standard cable mouse. The procedure was similar to that of Study 1; however, block design was not used for Study 3. For Study 3, the order of the stimuli was randomized for each participant. Upon giving their informed consent to participate in the study, participants were instructed to listen to the onomatopoeic word that was played in a loop of 5 seconds (including the silent onset and offset) and then rate each adjective based on how well they think the match is between the adjective and the onomatopoeic word on a 1 (not at all) to 7 (very) scale. The participants were not able to submit a response for the first three seconds of the audio, which was implemented in the design to ensure no responses are given before the onomatopoeic

Figure 3.1 Sample screenshot from Study 3. The participants simultaneously heard an onomatopoeic word on their headphones, which is not depicted in the figure.

word is heard at least once. After submitting their rating for an onomatopoeic word, another random adjective appeared on screen and a recording of a different onomatopoeic word was played. Before they started the experimental trials, participants completed 6 trials to familiarize with the experimental procedure, during

which all the necessary adjustments such as the audio volume were made, and any questions the participants had about the procedure were answered. The onomatopoeic words used in this section were not included in the experimental stimuli. Entire experiment was a single session and lasted around 40 minutes to complete.

3.1.2. Results

3.1.2.1. Principal Component Analysis

The experiment data was analyzed using the JAMOVI software (R Core Team 2018; The jamovi project, 2019). Similar to Study 1 and 2, the PCA was used to analyze the data for dimensionality reduction. I wanted to extract informative dimensions from a list of 29 adjectives. In total, 783 ratings from each participant (27 onomatopoeic words x 29 adjectives) were collected. Before initiating the PCA, the internal consistency of the data was checked by calculating the Cronbach's alpha levels for each adjective. Eleven of the total 29 adjectives yielded an "excellent" Cronbach's alpha value which is over .90, and 18 yielded a "good" value which is over .80 (Gliem & Gliem, 2003). This result shows that onomatopoeic words had high internal consistency as a group and the data was very suitable to move forward with further analysis (Table 3.2).

The responses were then over participants and calculated separately for each adjective and onomatopoeic word. The resulting data consisted of 27 rows (onomatopoeic words) and 29 columns (adjectives), which was used to conduct the PCA. The suitability of the data for PCA was checked using Bartlett's test of sphericity and Keiser-Meyer-Olkin (KMO) criterion. The KMO measure of sampling adequacy yielded a score of .535 which is above the required criteria of .5 for PCA. Bartlett's test of sphericity yielded a significant result, x^2 (210) = 995, $p < .001$, which suggests that observed correlations are meaningful. All these preliminary results showed that data were suitable for carrying out a PCA. Principal components were extracted using Kaiser normalization and varimax rotation. The PCA was carried out with eigenvalue

Table 3.2

Cronbach alpha values for adjectives used in Experiment 12

Adjective	**Cronbach Alpha**	**Adjective**	**Cronbach Alpha**	**Adjective**	**Cronbach Alpha**
airy	0.886	hard	0.866	slippery	0.849
compliant	0.949	inflexible	0.949	soft	0.856
delicate	0.923	malleable	0.952	spongy	0.916
doughy	0.877	moisturous	0.844	sticky	0.865
flexible	0.940	powdery	0.913	textured	0.954
fluffy	0.876	roughened	0.879	velvety	0.845
gelatinous	0.854	sandy	0.903	woody	0.864
glossy	0.935	scabby	0.875		
gooey	0.853	scaly	0.919		
granular	0.894	silky	0.869		
hairy	0.818	slimy	0.833		

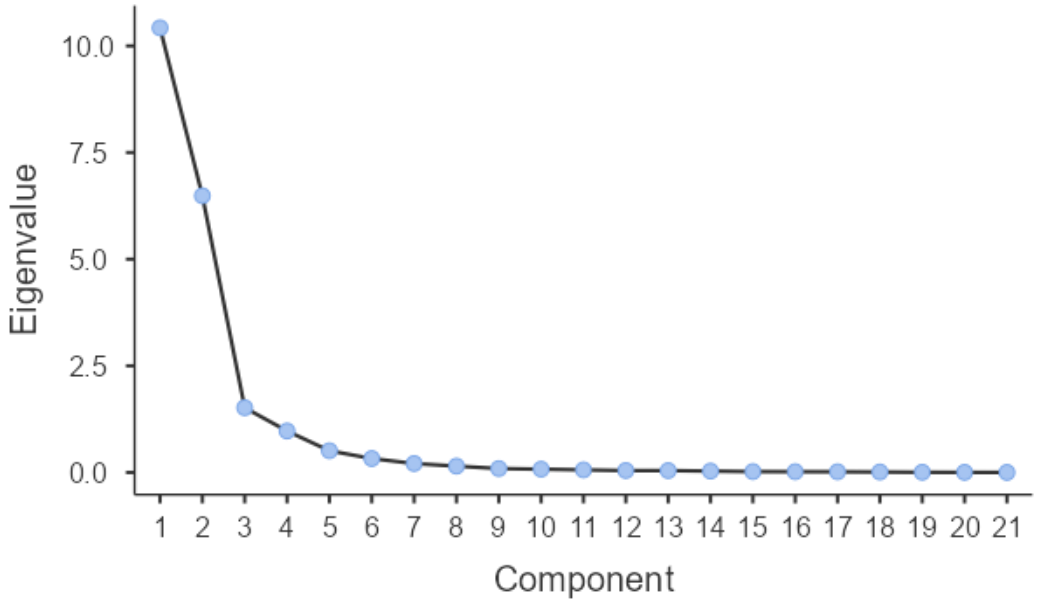


Figure 3.2 Scree plot for PCA of adjectives for Study 3. The x-axis shows all components that could possibly be extracted from the design (31). The y-axis shows the eigenvalues for the components. The dotted line is for eigenvalue = 1, which was the criterion used to extract components.

>1 which resulted in three dimensions. However, it was decided to force the number of components to four, since the fourth component had an eigenvalue of .97 and was greatly distant from the fifth component (eigenvalue = .5) (Table 3.3). The four components explained %92,36 of the total variability in the data. The four components explained %35.02, %32.91, %16.85, %7.58 of the variability in the data, respectively (Figure 3.3). The scree plot (Figure 3.2) displays the components based on their eigenvalues.

Table 3.3

Initial Eigenvalues

Component	Eigenvalue	% of Variance	Cumulative %
1	10.42312	49.63392	49.6
2	6.48563	30.88394	80.5
3	1.51689	7.22327	87.7
4	0.97146	4.62599	92.4
5	0.50814	2.41973	94.8

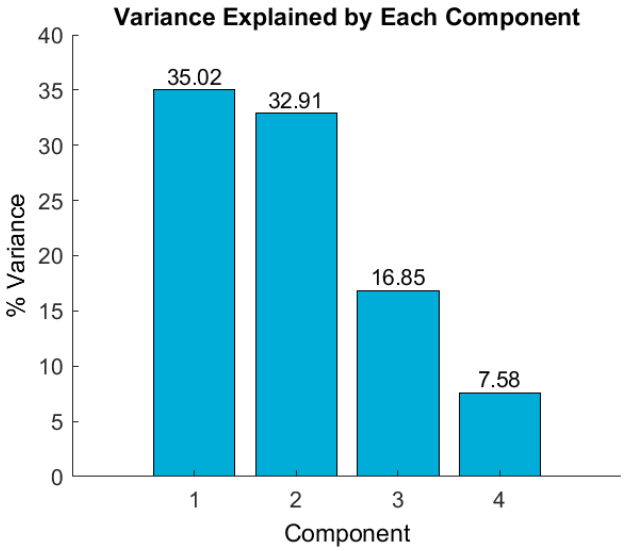


Figure 3.3 % Variance Explained by Each Component for Study 3. X-axis shows the components extracted from the analysis. The y-axis shows the % variance. Exact numbers for percentage are noted at the bar tips.

Table 3.4

Component Loadings from PCA for Study 3

	Component				
	1	2	3	4	Uniqueness
sticky	0.945				0.050
simy	0.944				0.041
gooey	0.928				0.014
gelatinous	0.924				0.081
moisturous	0.873		-0.324		0.084
slippery	0.837			-0.421	0.031
woody	-0.653	-0.629		0.308	0.046
roughened	-0.536	-0.515	0.524	0.348	0.052
velvety		0.937			0.101
hairy		0.919			0.100
silky		0.912			0.116
airy		0.899			0.155
fluffy		0.824			0.175
soft	0.486	0.799			0.048
hard	-0.604	-0.688			0.067
scabby	-0.609	-0.619	0.343		0.056
sandy	-0.327		0.915		0.046
scaly	-0.328	-0.347	0.824		0.091
powdery		0.393	0.802		0.086
granular	-0.404	-0.585	0.597		0.077
glossy				-0.902	0.076

Note. 'varimax' rotation was used

Table 3.4 shows the rotated factor loadings of each adjective in the four-factor solution. Factor one explained 35.02% of variance. Adjectives *sticky, slimy, gooey, gelatinous, moisturous, slippery, woody (-), roughened (-), soft, hard (-), scabby (-), sandy (-), scaly (-),* and *granular (-)* loaded in this factor. Because this factor seemed to be closely related to viscosity of materials, this factor was labeled Viscosity. The second factor explained 32.91% of variance. Adjectives *woody (-)*, *roughened (-), velvety, hairy, silky, airy, fluffy, soft, hard (-), scabby (-), scaly (-), powdery,* and *granular (-)* were loaded in this factor. The adjectives that were loaded in this factor seemed to relate to textile materials, therefore the second factor was labeled Surface Softness. The third factor explained 16.85% of the variance. Adjectives that loaded on this factor were *moisturous (-), roughened, scabby, sandy, scaly, powdery,* and

granular. This factor was therefore labeled Granularity. The fourth factor explained 7.85% of the variance. Adjectives *slippery (-), woody, roughened,* and *glossy (-)* were loaded on this factor. This factor was labeled Roughness. Appendix F displays the ratings obtained for each onomatopoeic word across all adjectives.

3.1.2.2. Multidimensional Scaling Analysis (MDS)

Similar to Study 1, multidimensional scaling analysis was applied to the averaged-over participant data in order to obtain a spatial distribution for spoken onomatopoeic words. The results show a clear distinction between four clusters that is determined by the distances between onomatopoeic words (Figure 3.4). Onomatopoeic words pofur pofur, efil efil, mışıl mışıl, mırıl mırıl, and tiril tiril are forming the first cluster. This corresponds to the dimension of Surface Softness based on the PCA results. Onomatopoeic words hışır hışır, lime lime, haşır huşur, and pıtır pıtır form the second cluster. These words are the ones that have received high ratings for the adjectives within the Granularity dimension of the PCA results. The third cluster is made of onomatopoeic words tıkır tıkır, çıt çıt, kırt kırt, kıtır kıtır, katur kutur, tak tak, kütür kütür, and tangur tungur. These words have received high ratings for the dimension Roughness on the PCA results. Finally, onomatopoeic words lıkır lıkır, şırıl şırıl, gıcır gıcır, şarıl şarıl, şıpır şıpır, şıp şıp, şapur şupur, şap şap, and vıcık vıcık are located close to each other and form the fourth cluster, which corresponds to the dimension of Viscosity based on the PCA results.

Obtaining four clusters in the MDS provides further support for the existence of four components for the dimensional distribution of spoken onomatopoeic words. As can be seen in Figure 3.4, the onomatopoeic words for the component *Roughness* create a distinct cluster, therefore supporting the decision to extract four dimensions, including an additional dimension for *Roughness* in the PCA solution.

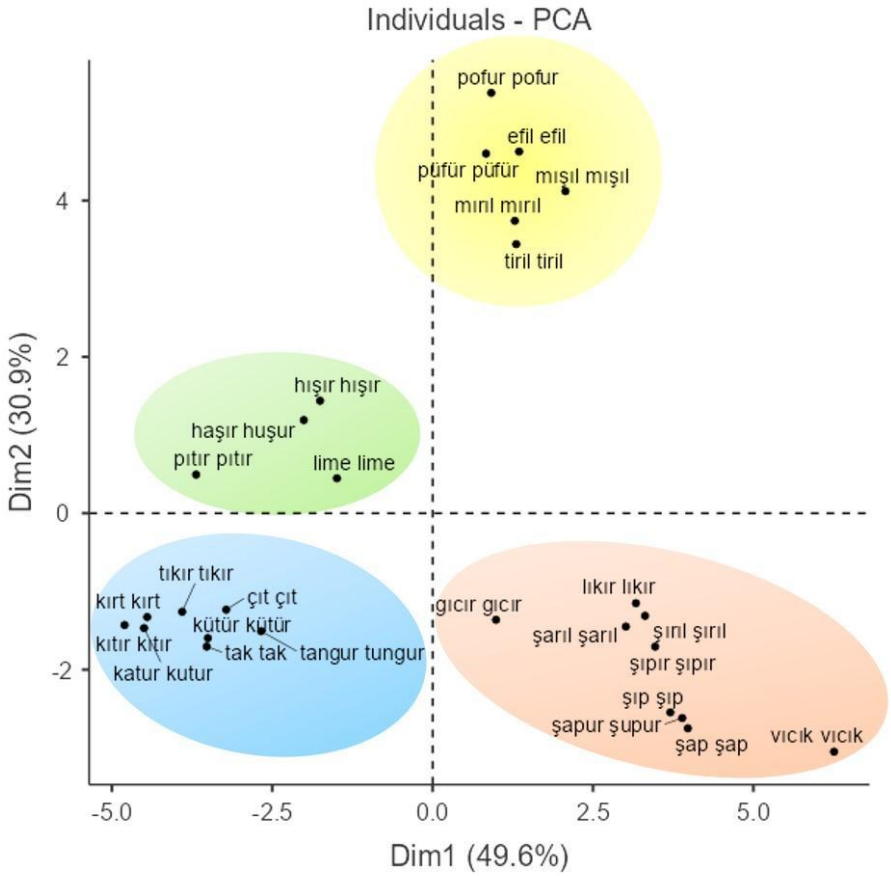


Figure 3.4 Individual plot showing the spatial distribution of onomatopoeic words. The colored circles were added afterwards to indicate the clusters.

3.1.3. Discussion

The findings of Study 3 were useful in understanding the association of spoken onomatopoeic words to perceived softness dimensions. It was hypothesized that the onomatopoeic words would have a similar dimensionality distribution to that of previous studies (Dövencioğlu et al., 2018, 2019, 2022; Cavdan et al., 2019) and to Study 1. A PCA was carried out which confirmed the existence of 4 dimensions that explain 92.36% of the variance in the data. These dimensions are Viscosity, Surface Softness, Granularity, and Roughness. Similar to Study 1, the Deformability dimension was not extracted using onomatopoeic words. This arguably results from

the fact that there are not many Turkish onomatopoeic words that are represented by the material sound as it is being deformed.

Figure 3.4 displays the ratings obtained for each onomatopoeic word for each adjective. A correlation between the adjective ratings and the meanings of the onomatopoeic words were observed. For instance, the adjective slippery had the highest ratings on words vıcık vıcık (ropy, sludgy, gooey, slushy), şap şap (kissing with a screed sound, alum alum), şıp şıp (making a 'flashing' sound, plop). Similarly, the adjective silky had high ratings on tiril tiril (crisp and clean, gauzy, floaty), efil efil (gently, intermittently and slowly (blowing wind, snowing, hair waving), and mışıl mışıl (sleeping peacefully and soundly, with a quiet and deep breath). This suggests that there is more at play than only sounds or physical characteristics of the words and letters, and the meanings of these words are strongly associated with the real-life objects whose sounds they were named after.

The results of Study 3 are similar to that of Study 1, which suggests that the written and spoken modalities of onomatopoeic words are both informative enough to make softness related judgements for materials. In this experiment, the onomatopoeic words were categorized based on the adjective list, and four dimensions were extracted from a list of 29 adjectives. This is the second study to be conducted using Turkish onomatopoeic words to study material perception, and first ever study to use the onomatopoeic words in the spoken form. Our results provide empirical evidence that sound-symbolic associations are observed for Turkish onomatopoeic words, and that sound-symbolism is associated to the perception of everyday objects.

3.2. Experiment 2: Effects of Spoken Onomatopoeic Words on Perceived Softness of Material Videos

This section includes an experiment (Experiment 2) conducted to see whether spoken onomatopoeic words has an effect on how softness perception of materials varies when materials are displayed as a 5 second exploratory video to participants and where the experiment is conducted in an experimental laboratory rather than being

conducted online as in Experiment 1. This experiment holds a similar methodological model to that of Experiment 1 (Chapter 2), where onomatopoeic words and materials are selected based on the PCA results of previous experiments (Study 3 for onomatopoeic words and Study 2 for materials) and congruency was used as the experimental manipulation where onomatopoeic words and materials were matched to be either congruent (both high or both low rated on respective adjectives) or incongruent (one high rated while the other is low rated for the respective adjectives),. However, Experiment 2 uses a selection of spoken onomatopoeic words that are gathered based on the results of Study 3, instead of written onomatopoeic words as in Experiment 1 (Chapter 2).

3.2.1. Method

3.2.1.1. Participants

The experiment was conducted at the Psychology Department within the Social Sciences Building at Middle East Technical University. All participants gave written consent prior to the experiment. Upon completing the experiment participants received course credits as compensation.

Data was from 30 participants (11 Male, M = 22.5, SD = 2.52), all but one was students at Middle East Technical University, and all were native Turkish speakers. Twenty-nine participants were right-handed and one participant was left-handed. All participants had normal or corrected to normal visual acuity and none reported having current or a history of hearing problems.

3.2.1.2. Stimuli

3.2.1.2.1. Onomatopoeic Words and Materials

The stimuli to be used in this study was selected based on the PCA results gathered from the previous two experiments: Study 3 (Chapter 3) and Study 2 (Chapter 2).

Only the common factors of both experiments were included in the selection process, resulting in four components: Viscosity, Surface Softness, Granularity, and Roughness (control). Adjective loadings for these factors were compared in both Experiments (Table 3.5) in order to select the same or similar factors to be used in the current experiment. The common adjectives that were loaded highest or lowest in both Experiments were selected as the 'Main Adjectives', on which the material and onomatopoeic word selection was based. There were six adjectives for Viscosity: *gelatinous*, *slimy*, *sticky*, *gooey*, *slippery*, and *moisturous*. There were three adjectives for Surface Softness: *silky*, *velvety*, and *hairy*. For Granularity, there were four adjectives: *sandy*, *powdery*, *granular*, and *scaly*. For the Roughness dimension, there was only one adjective found in both experiments: *roughened*. However, the adjective 'scaly' was removed since all the material loadings for this adjective were below 3.5/7 (highest being 2.9), resulting in 13 Main Adjectives.

After selecting the Main Adjectives, next the onomatopoeic words and materials were selected. For each Main Adjective, two onomatopoeic words (high and low rated) and two materials (high and low rated) were selected. High rated adjective was defined as a rating obtained for the said adjective above 3.5 out of 7. Low rated adjective was defined as being below 3.5 out of 7. Each adjective represented a softness dimension and all the adjectives and onomatopoeic words used were unique, that is, no stimulus (either material or onomatopoeic word) was used for more than one Main Adjective.

Onomatopoeic words and materials were paired to be either congruent (both high- or both low-rated) or incongruent (either high-rated while the other is low-rated). For example, shower gel was congruently paired with *şap şap* and incongruently paired with *tak tak*. Pairings were made for each Main Adjective separately, that is, each material was only paired with two onomatopoeic words selected for the same Main Adjective (Table 3.6).

3.2.1.2.2. Adjective List

Table 3.5.

PCA adjective loadings per component for the previous two experiments (Onomatopoeic Word – Study 3, Material – Study 2)

Component	Word Experiment	Material Experiment	Component	Word Experiment	Material Experiment
Viscosity	*sticky* *gooey* *slimy* *gelatinous* *moisturous* *slippery* woody (-) scabby (-) roughened (-) soft granular (-) hard (-) sandy (-) scaly (-)	*gooey* *gelatinous* *sticky* *moisturous* *slippery* glossy *slimy*	*Surface Softness*	woody (-) scabby (-) roughened (-) *velvety* *hairy* *silky* airy fluffy soft hard (-) granular (-) scaly (-) powdery (-) granular (-)	*silky* *velvety* *hairy*
Component	Word Experiment	Material Experiment	Component	Word Experiment	Material Experiment
Granularity	*sandy* *powdery* *scaly* *granular* roughened scabby moisturous (-) slippery (-)	*sandy* *powdery* *granular* *scaly*	*Roughness*	woody *roughened* slippery (-) glossy (-)	*roughened* textured

Thirteen adjectives of the previous list described in Study 2 (Chapter 2) and Study 3 (Chapter 3) were selected to be used in this experiment. These are the adjectives that were common to the PCA results of both the onomatopoeic word experiment (Study 3) and material experiment (Study 2). The adjectives are as follows: *gelatinous*, *slimy*, *sticky*, *gooey*, *slippery*, *moisturous*, *silky*, *velvety*, *hairy*, *sandy*, *powdery*, *granular*, and *roughened*. These are the same adjectives as the Main Adjectives which were used to select the onomatopoeic words and materials to be used in the current study.

3.2.2. Design and Procedure

Table 3.6
Stimuli List used in Experiment 2 based on the Main Adjectives and each adjective selected under the Main Adjectives

VISCOSITY

Gelatinous

Rating	*Word*	*Material*
High	*şap şap*	shower gel
Low	*tak tak*	wool

Slimy

Rating	*Word*	*Material*
High	*şıp şıp*	honey
Low	*kütür kütür*	chickpeas

Sticky

Rating	*Word*	*Material*
High	*şapur şupur*	slime
Low	*tangur tungur*	metal nuts

Gooey

Rating	*Word*	*Material*
High	*vıcık vıcık*	hair conditioner
Low	*çıt çıt*	green lentils

Slippery

Rating	*Word*	*Material*
High	*şıpır şıpır*	olive oil
Low	*tıkır tıkır*	matchstick

Moisturous

Rating	*Word*	*Material*
High	*şarıl şarıl*	handcream
Low	*lime lime*	foam

SURFACE SOFTNESS

Silky

Rating	*Word*	*Material*
High	*tiril tiril*	silk
Low	*katur kutur*	scourer

Silky

Rating	*Word*	*Material*
High	*mışıl mışıl*	velvet
Low	*kıtır kıtır*	stone

Velvety

Rating	*Word*	*Material*
High	*pofur pofur*	fur
Low	*haşır huşur*	cardboard pieces

GRANULARITY

Sandy

Rating	*Word*	*Material*
High	*hışır hışır*	sand
Low	*lıkır lıkır*	latex

Powdery

Rating	*Word*	*Material*
High	*püfür püfür*	flour
Low	*efil efil*	tulle

Granular

Rating	*Word*	*Material*
High	*pıtır pıtır*	poppy seeds
Low	*şırıl şırıl*	shaving cream

ROUGHENED

Roughened

Rating	*Word*	*Material*
High	*kırt kırt*	sandpaper
Low	*gıcır gıcır*	balloon

The experiment had one continuous dependent variable (Adjective Ratings) and 3 categorical independent variables (Main adjective, 13 levels; Onomatopoeic Word Rating, 2 levels; Material Rating, 2 levels). The design of the experiment is 13 (main adjective) x 2 (word rating; high or low) x 2 (material rating; high or low) x 13 (DV, adjective rating), resulting in 676 total trials. Before the experiment, participants completed 6-trials to familiarize with the procedure.

The experiment was conducted on a HP ENVY dv6 laptop using MATLAB R2020b and Psychtoolbox-3 and the responses were gathered by a standard mouse that was connected to the laptop via cable. Audio stimuli was presented using Sennheiser SK-507364 HD 206 headphones. The recordings used in the experiment were a selection of those used in Study 3, detailed technical information on the recording process can therefore be found in Chapter 3. Similarly, the material videos are the same as in Study 2, the detailed information for which can be found in Chapter 2.

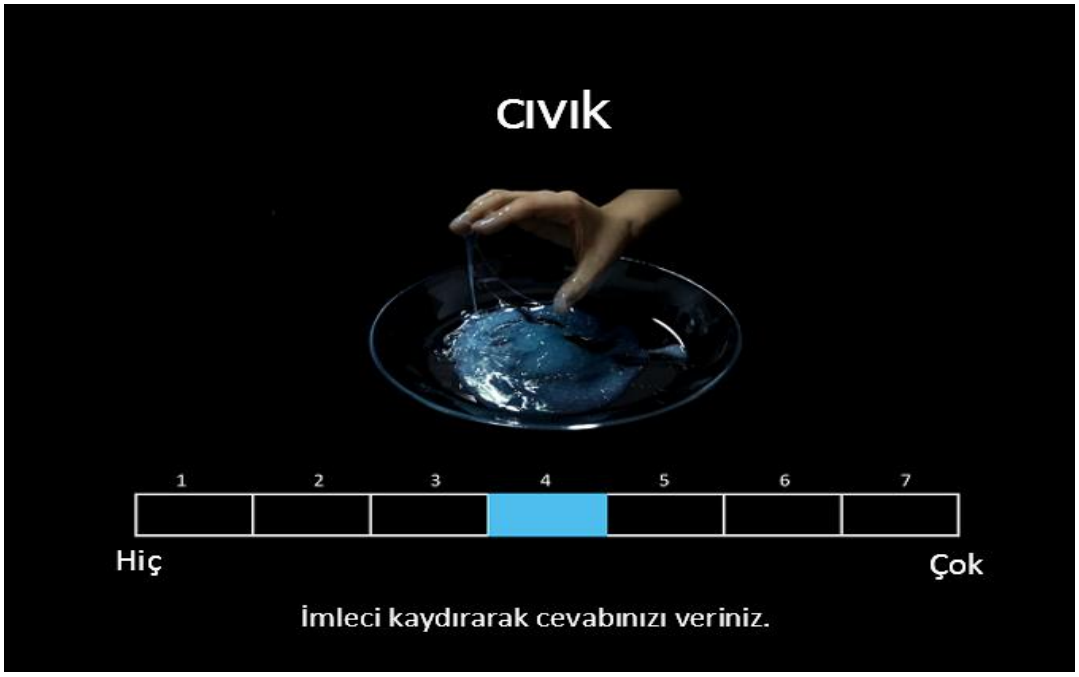


Figure 3.5 Sample trial screenshot from Experiment 2. Audio is not depicted in image, the adjective *'cıvık'* is displayed above the video of a material (i.e., shower gel) and the rating scale between 1 and 7 is displayed below.

During the experiment, participants heard a recording of spoken onomatopoeic word on a loop on their headphone while watching an exploratory video of a material that lasted for 5 seconds. They were also presented with an adjective written on top of the video, and a rating scale between 1 (Not at all) and 7 (Very) below the video. They were instructed to rate each pair of onomatopoeic word and material based on how well they think the combination matched the adjective displayed on screen. The responses were collected via mouse click by sliding the box on the scale. All conditions were randomly presented to each subject.

Each session lasted approximately 45 minutes. Participants were given a maximum of 10 minutes break once they complete the first half of the trials. During the break, participants remained in the experiment waiting room and use of any electrical devices was not allowed to assure minimum distraction from the experiment.

3.2.3. Results

The data was analyzed using the software JASP (JASP Team, 2022). In total, we collected 676 ratings from each participant (13x13x2x2). Thirteen repeated-measure ANOVAs were conducted to compare the effect of congruency on adjective ratings, each Main Adjective was analyzed separately. To correct for multiple comparisons, Bonferroni correction was used, resulting in $\alpha = .05/13 = .003$. The interaction effect of Onomatopoeic Word * Material was hypothesized to be significant for all Main Adjectives, which would suggest there is an effect of congruency on adjective ratings. Main effect of Adjective was observed for all 13 ANOVAs, the main effect of Onomatopoeic Word was observed for 8 out of 13 ANOVAs, and the main effect of Material was observed for 8 out of 13 ANOVAs (Table 4.3).

The main effect of Adjective was statistically significant for all 13 ANOVAs: Gelatinous ($F(12, 348) = 15.85$, $p < .001$, $\eta^2_p = .35$), Slimy ($F(12, 348) = 14.21$, $p < .001$, $\eta^2_p = .33$), Sticky ($F(12, 348) = 27.65$, $p < .001$, $\eta^2_p = .49$), Gooey ($F(12, 348) = 18.89$, $p < .001$, $\eta^2_p = .39$), Slippery ($F(12, 348) = 17.47$, $p < .001$, $\eta^2_p = .38$), Moisturous ($F(12, 348) = 11.21$, $p < .001$, $\eta^2_p = .28$), Silky ($F(12, 348) = 16.33$, $p < .001$, η^2_p

= .36), Velvety (F(12, 348) = 21.78, p <.001, η^2_p = .43), Hairy (F(12, 348) = 13.83, p <.001, η^2_p = .32), Sandy (F(12, 348) = 9.04, p <.001, η^2_p = .24), Powdery (F(12, 348) = 20.32, p <.001, η^2_p = .41), Granular (F(12, 348) = 8.89, p <.001, η^2_p =.23), and Roughened (F(12, 348) = 11.75, p <.001, η^2_p = .29).

The main effect of Onomatopoeic Word was significant 8 out of 13 ANOVAs: Gelatinous (F(1,29) = 154.6, p < .001, η^2_p = .84), Slimy (F(1,29) = 40.84, p <.001, η^2_p = .59), Sticky (F(1,29) = 11.7, p <.001, η^2_p = .29), Gooey (F(1,29) = 31.32, p < .001, η^2_p = .52), Slippery (F(1,29) = 73.38, p <.001, η^2_p = .72), Moisturous (F(1,29) = 11.37, p < .001, η^2_p = .28), Hairy (F(1,29) =11.79, p <.001, η^2_p = .29), and Sandy (F(1,29) = 21.61 p <.001, η^2_p = .43). The remaining five were not significant: Silky (F(1,29) = 7.4, p = .011, η^2_p = .2), Velvety (F(1,29) = .17, p = .687, η^2_p = .01), Powdery (F(1,29) = .38, p = .541, η^2_p = .01), Granular (F(1,29) = 2.36, p = .135, η^2_p = .07) and Roughened (F(1,29) = 7.41, p = .012, η^2_p = .19).

The main effect of Material was significant for 8 out of 13 ANOVAs: Gelatinous (F(1,29) = 103.9, p < .001, η^2_p = .78), Slimy (F(1,29) = 13.98, p <.001, η^2_p = .33), Gooey (F(1,29) = 39.42, p < .001, η^2_p = .58), Slippery (F(1,29) = 42.06, p <.001, η^2_p = .59), Velvety (F(1,29) = 10.36, p <.001, η^2_p = .26), Hairy (F(1,29) = 44.6, p <.001, η^2_p = .61), Sandy (F(1,29) = 23.34 p <.001, η^2_p = .45), and Roughened (F(1,29) = 13.43, p <.001, η^2_p = .32). The remaining five were not significant: Sticky (F(1,29) = 10, p = .004, η^2_p = .26), Moisturous (F(1,29) = .59, p = .448, η^2_p = .02), Silky (F(1,29) = 7.4, p = .011, η^2_p = .2), Powdery (F(1,29) = .38, p = .541, η^2_p = .01), Granular (F(1,29) = 2.36, p = .135, η^2_p = .07).

The interaction effect of Adjective * Onomatopoeic Word significant for 11 out of 13 ANOVAs: Gelatinous (F(12, 348) = 12.73, p < .001, η^2_p = .31), Slimy (F(12, 348) =11.48, p <.001, η^2_p = .28), Sticky (F(12, 348) = 13.11, p <.001, η^2_p = .31), Gooey (F(12, 348) = 15.67, p < .001, η^2_p = .35), Slippery (F(12, 348) = 13.15, p <.001, η^2_p = .31), Moisturous (F(12, 348) = 6.71, p < .001, η^2_p = .19), Silky (F(12, 348) = 6.93, p <.001, η^2_p = .19), Velvety (F(12, 348) = 8.57, p <.001, η^2_p = .23), Sandy (F(12, 348) = 6.84, p <.001, η^2_p = .19), Granular (F(12, 348) = 8.66, p <.001, η^2

$_p$ =.23), and Roughened (F(12, 348) = 3.98, p <.001, η^2_p = .12). The remaining two were not significant: Hairy (F(12, 348) = 2.64, p = .011, η^2_p = .08), Powdery (F(12, 348) = 1.63, p = .11, η^2_p = .05).

Table 3.7.

ANOVA results for adjectives in Experiment 2

	Gelatinous		Slimy		Sticky		Gooey		Slippery		Moisturous	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Adjective	15.85*	0.35	14.21*	0.33	27.65*	0.49	18.89*	0.39	17.47*	0.38	11.21*	0.28
Word	154.60*	0.84	40.84*	0.59	11.7*	0.29	31.32*	0.52	73.38*	0.72	11.37*	0.28
Material	103.99*	0.78	13.98*	0.33	10	0.26	39.42*	0.58	42.06*	0.59	0.59	0.02
Adjective * Word	12.73 *	0.31	11.48*	0.28	13.11*	0.31	15.67*	0.35	13.15*	0.31	6.71*	0.19
Adjective * Material	23.25 *	0.45	26.62*	0.48	22.38*	0.44	28.13*	0.49	17.16*	0.37	18.84*	0.39
Word * Material	52.11 *	0.64	49.72*	0.63	69.23*	0.71	82.65*	0.74	58.88*	0.67	24.63*	0.46
Adjective * Word * Material	5.50 *	0.16	2.64*	0.08	3.43*	0.11	2.27	0.07	2.34	0.08	0.72	0.02

Note. * donates a statistical significant effect for α = .003

The interaction effect of Adjective * Material was significant for all 13 ANOVAs: Gelatinous (F(12, 348) = 23.25, p < .001, η^2_p = .45), Slimy (F(12, 348) = 26.62, p <.001, η^2_p = .48), Sticky (F(12, 348) = 22.38, p <.001, η^2_p = .44), Gooey (F(12, 348) = 28.13, p < .001, η^2_p = .49), Slippery (F(12, 348) = 17.16, p <.001, η^2_p = .37), Moisturous (F(12, 348) = 18.84, p < .001, η^2_p = .39), Silky (F(12, 348) = 8.49, p <.001, η^2_p = .23), Velvety (F(12, 348) = 18.52, p <.001, η^2_p = .39), Hairy (F(12, 348) = 9.36, p <.001, η^2_p = .24), Sandy (F(12, 348) = 14.02, p <.001, η^2_p = .33), Powdery (F(12, 348) = 4.94, p <.001, η^2_p = .15), Granular (F(12, 348) = 26.23, p <.001, η^2_p =.47), and Roughened (F(12, 348) = 5.2, p <.001, η^2_p = .15).

There was a statistically significant Onomatopoeic Word * Material interaction effect for 10 out of 13 ANOVAs at a level of alpha < .003 : Gelatinous (F(1,29) = 52.1, p < .001, η^2_p = .64), Slimy (F(1,29) = 49.7, p <.001, η^2_p = .63), Sticky (F(1,29) = 69.2, p <.001, η^2_p = .70), Gooey (F(1,29) = 82.6, p < .001, η^2_p = .74), Slippery (F(1,29) = 58.9, p <.001, η^2_p = .67), Moisturous (F(1,29) = 24.6, p < .001, η^2_p = .46), Silky (F(1,29) =24.7, p <.001, η^2_p = .75), Velvety (F(1,29) = 29.8, p <.001, η^2_p = .51), Granular (F(1,29) = 11.9, p <.001, η^2_p =.29), Roughened (F(1,29) = 17.8, p <.001, η^2_p = .38). No significant Onomatopoeic Word * Material interaction effect was observed for Main Adjectives Hairy (F(1,29) = 1.14, p =.29, η^2_p = .04), Sandy (F(1,29) = .623, p = .43, η^2_p = .02), and Powdery (F(1,29) = 3.45, p = .07, η^2_p = .1) (Table 4.3). This interaction effect is the congruency effect and thus was hypothesized to be significant for all Main Adjectives. However, we were not able to observe a significant effect for the Main Adjectives hairy, sandy, and powdery. This could be in due to the stimuli selected to represent these adjectives.

Table 3.7. continued

ANOVA results for adjectives in Experiment 2

	Silky		Velvety		Hairy	
	F	η^2_p	F	η^2_p	F	η^2_p
Adjective	16.33*	0.36	21.78*	0.43	13.83*	0.32
Word	7.4	0.20	0.17	0.01	11.79*	0.29
Material	6.37	0.18	10.36*	0.26	44.60*	0.61
Adjective * Word	6.93*	0.19	8.57*	0.23	2.64	0.08
Adjective * Material	8.49*	0.23	18.52*	0.39	9.36*	0.24
Word * Material	24.75*	0.46	29.9*	0.51	1.14	0.04
Adjective * Word * Material	1.59	0.05	2.71	0.08	1.29	0.04

Note. * donates a statistical significant effect for α = .003

For the interaction effect of Adjective * Onomatopoeic Word * Material, only 4 out of 13 ANOVAs were significant: Gelatinous (F(12, 348) = 5.5, p < .001, η^2_p = .16), Slimy (F(12, 348) = 2.64, p <.001, η^2_p = .08), Sticky (F(12, 348) = 3.43, p <.001, η^2_p = .11), Roughened (F(1,29) = .44, p <.001, η^2_p = .01). Although these results

were significant, the effect sizes for them were very small, especially for Roughness. No significant effect was seen for the remaining 9 ANOVAs: Gooey (F(12, 348) = 2.27, p = .009, η^2_p = .07), Slippery (F(12, 348) = 2.34, p = .007, η^2_p = .08), Moisturous (F(12, 348) = .72, p = .66, η^2_p = .02), Silky (F(12, 348) = 1.59, p = .14, η^2_p = .05), Velvety (F(12, 348) = 2.71, p = .009, η^2_p = .08), Hairy (F(12, 348) = 1.29, p = .22, η^2_p = .04), Sandy (F(12, 348) = 1.27, p = .23, η^2_p = .04), Powdery (F(12, 348) = .87, p = .53, η^2_p = .03), Granular (F(12, 348) = 2.04, p = .02, η^2_p =.07).

Table 3.7. continued

ANOVA results for adjectives in Experiment 2

	Sandy		Powdery		Granular		Roughened	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Adjective	9.04*	0.24	20.32*	0.41	8.89*	0.23	11.75*	0.29
Word	21.61*	0.43	0.38	0.01	2.36	0.07	7.14	0.19
Material	23.34*	0.45	0.96	0.03	2.43	0.08	13.43*	0.32
Adjective * Word	6.84*	0.19	1.63	0.05	8.66*	0.23	3.98*	0.12
Adjective * Material	14.02*	0.33	4.94*	0.15	26.23*	0.47	5.2*	0.15
Word * Material	0.62	0.02	3.45	0.11	11.94*	0.29	17.85*	0.38
Adjective * Word * Material	1.27	0.04	0.87	0.03	2.04	0.07	0.44*	0.01

Note. * donates a statistical significant effect for α = .003

Post-hoc analyses using Bonferroni indicated several significant effects for congruency (Figure 3.6). Within the high rated materials, mean onomatopoeic word rating difference for shower gel (Gelatinous), honey (Slimy), slime (Sticky), and hair conditioner (Gooey) was significant for the adjectives gelatinous, slimy, sticky, gooey, slippery, and moisturous, making up all the adjectives selected for Viscosity dimension. For instance, shower gel ratings were significantly higher for adjectives gelatinous, slimy, sticky, gooey, slippery, and moisturous, however the difference was small and not significant for powdery, sandy, granular, silky, hairy, velvety, and roughened. For olive oil (Slippery) the difference was significant for gelatinous, slimy, sticky, gooey, and slippery, but not moisturous. For hand cream (Moisturous), the

difference was only significant for adjectives sticky, slippery, and moisturous. For these results the ratings were significantly higher when the materials were presented together with a high rated onomatopoeic word compared to when they are presented with a low rated onomatopoeic word, suggesting the manipulation of congruency was successful. In materials from Surface Softness dimension, for silk (Silky) the difference was significant for adjectives moisturous and silky. For velvet (Velvety) the difference was only significant for adjective silky. For fur (Hairy), no significant differences were found.

In materials from Granularity dimension, there was a significant difference for sand (Sandy) for adjective powdery ratings. For flour (Powdery), no significant differences were observed. For poppy seeds (Granular) the difference was significant for the adjectives powdery and granular ratings. For the Roughness dimension, we found no significant difference for sandpaper (Roughened) for any of the adjectives.

Overall, for high-rated materials, the significant differences were observed mostly for adjectives that are within the same dimension as the materials.

Within the low-rated materials, there were fewer instances where we observed overall significant differences. For chickpeas (Slimy), and cardboard pieces (Hairy), the difference was only significant for adjective roughened. For metal nuts (Sticky), matchstick (Slippery), and stone (Velvety), the difference was significant for adjectives granular and roughened. For green lentils (Gooey), the difference was significant for adjectives sandy and granular.

Overall, with the low-rated materials the manipulation of congruency did not seem to successfully work. For instance, we expected to manipulate the ratings, such as obtaining a positive mean rating difference in latex for the adjective sandy. This might be because when the material in question is not related to the adjective displayed on the screen (e.g., low-rated materials) participants might have disregarded the onomatopoeic word that they heard and solely focused on the properties of the material. However, when the materials were related to adjectives (e.g., high rated

materials), the ratings were affected by whether or not the onomatopoeic words were also related to that adjective. Green lentils was rated sandier when presented with 'çıt çıt' compared to when presented with 'vıcık vıcık'; stone was rated more granular when presented with 'kıtır kıtır' compared to 'mışıl mışıl' (Appendix G).

Even though we obtained several significant differences for the dimensions of Surface Softness, Granularity, and Roughness, the rating difference between the congruent and the incongruent condition for the High rated materials seems to be more prevalent for adjectives (and therefore materials) related to the Viscosity dimension.

3.2.3. Discussion

This experiment was conducted to test whether there is an effect of spoken onomatopoeic words on perceived softness of materials. With the current experimental design, we were able to observe a significant effect of congruency, which refers to the interaction effect of Onomatopoeic Word * Material, in 10 out of the 13 ANOVAs. These results suggest that we managed to support our hypothesis. We did not observe a significant effect of congruency for the Main Adjectives Hairy, Sandy, and Powdery. This might be caused by the materials and the onomatopoeic words that were chosen to represent these Main Adjectives. Because we selected the materials from previous experiments, and we wanted to select a unique material for each of the Main Adjectives so no material or onomatopoeic word would be used more than once, the options were somewhat limited during selection. For example, the materials fur (high) and cardboard pieces (low) were selected for the Main Adjective Hairy, along with the onomatopoeic words *pofur pofur* (high) and *haşır huşur* (low). The principle was followed in the same manner as when selecting for other Main Adjectives, and the materials and onomatopoeic words that have received the highest rating for each adjective was selected unless it had already been selected for another Main Adjective. This may have resulted in this selection for Hairy to be less representative than it could potentially have been with better rated materials.

Although the congruency effect was significant for 10 out of 13 ANOVAs, the effect sizes were generally larger for the Main Adjectives that were selected for Viscosity dimension. It appears that when a material from Viscosity dimension is presented with a congruent onomatopoeic word, the rating for related adjectives is high, however when presented with an incongruent onomatopoeic word, the ratings drastically lower for the same adjective. This could be because neither the onomatopoeic word or the material has greater saliency when participants are making their judgements, instead they did in fact consider both the onomatopoeic word and the material. The reason why the effect sizes and rating differences are smaller in other dimensions compared to the Viscosity dimension could be because the materials selected for other Main Adjectives in the dimension Surface Softness, Granularity, and Roughness were more salient than the onomatopoeic words, and even though the difference is significant, the actual rating difference was small.
Overall, the significant differences for each Main Adjective were observed for the adjectives that also belong to that dimension. For example, for Main Adjective Silky, the significant differences were observed for adjectives *silky* and *velvety.* This trend is also very prevalent in Main Adjectives belonging to the Viscosity dimension. This result suggests that the material selection was successful and we managed to identify the materials that best represent the Main Adjective, with the exception of Hairy, Sandy, and Powdery.

This experiment is the first to demonstrate an effect of Turkish onomatopoeic words on perceived softness of materials. We were able to gather softness dimensions in previous experiments, and in this experiment, we were successful in using the onomatopoeic word in one modality (auditory) and the materials in a different modality (visual) and manipulate the softness related adjective ratings.

CHAPTER 4

EXPERIMENT 3

This chapter includes an experiment (Experiment 3) which was conducted to see whether written onomatopoeic words effect softness perception of materials, and to see whether there would be a significant difference between the modality of onomatopoeic words. Experiment 3 was conducted to specifically to compare the written and spoken forms of onomatopoeic words. Experiment 3 holds a very similar design to that of Experiment 2, and uses the same pairing as stimuli. The difference between Experiment 2 and 3 is that, Experiment 2 presented the onomatopoeic words in the spoken modality, whereas Experiment 3 presented the onomatopoeic words in the visual modality. All other aspects of experimental design and material selection are identical to Experiment 2. Here, again, the manipulation was 'congruency', and onomatopoeic words and materials were matched to be either congruent of incongruent with each other.

4.1. Method

4.1.1. Participants

The experiment was conducted at the Psychology Department within the Social Sciences Institute at Middle East Technical University. All participants gave written consent prior to the experiment and after completing the experiment participants received course credits as compensation.

Data were collected from 30 participants (15 Male, *M* = 23.51, *SD* = 2.93). All participants were native Turkish speakers. Three participants were left-handed. All participants had normal or corrected to normal visual acuity, and none reported having current or a history of hearing problems.

4.1.2. Stimuli

4.1.2.1. Onomatopoeic Words and Materials

The stimuli to be used in this experiment is identical to that used in Experiment 2. For detailed descriptions in the stimuli selection process, refer to Chapter 3.2. A significant difference between Experiment 2 and Experiment 3 is the modality of onomatopoeic word presentation. Experiment 2 used the auditory modality and presented the onomatopoeic words in spoken word form over the participants' headphones, while they were simultaneously watching the material video on screen. Experiment 3 uses the visual modality and the onomatopoeic word is displayed on screen in written word form, simultaneously as the material video is playing. Another difference between the experiments is regarding the location of the adjective (DV) on test screen. Experiment 2 presented the adjective above the material video. However, in Experiment 3, the on-screen flow of stimuli is as follows: On top, there is the onomatopoeic word in written form. Right under the onomatopoeic word, there is the material video (displayed here in the same resolution and location as Experiment 2). Under the video, there is the adjective which the rating is going to be made on. The decision to move the adjective from above the video to below was made to ensure the participants would easily follow the stimuli displayed on screen without confusion. Figure 4.1 displays a sample screenshot from the experiment.

There are a total of 13 'Main Adjectives' which the stimulus selection was made for. There were six adjectives for Viscosity: gelatinous, slimy, sticky, gooey, slippery, and moisturous; three for Surface Softness: silky, velvety, and hairy; four for Granularity: sandy, powdery, granular, and scaly; and finally only one adjective for the Roughness dimension: roughened.

Onomatopoeic words and materials were, same as in Experiment 2, paired to be either congruent or incongruent. For example: material *slime* was congruently paired with the onomatopoeic word 'şapur şupur', and incongruently paired with the onomatopoeic word 'tangur tungur'. Similarly, material *silk* was congruently paired with 'tiril tiril', and incongruently paired with the onomatopoeic word 'katur kutur'. All pairings based on the respective Main Adjectives can be found on Table 3.6.

4.1.2.2. Adjective List

The adjective list is the identical list to that used in Experiment 2. The adjectives for that study were selected based on the PCA loadings of Study 2 (Chapter 2) and Study 3 (Chapter 3).

The adjectives are as follows: gelatinous, slimy, sticky, gooey, slippery, moisturous, silky, velvety, hairy, sandy, powdery, granular, and roughened. This list of adjectives is used both as the Main Adjectives, and as the dependent variable were the ratings are collected.

4.1.3. Design and Procedure

The experimental design is identical to that of Experiment 2, with the only difference being the modality of the onomatopoeic word presentation. The experiment had one continuous dependent variable (Adjective Ratings) and 3 categorical independent variables (Main adjective, 13 levels; Onomatopoeic Word Rating, 2 levels; Material Rating, 2 levels). The design of the experiment is 13 (main adjective) x 2 (word rating; high or low) x 2 (material rating; high or low) x 13 (DV, adjective rating), resulting in 676 total trials. Before the experiment started, participants were given instructions as to how to complete the trials, and they complete 6-trials (with non-experimental stimuli) while the experimenter is present in the room to familiarize with the experimental procedure. After participants completed this first step, the experimenter then left the room and participants started the experiment.

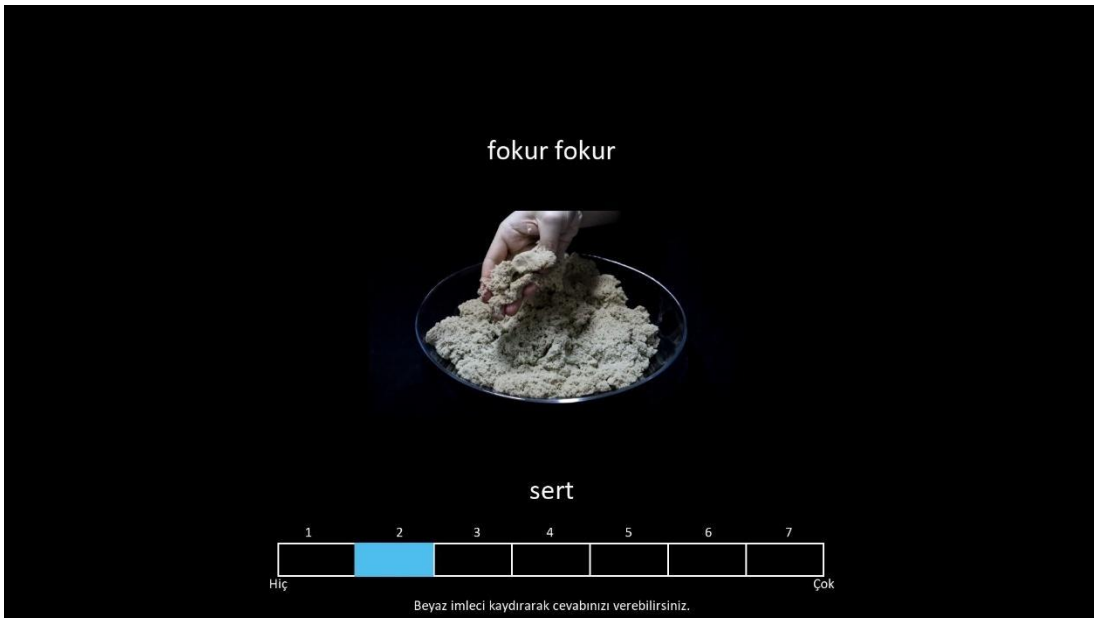


Figure 4.1 Sample trial screenshot from Experiment 3. The onomatopoeic word 'fokur fokur' is at the top, the adjective *'sert'* is displayed below the video of a material (i.e., kinetic sand) and the rating scale between 1 and 7 is displayed below.

The experiment was conducted on an ASUS N550J laptop using MATLAB R2020b and Psychtoolbox-3. The participant responses were collected by a standard mouse that was connected to the laptop via cable. Material videos that are used in the study are the same videos created for Study 2 (Chapter 2) and detailed information about the videos can be found in Chapter 2.

Each trial of the experiment consisted of an onomatopoeic word and material pair (either a congruent or incongruent pair) that was displayed on the screen together, the adjective which the rating was being made on, and the rating bar on screen. During the experiment, participants saw the onomatopoeic word written above the material video, the material video at the center of the screen that played for 5 seconds, and the adjective below the material video. Below these were the rating scale that ranged between 1 (Not at all) to 7 (Very).

The participants were instructed to rate each pair of onomatopoeic word and material based on how well they think the combination matched the adjective displayed on screen. All responses were collected via mouse click, where participants were able to slide the bar freely and make a decision between 1 and 7. The order of the experimental stimuli was randomized completely for each participant.

Each session lasted approximately 40 minutes. Participants had the chance to take a 10-minute break upon completing the first half of the trials. During the break, they remained in the waiting room without using any devices that could cause distraction from the experiment. This procedure was the same as in Experiment 2.

4.2. Results

The data was analyzed using the software JASP (JASP Team, 2022). In total, 676 ratings were collected from each participant (13x13x2x2). Thirteen repeated-measure ANOVAs were conducted to compare the effect of congruency on adjective ratings, analyzing each Main Adjective separately. Bonferroni correction was used to correct for multiple comparisons, resulting in $\alpha = .05/13 = .003$. Similar to Experiment 1 and 2, the interaction effect of Onomatopoeic Word * Material was hypothesized to be significant for all Main Adjectives. This interaction corresponds to the *congruency* for onomatopoeic word and material pairings. A significant interaction effect would therefore suggest an effect of congruency on adjective ratings. Main effect of Adjective was observed for all 13 ANOVAs, the main effect of Onomatopoeic Word was observed for 5 out of 13 ANOVAs, and the main effect of Material was observed for 10 out of 13 ANOVAs (Table 4.1).

The main effect of Adjective was statistically significant for all 13 ANOVAs: Gelatinous ($F(12, 348) = 22.11$, $p < .001$, $\eta^2_p = .43$), Slimy ($F(12, 348) = 13.73$, $p < .001$, $\eta^2_p = .32$), Sticky ($F(12, 348) = 24.6$, $p < .001$, $\eta^2_p = .46$), Gooey ($F(12, 348) = 75.53$, $p < .001$, $\eta^2_p = .34$), Slippery ($F(12, 348) = 15.21$, $p < .001$, $\eta^2_p = .34$), Moisturous ($F(12, 348) = 20.23$, $p < .001$, $\eta^2_p = .41$), Silky ($F(12, 348) = 12.66$, $p < .001$, $\eta^2_p = .3$), Velvety ($F(12, 348) = 24.17$, $p < .001$, $\eta^2_p = .45$), Hairy ($F(12, 348) = 29.74$,

p <.001, η^2_p = .50), Sandy (F(12, 348) = 13.75, p <.001, η^2_p = .32), Powdery (F(12, 348) = 28.11, p <.001, η^2_p = .49), Granular (F(12, 348) = 8.92, p <.001, η^2_p =.06), and Roughened (F(12, 348) = 10.6, p <.001, η^2_p = .27).

The main effect of Onomatopoeic Word was significant 5 out of 13 ANOVAs: Gelatinous (F(1,29) = 43.13, p < .001, η^2_p = .06), Slimy (F(1,29) = 40.33, p <.001, η^2_p = .58), Gooey (F(1,29) = 41.5, p < .001, η^2_p = .59), Slippery (F(1,29) = 13.65, p <.001, η^2_p = .32), and Sandy (F(1,29) = 11.56 p <.001, η^2_p = .28). The remaining eight were not significant: Sticky (F(1,29) = 2.66, p = .11, η^2_p = .08), Moisturous (F(1,29) = 0.35, p = .55, η^2_p = .01), Hairy (F(1,29) =2.56, p = .12, η^2_p = .08), Silky (F(1,29) = 2.36, p = .135, η^2_p = .07), Velvety (F(1,29) = 1.63, p = .211, η^2_p = .05), Powdery (F(1,29) = 0.02, p = .88, η^2_p < .001), Granular (F(1,29) = 4.1, p = .05, η^2_p = .001) and Roughened (F(1,29) = 5.18, p = .03, η^2_p = .15).

Table 4.1

ANOVA results for adjectives in Experiment 3

	Gelatinous		Slimy		Sticky		Gooey		Slippery		Moisturous	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Adjective	22.11*	0.43	13.73*	0.32	24.6*	0.46	75.53*	0.34	15.21*	0.34	20.23*	0.41
Word	43.13*	0.6	40.33*	0.58	2.664	0.08	41.50*	0.59	13.65*	0.32	0.35	0.01
Material	126.91*	0.81	64.83*	0.69	27.55*	0.49	84.34*	0.74	54.76*	0.65	19.6*	0.40
Adjective * Word	2.84*	0.09	4.63*	0.14	6.65*	0.19	7.13*	0.2	7.12*	0.2	2.44	0.08
Adjective * Material	40.18*	0.58	43.37*	0.6	54.42*	0.65	48.38*	0.62	26.54*	0.48	47.91*	0.62
Word * Material	24.26*	0.45	29.6*	0.5	30.19*	0.51	42.22*	0.6	33.98*	0.54	14.68*	0.33
Adjective * Word * Material	3.13	0.1	2.44	0.8	1.99	0.06	1.43	0.05	1.00	0.03	1.39	0.04

Note. * donates a statistical significant effect for α = .003

The main effect of Material was significant for 10 out of 13 ANOVAs: Gelatinous ($F(1,29) = 126.91$, $p < .001$, $\eta^2_p = .43$), Slimy ($F(1,29) = 64.83$, $p < .001$, $\eta^2_p = .58$), Sticky ($F(1,29) = 27.55$, $p < .001$, $\eta^2_p = .49$), Gooey ($F(1,29) = 84.34$, $p < .001$, $\eta^2_p = .74$), Slippery ($F(1,29) = 54.76$, $p < .001$, $\eta^2_p = .65$), Moisturous ($F(1,29) = 19.6$, $p = .448$, $\eta^2_p = .40$), Silky ($F(1,29) = 18.14$, $p = .011$, $\eta^2_p = .38$), Hairy ($F(1,29) = 86.53$, $p < .001$, $\eta^2_p = .74$), Powdery ($F(1,29) = 15.12$, $p < .001$, $\eta^2_p = .34$), and Sandy ($F(1,29) = 46.93$, $p < .001$, $\eta^2_p = .61$). The remaining three were not significant: Velvety ($F(1,29) = 9.86$, $p = .004$, $\eta^2_p = .25$), Granular ($F(1,29) = 0.86$, $p = .36$, $\eta^2_p < .001$), and Roughened ($F(1,29) = 0.87$, $p = .35$, $\eta^2_p = .03$).

The interaction effect of Adjective * Onomatopoeic Word significant for 6 out of 13 ANOVAs: Gelatinous ($F(12, 348) = 2.84$, $p < .001$, $\eta^2_p = .09$), Slimy ($F(12, 348) = 4.63$, $p < .001$, $\eta^2_p = .14$), Sticky ($F(12, 348) = 6.65$, $p < .001$, $\eta^2_p = .19$), Gooey ($F(12, 348) = 7.13$, $p < .001$, $\eta^2_p = .2$), Slippery ($F(12, 348) = 7.12$, $p < .001$, $\eta^2_p = .2$), and Silky ($F(12, 348) = 5.95$, $p < .001$, $\eta^2_p = .17$. The remaining seven were not significant: Moisturous ($F(12, 348) = 2.44$, $p = .021$, $\eta^2_p = .08$), Hairy ($F(12, 348) = 1.94$, $p = .06$, $\eta^2_p = .06$), Powdery ($F(12, 348) = 1.06$, $p = .38$, $\eta^2_p = .03$),), Velvety ($F(12, 348) = 2.53$, $p = .017$, $\eta^2_p = .08$), Sandy ($F(12, 348) = 2.68$, $p = .009$, $\eta^2_p = .08$), Granular ($F(12, 348) = 2.38$, $p = .025$, $\eta^2_p = .01$), and Roughened ($F(12, 348) = 2.65$, $p = .013$, $\eta^2_p = .08$).

The interaction effect of Adjective * Material was significant for all 13 ANOVAs: Gelatinous ($F(12, 348) = 40.18$, $p < .001$, $\eta^2_p = .58$), Slimy ($F(12, 348) = 43.37$, $p < .001$, $\eta^2_p = .6$), Sticky ($F(12, 348) = 54.42$, $p < .001$, $\eta^2_p = .65$), Gooey ($F(12, 348) = 48.38$, $p < .001$, $\eta^2_p = .62$), Slippery ($F(12, 348) = 26.54$, $p < .001$, $\eta^2_p = .48$), Moisturous ($F(12, 348) = 47.91$, $p < .001$, $\eta^2_p = .62$), Silky ($F(12, 348) = 12.84$, $p < .001$, $\eta^2_p = .31$), Velvety ($F(12, 348) = 32.33$, $p < .001$, $\eta^2_p = .52$), Hairy ($F(12, 348) = 23.69$, $p < .001$, $\eta^2_p = .45$), Sandy ($F(12, 348) = 20.03$, $p < .001$, $\eta^2_p = .41$), Powdery ($F(12, 348) = 13.97$, $p < .001$, $\eta^2_p = .32$), Granular ($F(12, 348) = 46.64$, $p < .001$, $\eta^2_p = .27$), and Roughened ($F(12, 348) = 13.99$, $p < .001$, $\eta^2_p = .32$).

Table 4.1

ANOVA results continued for adjectives Surface Softness Dimension

	Silky		Velvety		Hairy	
	F	η^2_p	F	η^2_p	F	η^2_p
Adjective	12.66*	0.3	24.17*	0.45	29.74*	0.50
Word	2.36	0.07	1.63	0.05	2.56	0.08
Material	18.14*	0.38	9.86	0.25	86.53*	0.74
Adjective * Word	5.95*	0.17	2.53	0.08	1.94	0.06
Adjective * Material	12.84*	0.31	32.33*	0.52	23.69*	0.45
Word * Material	12.13*	0.29	30.26*	0.51	0.77	0.02
Adjective * Word * Material	0.95	0.03	1.74	0.05	0.78	0.02

Note. * donates a statistical significant effect for α = .003

Table 4.1

ANOVA results continued for adjectives Granularity and Roughness Dimensions

	Sandy		Powdery		Granular		Roughened	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Adjective	13.75*	0.32	28.11*	0.49	8.92*	0.06	10.60*	0.27
Word	11.56*	0.28	0.02	6.993e-4	4.1	0.001	5.18	0.15
Material	46.93*	0.61	15.12*	0.34	0.86	8.892e-4	0.87	0.03
Adjective * Word	2.68	0.08	1.06	0.03	2.38	0.01	2.65	0.08
Adjective * Material	20.03*	0.41	13.97*	0.32	46.64*	0.27	13.99*	0.32
Word * Material	0.17	0.01	0.17	0.01	7.67	0.003	8.94	0.23
Adjective * Word * Material	0.55	0.02	1.18	0.04	0.86	0.003	0.77	0.03

Note. * donates a statistical significant effect for α = .003

There was a statistically significant Onomatopoeic Word * Material interaction effect for 8 out of 13 ANOVAs at a level of alpha < .003 : Gelatinous ($F(1,29) = 24.26$, $p < .001$, $\eta^2_p = .45$), Slimy ($F(1,29) = 29.6$, $p < .001$, $\eta^2_p = .5$), Sticky ($F(1,29) = 30.19$, $p < .001$, $\eta^2_p = .51$), Gooey ($F(1,29) = 42.22$, $p < .001$, $\eta^2_p = .6$), Slippery ($F(1,29) = 33.98$, $p < .001$, $\eta^2_p = .54$), Moisturous ($F(1,29) = 14.68$, $p < .001$, $\eta^2_p = .33$), Silky ($F(1,29) = 12.13$, $p < .001$, $\eta^2_p = .29$), and Velvety ($F(1,29) = 30.26$, $p < .001$, $\eta^2_p = .51$). No significant Onomatopoeic Word * Material interaction effect was observed for Main Adjectives Hairy ($F(1,29) = 0.77$, $p = .38$, $\eta^2_p = .02$), Sandy

(F(1,29) = 0.17, p = .68, η^2_p = .01), Powdery (F(1,29) = 0.17, p = .68, η^2_p = .01), Granular (F(1,29) = 7.67, p = .01, η^2_p =.003), and Roughened (F(1,29) = 8.94, p = .006, η^2_p = .23). (Table 4.3). This interaction effect is the congruency effect and thus was hypothesized to be significant for all Main Adjectives. However, we were not able to observe a significant effect for the Main Adjectives hairy, sandy, powdery, granular, and roughened.

For the interaction effect of Adjective * Onomatopoeic Word * Material, none of the 13 ANOVAs were significant: Gelatinous (F(12, 348) = 3.13, p = .005, η^2_p = .1), Slimy (F(12, 348) = 2.44, p = .014, η^2_p = .8), Sticky (F(12, 348) = 1.99, p = .05, η^2_p = .06), Gooey (F(12, 348) = 1.43, p = .019, η^2_p = .05), Slippery (F(12, 348) = 1.00, p = .432, η^2_p = .03), Moisturous (F(12, 348) = 1.39, p = .21, η^2_p = .04), Silky (F(12, 348) = 0.95, p = .47, η^2_p = .03), Velvety (F(12, 348) = 1.74, p = .095, η^2_p = .05), Hairy (F(12, 348) = 0.78, p = .59, η^2_p = .02), Sandy (F(12, 348) = 0.55, p = .79, η^2_p = .02), Powdery (F(12, 348) = 1.18, p = .31, η^2_p = .04), Granular (F(12, 348) = 0.86, p = .54, η^2_p =.003), and Roughened (F(1,29) = .77, p = .59, η^2_p = .03).

4.2.1. Comparing the Written and Spoken Modalities for the Effects of Onomatopoeic Words on Perceived Softness Ratings

A separate set of 13 ANOVAs were conducted to test where the manipulation of onomatopoeic word modality had a significant effect on the ratings obtained for congruent and incongruent pairs of onomatopoeic words and material videos. This was achieved by analyzing the data from Experiment 2 (spoken onomatopoeic words and materials videos were presented together, Chapter 3) and Experiment 3 (written onomatopoeic words and materials were presented together, Chapter 4). This analysis was possible since both experiments were conducted with the same design and with the exact same set of stimuli. The analyses were conducted in R (version 4.2.1) (R Core Team, 2022) and RStudio (version 2022.2.3.492) (RStudio Team, 2022) software with tidyverse (Wickham & Wickham, 2019), ggpubr (Kassambara & Kassambara, 2020), and rstatix (Kassambara, 2021) packages. Each main adjective

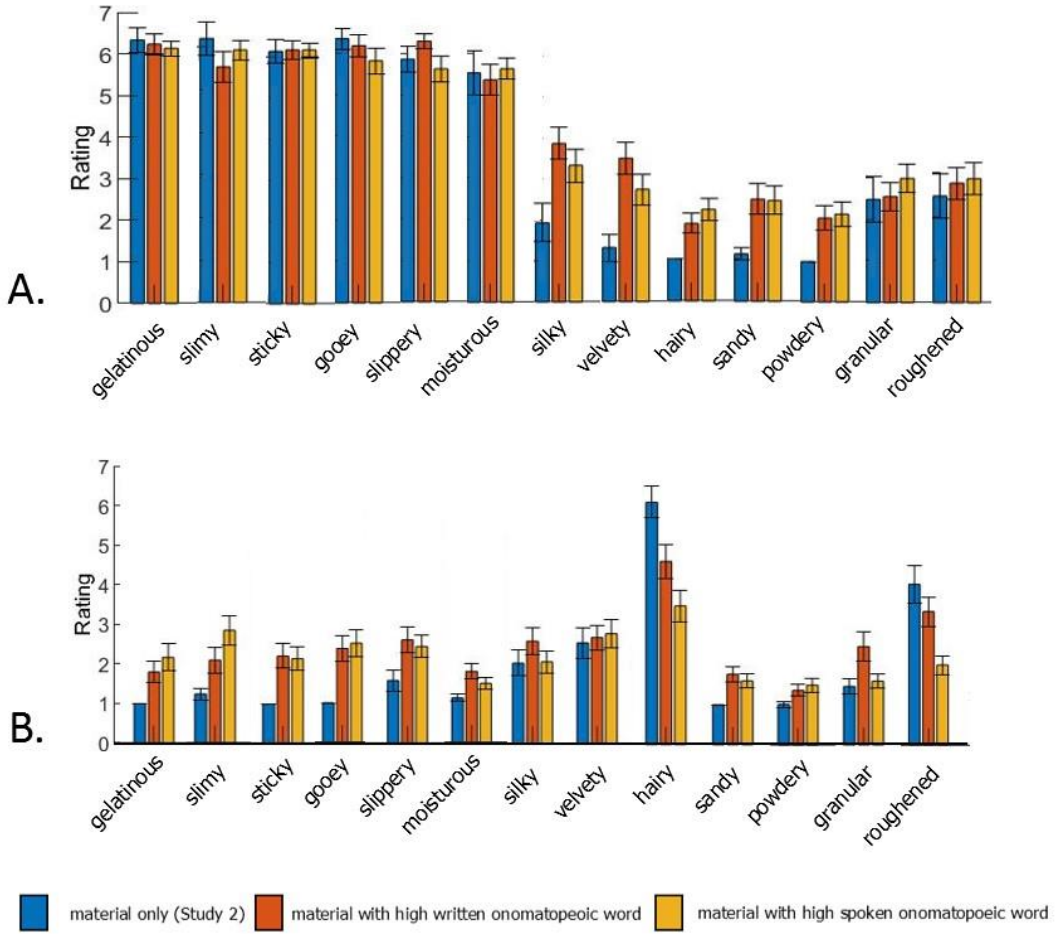


Figure 4.2 Ratings obtained for each adjective for the materials in Main Adjective 'Gelatinous' with high-rated onomatopoeic word ('şap şap'). The ratings are compared with the results of Study 2 where materials were presented on their own, and the results of Experiment 2 where materials were presented with a spoken onomatopoeic word. Graph A displays the ratings for material 'shower gel' and Graph B displays the ratings for material 'wool'.

was analysed separately which resulted in 13 ANOVAs. The variable of Modality (written vs. spoken) was between-group since the data was collected within two experiments with two different sets of participants. The remaining variables of Onomatopoeic Word Rating (high vs. low), Material Rating (high vs. low), and Adjective (13 adjectives) were all within-group. The resulting ANOVA tables can be found in Appendix I.

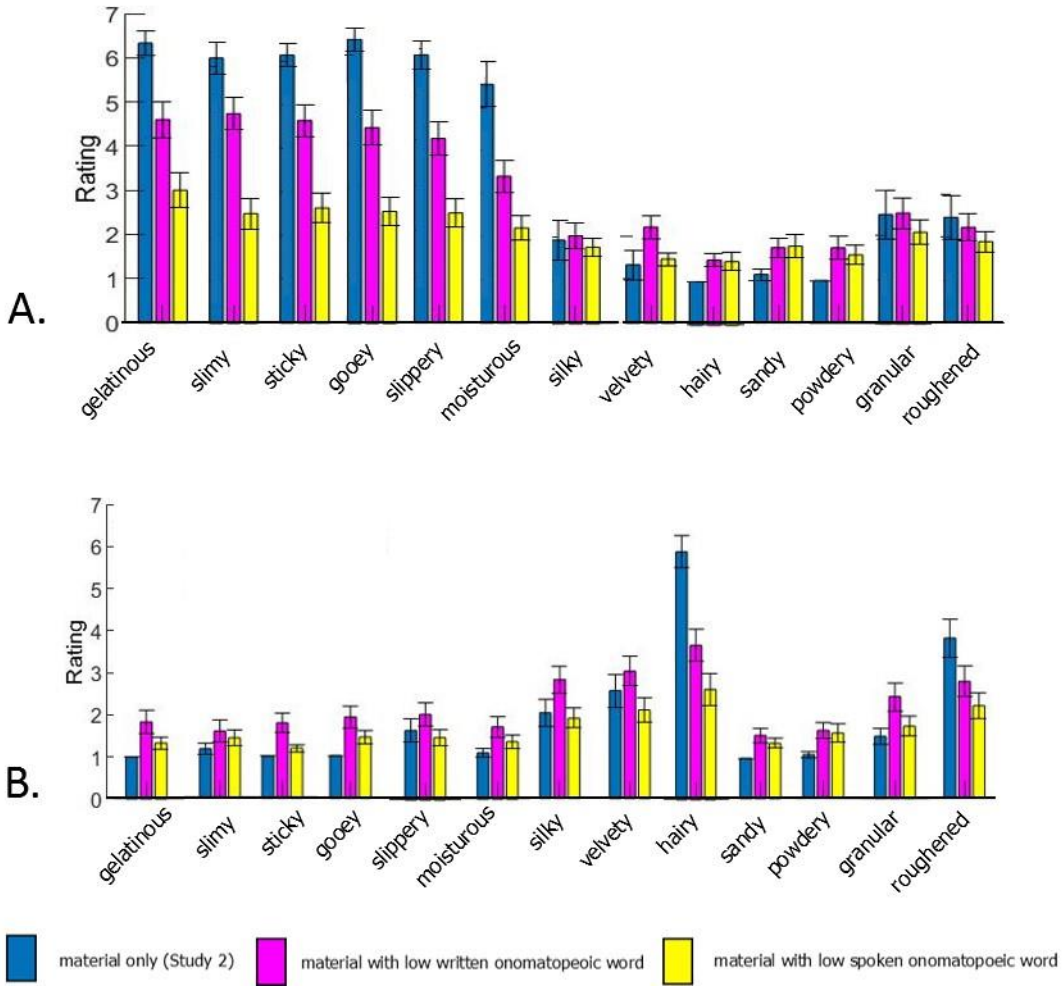


Figure 4.3 Ratings obtained for each adjective for the materials in Main Adjective 'Gelatinous' with low-rated onomatopoeic word ('tak tak'). The ratings are compared with the results of Study 2 where materials were presented on their own, and the results of Experiment 2 where materials were presented with a spoken onomatopoeic word. Graph A displays the ratings for material 'shower gel' and Graph B displays the ratings for material 'wool'.

For the 13 ANOVAs, only one resulted with a significant main effect of Modality. This was the Main Adjective of 'Gelatinous', which used the onomatopoeic words 'şap şap' (high) and 'tak tak' (low), and the materials shower gel (high) and wool (low), $F(1,58) = 5.85$, $p < .001$, $\eta^2_p = .09$. The main effect for Modality in the remaining Main Adjectives was not significant: for Slimy, $F(1,58) = 1.29$, $p = .261$, $\eta^2_p = .02$; for

Sticky, $F(1,58) = 0.15$, $p = .701$, $\eta^2_p = .003$; for Gooey, $F(1,58) = 0.67$, $p = .417$, $\eta^2_p = .01$; for Slippery, $F(1,58) = 0.04$, $p = .846$, $\eta^2_p = .0006$; for Moisturous, $F(1,58) = 1.91$, $p = .172$, $\eta^2_p = .03$; for Silky, $F(1,58) = 0.013$, $p = .911$, $\eta^2_p = .0002$; for Velvety, $F(1,58) = 0.56$, $p = .456$, $\eta^2_p = .01$; for Hairy, $F(1,58) = 0.005$, $p = .942$, $\eta^2_p = .00$; for Sandy, $F(1,58) = 0.00$, $p = .975$, $\eta^2_p = .00$; for Powdery, $F(1,58) = 0.12$, $p = .729$, $\eta^2_p = .002$; for Granular, $F(1,58) = 0.32$, $p = .569$, $\eta^2_p = .006$; for Roughened, $F(1,58) = 2.57$, $p = .114$, $\eta^2_p = .04$. There were, however, significant interaction effects observed for some of the Main Adjectives. These can be seen in the tables in Appendix I. Moreover, Appendix H displays the comparison graphs between Experiment 2 and Experiment 3.

4.3. Discussion

This experiment was conducted to test whether there is an effect of written onomatopoeic words on perceived softness of materials, and to understand how this is different compared the effects of spoken onomatopoeic words. Based on our hypothesis that an effect of onomatopoeic words would be observed, the interaction effect of Onomatopoeic word * Material was expected to be significant. This interaction effect corresponds to the 'congruency' manipulation that is explained previously on this chapter and also in Chapter 3. For the results of Experiment 3, 7 out of 13 ANOVAs yielded a significant interaction effect of Onomatopoeic Word * Material. These results support the hypothesis that onomatopoeic words will have an effect on the perception of soft materials. A significant interaction effect of Onomatopoeic Word * Material was observed for the Main Adjectives Gelatinous, Slimy, Sticky, Gooey, Slippery, Moisturous, Silky, and Velvety; and was not observed for the Main Adjectives Hairy, Sandy, Powdery, Granular, and Roughened.

One thing to note here is that the effect of congruency was observed for all Main Adjectives selected for the Viscosity dimension. When taken together with the results of previous experiments (especially Experiment 2), this result is not surprising. Similarly, experiment 2 showed the effect congruency to be significant for all Main Adjectives from the Viscosity dimension.

This experiment was specifically conducted to compare the written and spoken modalities for onomatopoeias for their effects in perception of material softness. The main effect of Modality was not significant for any of the Main Adjectives except for Gelatinous, therefore suggesting the two modalities are not significantly different from each other for the perception of soft materials.

CHAPTER 5

GENERAL DISCUSSION

Over the three studies and three experiments conducted in this thesis, it was attempted to extract softness related perceptual dimensions from a list of Turkish onomatopoeic words that were presented in the written (Study 1) and spoken (Study 3) form, to extract softness related perceptual dimensions from materials (Study 2), and to manipulate the softness related ratings of materials by using congruency variable (Experiment 1, 2, and 3). The results suggested the existence of at least four softness related dimensions from onomatopoeic words, and managed to successfully manipulate the softness ratings with onomatopoeic words. The results of the experiments are discussed in relation to other studies previously mentioned, the limitations of the current experiments, and the possible future directions for research in this area.

5.1. Discussion

Previous research on haptic perception has focused mostly on texture perception and with the few limited exceptions where soft materials were included. Even then, softness was considered a single dimension was used as a contrast to hardness/roughness. Dövencioğlu et al. (2018, 2019, 2022) provided evidence for the multidimensionality of softness by studying soft materials with a specifically adapted adjective list. The results of the studies and experiments in this thesis provide further support for this, which will be further discussed later on this chapter. In Study 2, by using 40 materials with the 29 softness-related adjectives, 7 dimensions were

extracted. Six of these dimensions were softness related: Viscosity, Deformability, Surface Softness, Granularity, Fluffiness, and Scabbiness; and one dimension was for Roughness. This result is in line with Dövencioğlu et al. (2018, 2019, 2022) where they reported five dimensions: Compliance, Viscosity, Surface Softness, Granularity, and Roughness; and with Cavdan et al. (2019) where they extracted the dimensions Granularity, Furriness, Visco-Elasticity, Deformability, and Roughness. Study 2 has extracted the five dimensions that are in line with the literature, with the addition of two new dimensions that were not reported before. These are Fluffiness and Scabbiness. It is possible that these dimensions were extracted because a different set of materials are used in this study compared to the previous ones. Moreover, the previous studies employed the haptic modality whereas our study employed the visual modality by presenting the materials in a video rather than allowing participants to physically explore the materials. This result also constitutes further support for studying haptic perception using the visual modality as the two modalities were found to have similar perceptual spaces (Baumgartner et al., 2013; Okamoto et al., 2013). It is shown that the information gathered from watching the material videos were sufficient enough to make judgements about the material properties.

The results of onomatopoeic word studies showed a direct relation between Turkish onomatopoeic words and softness related material dimensions. I was able to successfully extract softness related dimensions from both written and spoken onomatopoeic word lists. The dimensions that were common for both studies (Study 1 and Study 3) included Viscosity, Surface Softness, Granularity, and Roughness. This result shows a similarity between the onomatopoeic word space and the softness related dimensions that were extracted using materials (Dövenciöoğlu et al., 2018, 2019, 2022; Cavdan et al. 2019), providing further support for the idea of sound symbolism. This result is also similar to that of Hanada (2016) where they extracted three dimensions: wetness/stickiness, fluffiness/softness, and smoothness-roughness/gloss-dullness. I was unable to extract a dimension that could be labeled as 'Deformability' from either of the studies, and this is attributed to the lack of words in Turkish describing the sound an object makes when it is being deformed. This result can be discussed with regards to the study of Gaver (1993), who identified three categories for the sound generating objects: solids, liquids, and gaseous sources.

There are several sounds made by solid materials that have found their word equivalence as an onomatopoeia in language, such as: tak tak, çatır çatır, kıtır kıtır, etc. for solid materials. For the liquid sound sources, the words were as: şıp şıp, şarıl şarıl, şıpır şıpır, etc. For the gaseous sounds, there were pofur pofur, and efil efil, which are based on sounds coming from an air being let out or the wind blowing. All these sounds are from a state of matter of a material, and none of these sounds describe a change in the form of the material. Taken together with Gaver (1993)'s categorization, it is understandable that I could not find words that describe the sound of a deforming object, and therefore also failed to extract a deformability dimension from onomatopoeic words. However, the extracted four dimensions are similar to those obtained from studies using materials, suggesting the onomatopoeic words are informative in terms of describing material properties. Study 1 with written onomatopoeic words extracted a total of 7 dimensions: Viscosity, Roughness, Surface Softness, Granularity, Texture, Glossiness, and Fluffiness. The dimensions of Texture, Glossiness and Fluffiness are specific to this study. However, since the adjectives that were loaded in these dimensions were not unique, meaning they had higher component loadings for other components, these dimensions were not very informative. Moreover, the MDS space for written onomatopoeic words did not reveal distinct clusters between the onomatopoeic words. More research could be conducted to explore these dimensions and whether they can be extracted with a different set of stimuli as well. The MDS space of spoken onomatopoeic words, on the other hand, revealed four distinct clusters for the words that were very similar to the dimensions extracted using the PCA. Obtaining this result also provides further support for the existence of four dimensions for spoken onomatopoeic words.

I also carried out a phonetic analysis with the results of Study 1, however, the results of this analysis were mostly not significant. This approach was adapted from the study of Fujisawa, Iwamiya & Takada (2004) by using the phonetic parameters of Turkish instead of Japanese. There were only a number of significant correlations between the parameters of phonetic properties and the principal component loadings of the onomatopoeic words. The results showed that onomatopoeic words that contained the consonants /f/, /ğ/, /h/, /j/, /s/, /ş/, /v/, /z/ had a less 'rough' impression ('vıcık', 'şırıl', 'hışır'), and onomatopoeic words that contained plosive consonants /b/, /c/, /ç/,

/d/, /g/, /k/, /p/, /t/ ('tıkır' and 'kıtır') and the post-alveolar consonants /d/, /n/, /s/, /t/, /z/ ('zangır' and 'zır') were associated with a 'rough' impression. Moreover, that onomatopoeic words that contained the consonants /f/, /ğ/, /h/, /j/, /s/, /ş/, /v/, /z/ ('fısır', 'haşır')had a less 'viscous' or 'elastic' impression. And finally, onomatopoeic words that contained the vowel /o/ and the consonants /g/, /k/, /l/, /r/, /y/ ('gürül', 'fokur') had a more 'dynamic' impression. These were the only significant correlations for all the components and parameters included in the analysis. This result might indicate that phonetic properties of the speech sounds are not solely responsible for the effects that are observed in the experiments. They might have other explanations about the use of visual imagery (similar to the approach of Cuskley, Simner, and Kirby (2015)) or a process where both visual and auditory systems play a role.

The results of Experiment 1 were not in the way that was expected and it did not support the hypothesis. The effect of congruency was not significant for any of the 13 ANOVAs that was conducted for the different set of material pairs. There are several reasons for this result. Firstly, conducting the experiment online was not the optimal mode of delivery, the layout of the experiment on Qualtrics was not desirable. The participants were able to play the video depicting the onomatopoeic word for two seconds, then watch the material being explored by the researcher's hand. Then they had to move forward with the adjective ratings that were located under the video prompt. As the experiment was conducted online, whether each participant completed each step in the instructed way was not controlled. Secondly, the mode of delivery where we first present the onomatopoeic word and then the material video might not have been strong enough for an association to be made and for the adjective ratings to have been affected by the onomatopoeic word presented. It is likely that participants focused on either only the onomatopoeic word or only the material, and completed their adjective ratings accordingly. An alternative design for this study would have been to display the onomatopoeic word and the material video in the same screen. And this was further achieved in Experiment 3, which was conducted in a laboratory environment.

Experiment 2 was conducted with significant differences in the methodology and in terms of stimuli compared to Experiment 1. Spoken onomatopoeic words were used

to be matched with the material videos. Different to Experiment 1, the spoken onomatopoeic word and the material video were presented simultaneously. Another significant difference between the studies is that Experiment 2 was conducted in a controlled laboratory environment, meaning participants were more likely to give their full attention to the tasks and they completed the task in an environment with minimum number of distractors. 13 ANOVAs were conducted to test the hypothesis and obtained significant results for 10 out of 13 ANOVAs. The three ANOVAs that were not significant were Main Adjectives Hairy, Sandy, and Powdery. As discussed previously at the end of Chapter 3, this result was attributed to the selection of materials. The materials and onomatopoeic words for each Main Adjective were selected to be unique, meaning each was only used for a single Main Adjective, which limited the selection for the congruent and incongruent pairings. We believe this may have resulted for the selection of pairings to be less representative for those Main Adjectives than it could have been otherwise. Also, inclusion of granular materials and therefore a dimension of 'Granularity' has not been studied extensively in the literature. Dövencioğlu et al. (2018, 2019, 2022) were one the first ones to include granular materials in their study of softness perception, and it was attempted to explore these materials to a greater extent. However, because of the selection of onomatopoeic words and materials, the expected effect was not observed for these Main Adjectives.

The onomatopoeic word and material pairing that was selected for each Main Adjective, also received similar ratings for adjectives that belong to the same dimension. For example, for the Main Adjective 'gelatinous', we observed significant results for adjectives gelatinous, slimy, sticky, gooey, slippery, and moisturous; which are all adjectives that belong to Viscosity dimension. This was similarly observed for Surface Softness and Granularity dimensions. This result further supports the unity of the dimensions, and provides additional support that materials and onomatopoeic words were adequately selected for each dimension.

The onomatopoeic words were presented in the auditory modality and the materials in the visual modality, and it was managed to manipulate the adjective ratings related to certain material properties. This suggests the information obtained from the

auditory modality was strong enough to manipulate the judgements that were made for a material, which was presented visually. This result provides further support for the idea of sound symbolism, going as early as Sapir (1929) and Köhler (1929)'s original studies in the subject. As detailly described in the introduction chapter, sound-shape associations were observed for pseudowords (Tarte and Barritt, 1971; Ramachandran and Hubbard, 2001; Westbury, 2005; Parise & Spence, 2012) and also for onomatopoeic words (Laing, 2017; Fujisawa, Iwamiya & Takada, 2004). Information obtained from one modality (here it is the onomatopoeic words that are presented in the auditory modality) influenced the ratings made about the material properties.

A final experiment was conducted to compare the written and spoken modalities of onomatopoeic words. Experiment 3, had the same methodological design to that of Experiment 2 (spoken onomatopoeic words), and used the same set of stimuli and onomatopoeic word – material pairings. This experiment was also conducted in a laboratory environment. 13 ANOVAs were conducted for the 13 Main Adjectives in this study, and the manipulation of congruency was significant for 8 out of the 13 ANOVAs: Gelatinous, Slimy, Sticky, Gooey, Slippery, Moisturous, Silky, and Velvety. The congruency effect was not significant for the Main Adjectives of Hairy, Sandy, Powdery, Granular, and Roughened. These results show, similar to Experiment 2, that the Main Adjectives that were selected from the Viscosity dimension seem to display the effect significantly. And additional analysis for the main effect of modality (written vs. spoken) was also carried out. This analysis showed that the effect of modality was only significant for the Main Adjective Gelatinous and not for the 12 other Main Adjectives. This result suggests that the written and spoken modalities of language are not significantly different from each other. There are differences between spoken and written modalities of language (such as pitch and tone to exist for spoken language, and visual characteristics of letters for written language). In the contrary, the MDS results with written onomatopoeic words and spoken onomatopoeic words yielded different results: one displaying distinct clusters (spoken) and the other not displaying any distinct clusters. This result suggests the two modalities to be different. The effects of sound-symbolism are observed when the pseudowords are presented in either the written or the auditory modality (Sapir, 1929; Köhler, 1929; Fryer et al.,

2014; Etzi et al., 2016) or with onomatopoeias (Wakamatsu et al., 2017). One possible explanation to this is that the onomatopoeic words, when presented on their own, the two modalities differ from each other. However, when they are presented with a material, the softness related adjective ratings are not significantly different for the two modalities.

5.2. Limitations

The timeline of this thesis coincides with the global pandemic of COVID-19, which has forced us to conduct our initial studies in an online platform rather than conducting them in a controlled laboratory environment. Given the nature of our tasks, and the duration it takes for each experiment to be completed, the online platform (Qualtrics) was not the most suitable for our experiments. There are a number of problems that could have arisen which led us to not be able to demonstrate a significant effect with Experiment 1. The mode of delivery was not optimal, as the platform we decided to use did not have an option to display the experiment the way we would have displayed it in MATLAB. We had to include a video of the material, and the participants were instructed to watch the video before they gave their ratings. However, there was no way of controlling whether they have actually watched the entirety of the video. We tried to counter this by asking the participants to report the onomatopoeic word they had seen in the beginning of the video; however, it still does not guarantee that the entire video is watched. Conducting the Experiment 3 in the laboratory environment aided us in testing the hypothesis in a controlled environment without the pitfalls of online testing, and the results obtained were more in line with what was hypothesized. However, this remains as a limitation for the Study 1, Study 2, and Experiment 1.

Moreover, the results of Experiment 2 and Experiment 3 were compared to each other to analyze the effect of onomatopoeic word modality. This approach was chosen since the two experiments had the exact same stimuli list, and the methodology was similar. However, the timelines to collect data from the participants differed, where Experiment 3 was completed approximately eight months after Experiment 2. The time difference in data collection remains as a possible limitation for this analysis.

Finally, another possible limitation relates to Experiment 3. On the trial screen, onomatopoeic word, video of the material, adjective, and rating bar were all displayed

simultaneously. This design was preferred since it meant the experiment was more similar to Experiment 2 and comparison analysis would be possible. A limitation remains, however, that there were possibly too many stimulants on the screen. One way of dealing with this might be to introduce a manipulation check and ensure all the stimuli are attended for.

5.3. Future Research

The future directions of this research will be discussed in terms of methodological implications. For the experiments using material videos, we used five seconds material videos depicting an EP, where observers were able to see both the material being explored and the hand that is exploring it. We chose the EPs based on whichever could transfer the greatest amount of information about the material to an observer. This selection was mainly based on previous research (Cavdan et al., 2019; Dövencioğlu et al., 2018, 2019, 2022), we tried to adapt the EPs for each dimension based on their report of most common EPs used when the materials were being haptically explored. Future studies could explore this further, by employing a design where each of the EPs are presented separately and participants are asked to rate the amount of information about the material that they can obtain from only watching the videos. This could provide an empirical ground on which the stimuli are selected.

Moreover, there could be an effect of familiarity of the materials being used in the study, which we did not control for. Future research may study this in relation to the softness ratings being collected. Familiarity rating for each material could be obtained during or after the test phase of the experiment, which could later be analyzed to explore possible effects of familiarity.

5.4. Conclusion

The present study is the first to explore the effects of Turkish onomatopoeic words in relation to softness perception of materials. I used the onomatopoeic words in both written and spoken for to study our hypotheses. I expected to extract softness related dimension from the onomatopoeic words and we were able to extract four dimensions from both written and spoken forms: Viscosity, Surface Softness, Granularity, and Roughness. This result is in line with the softness dimensions extracted by using

materials in previous studies (Dövencioğlu et al., 2019; 2022; Cavdan et al., 2019), and with our own study using material videos (Study 2). The only exception is the dimension of Deformability, which as we discussed earlier, was mainly due to the lack of onomatopoeic words describing the sound of a deforming object.

The manipulation of congruency was significant in the experiment using spoken onomatopoeic words; and in the experiment using written onomatopoeic words conducted in the laboratory environment (Experiment 3). The significant result in spoken onomatopoeic word and material pairings suggest that it is possible to manipulate a material related judgement in one modality by presenting a conflicting stimulus in another modality.

The present study fills a significant gap in the literature by providing further support on the effects of language in perceived softness of materials. This study was the first to be conducted using Turkish onomatopoeic words, and first to use the onomatopoeic words to manipulate the ratings of material related adjectives. Future studies should address the abovementioned limitations of the study and focus on investigating the effects other variables such as familiarity.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

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Sayı: 28620816 /

16 HAZİRAN 2020

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Dr.Öğr.Üyesi Nahide Dicle DÖVENCİOĞLU

Danışmanlığını yaptığınız **Beyza Melis HAZIR'ın "Dilin dokunsal algı üzerine etkisi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **146-ODTU-2020** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
Başkan

B. THE INFORMED CONSENT FORM

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu çalışma ODTÜ Psikoloji Bölümü yüksek lisans öğrencilerinden Beyza Melis Hazır tarafından yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Çalışmanın amacı, katılımcılardan malzemelerin yumuşaklık algısı ile ilgili bilgi toplamaktır. Malzemelerin algılanan dokunsal yumuşaklığı çoğunlukla tek bir boyut olarak incelenmiştir, ancak son zamanlarda algılanan yumuşaklığın çok boyutlu olduğu gösterilmiştir. Bu çalışmanın amacı, kelimelerin ve farklı frekanstaki seslerin yumuşak malzemelerin algılanmasında ne ölçüde rol oynadığını anlamaktır.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırma psikoloji bölüm laboratuvarında yapılacaktır. Çalışma sırasında ekranda sizlere çeşitli malzeme adları, resimleri veya videoları göreceksiniz. Her ekranda bir soru yazılı olacak ve sizden verilen malzemeye uygun olarak değerlendirme yapmanız istenecek. Sorudaki kelimelerin verilen malzemeye ne kadar uygun olduğunuzu düşünüyorsanız ekrandaki değerlendirme çubuğunu mouse yardımıyla oynatarak işaretleyeceksiniz. Değerlendirme 1 (hiç uymuyor) ve 7 (çok uyuyor) arasında olacak. Deneye katılım süresi ortalama olarak 60 dakika (1 saat) sürmektedir.

Sizden Topladığımız Bilgileri Nasıl Kullanacağız?

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Deneyde sizden kimlik veya çalıştığınız kurum/bölüm/birim belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak, sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır. Sağladığınız veriler gönüllü katılım formlarında toplanan kimlik bilgileri ile eşleştirilmeyecektir.

Katılımınızla ilgili bilmeniz gerekenler:

Çalışma, genel olarak kişisel rahatsızlık verecek sorular içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda çalışmayı uygulayan kişiye, çalışmadan çıkmak istediğinizi söylemek yeterli olacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için ODTÜ öğretim üyelerinden Dr. Dicle Dövencioğlu (E-posta: [redacted] ya da Beyza Melis Hazır (E-posta: [redacted] ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

C. GRAPHS FOR STUDY 1

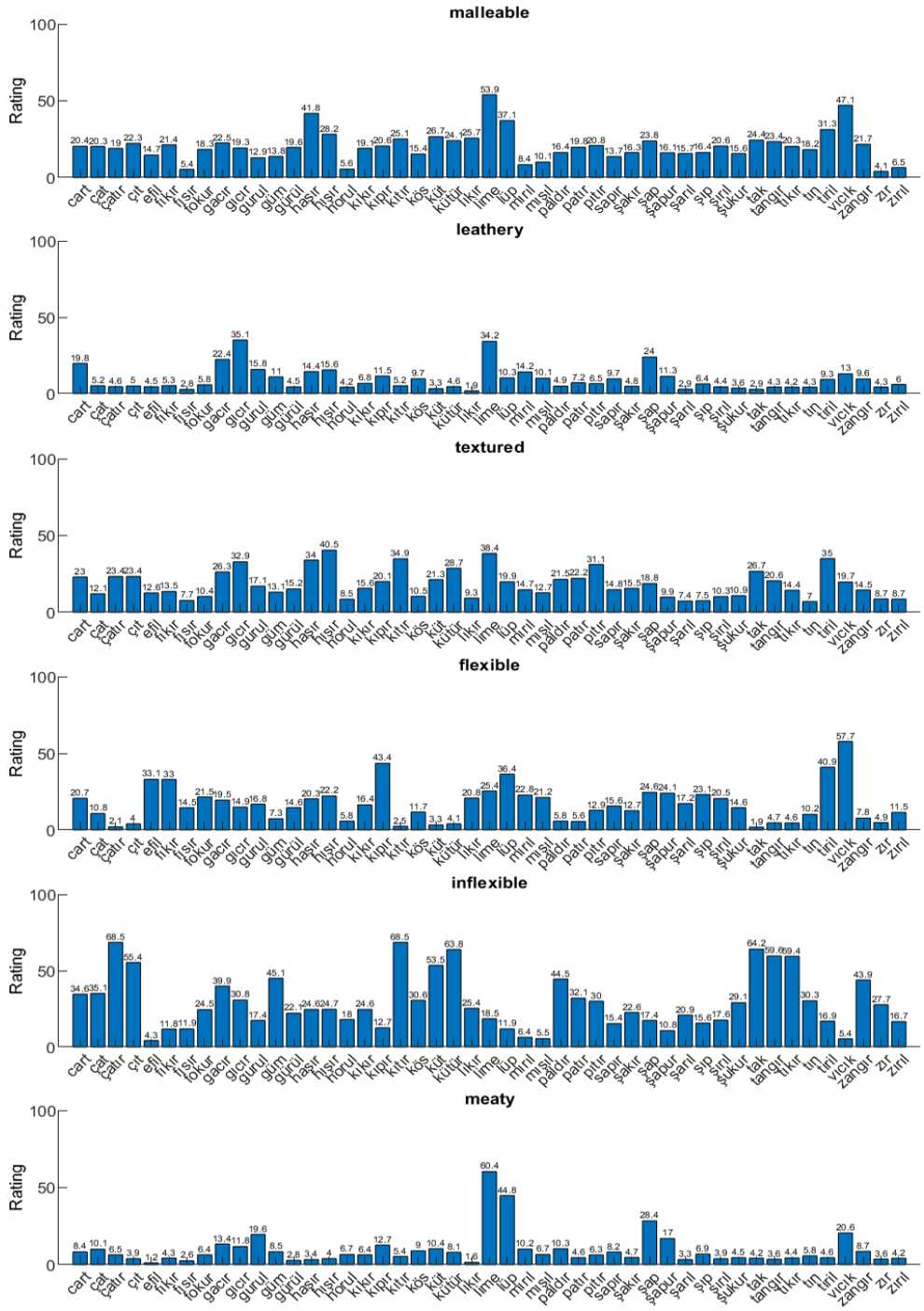

Figure C.1 The ratings of adjectives on all onomatopoeic words for Study 1. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the materials.

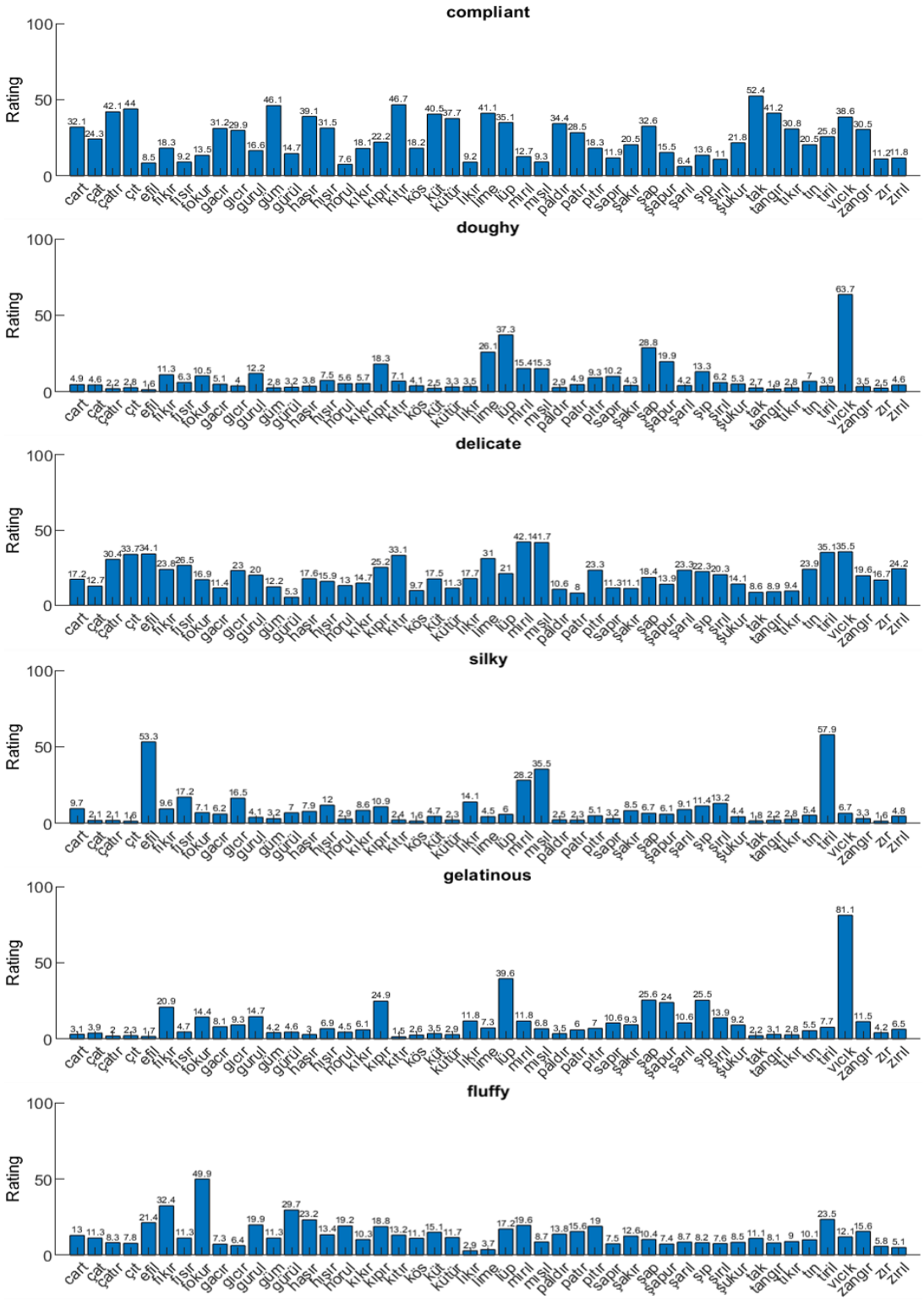

Figure C.1 (continued) The ratings of adjectives on all onomatopoeic words for Study 1. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the materials.

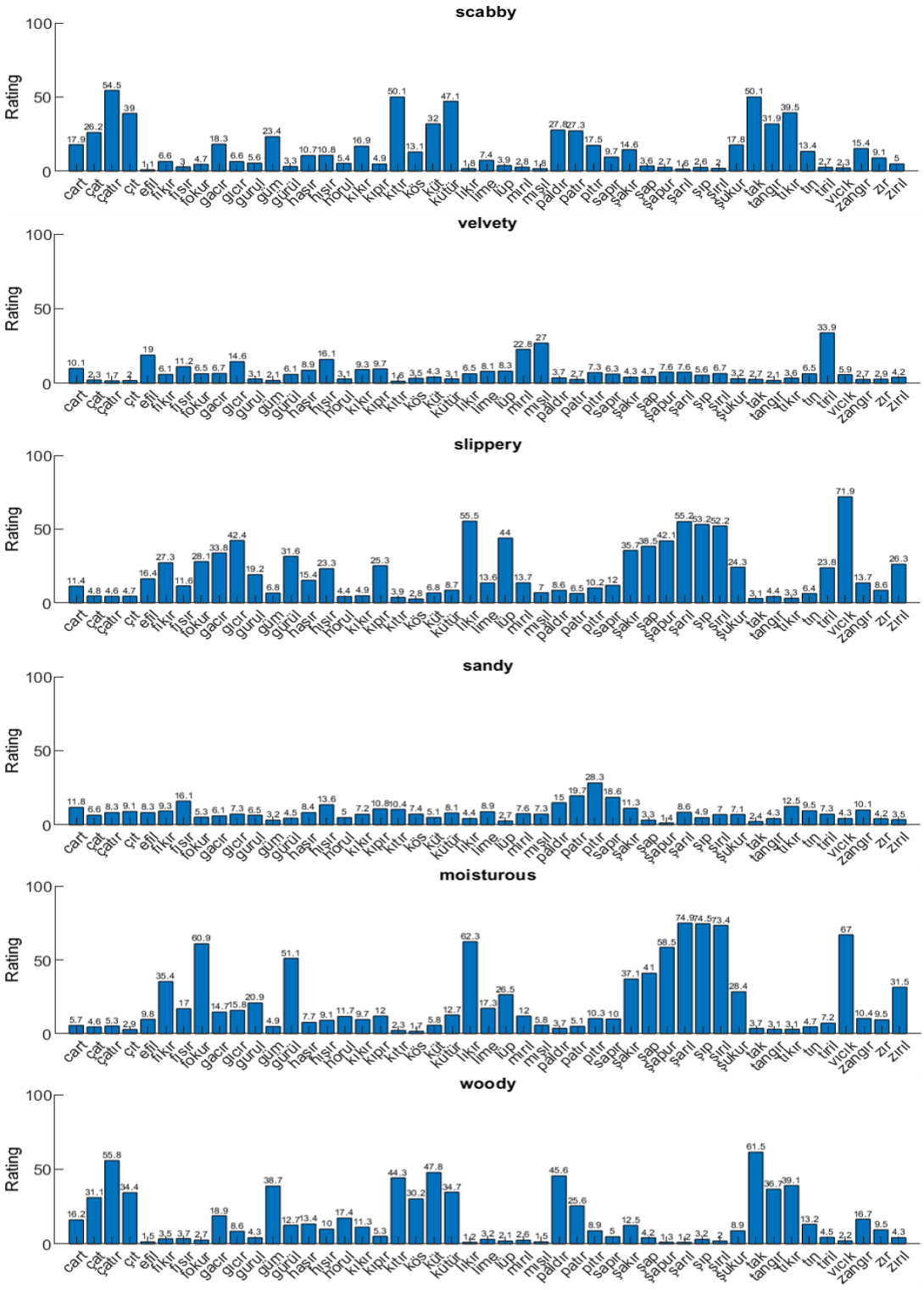

Figure C.1 (continued) The ratings of adjectives on all onomatopoeic words for Study 1. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the materials.

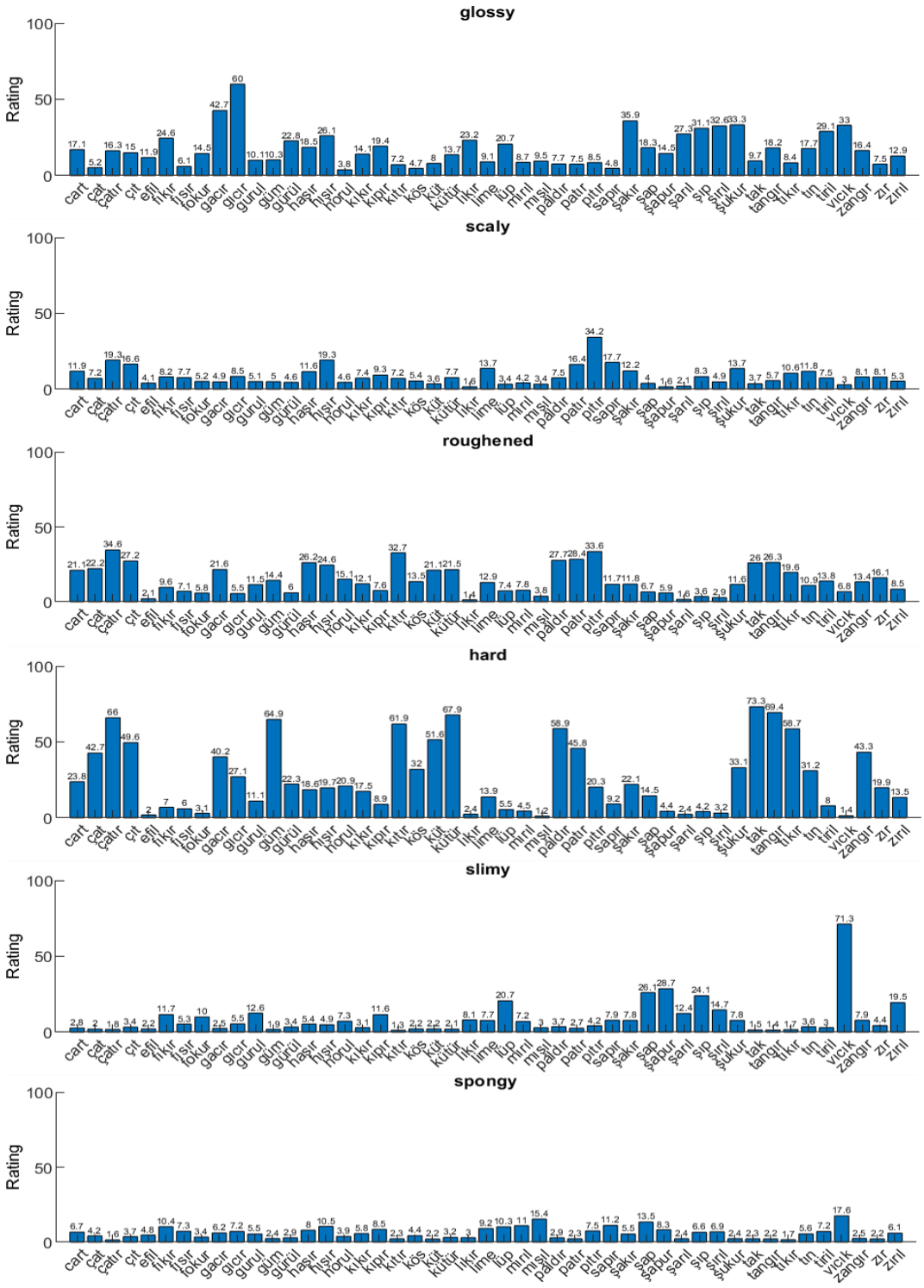

Figure C.1 (continued) The ratings of adjectives on all onomatopoeic words for Study 1. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the materials.

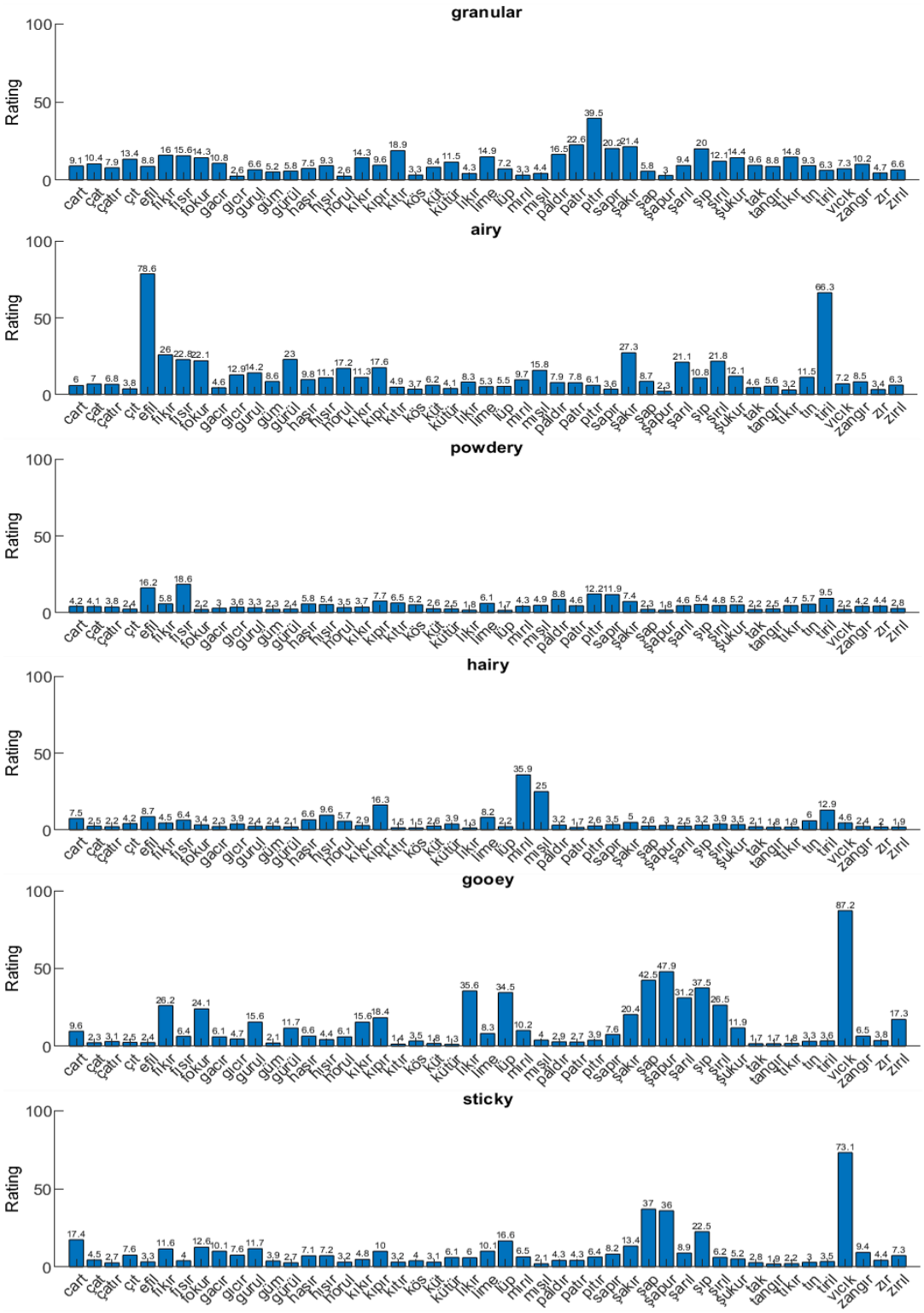

Figure C.1 (continued) The ratings of adjectives on all onomatopoeic words for Study 1. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the materials.

D. GRAPHS FOR STUDY 2

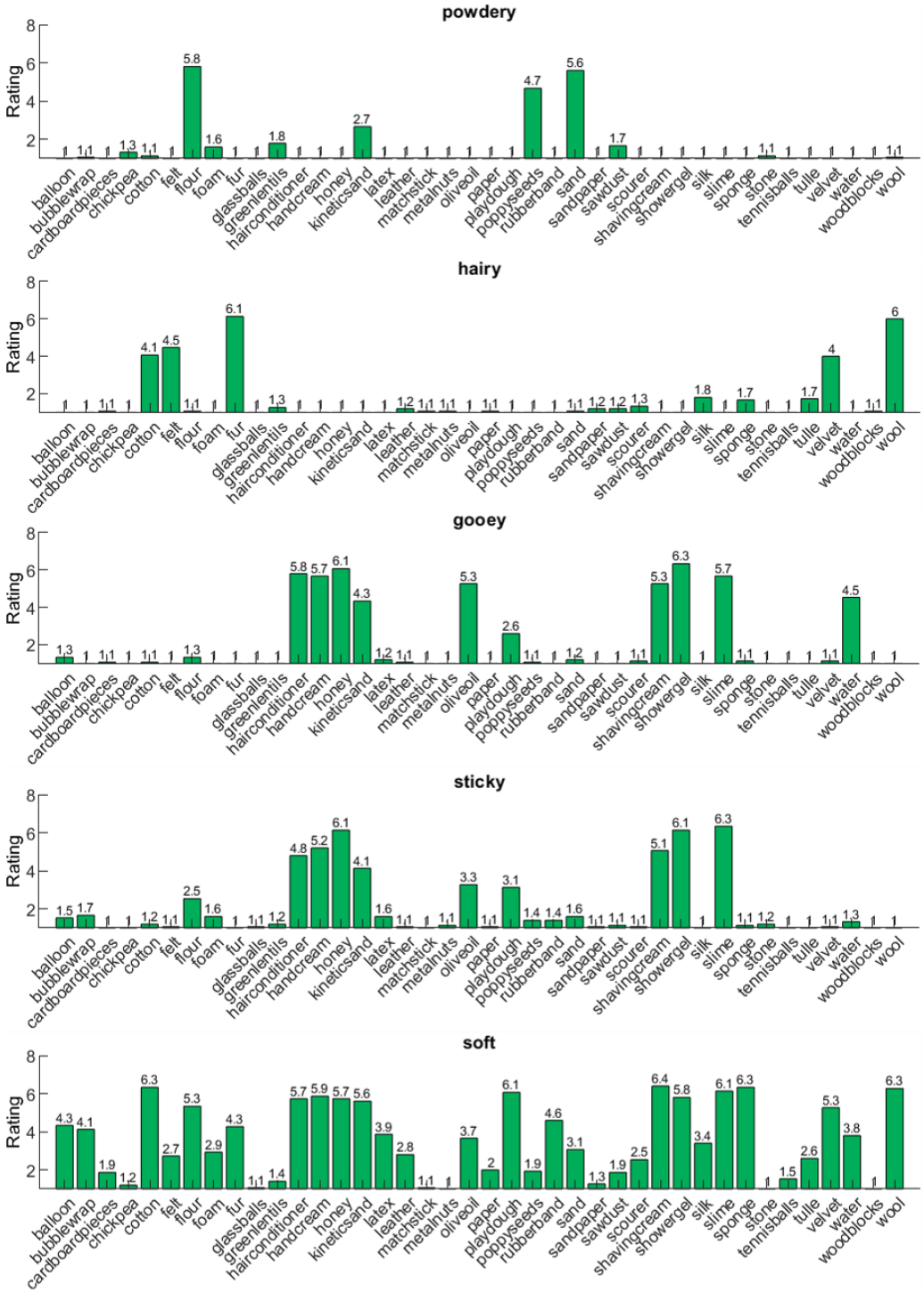

Figure D.1 The ratings for all adjectives across all materials for Study 2. Each panel shows a separate adjective. The x-axis lists the materials, the y-axis is the ratings obtained for that adjective for each of the materials.

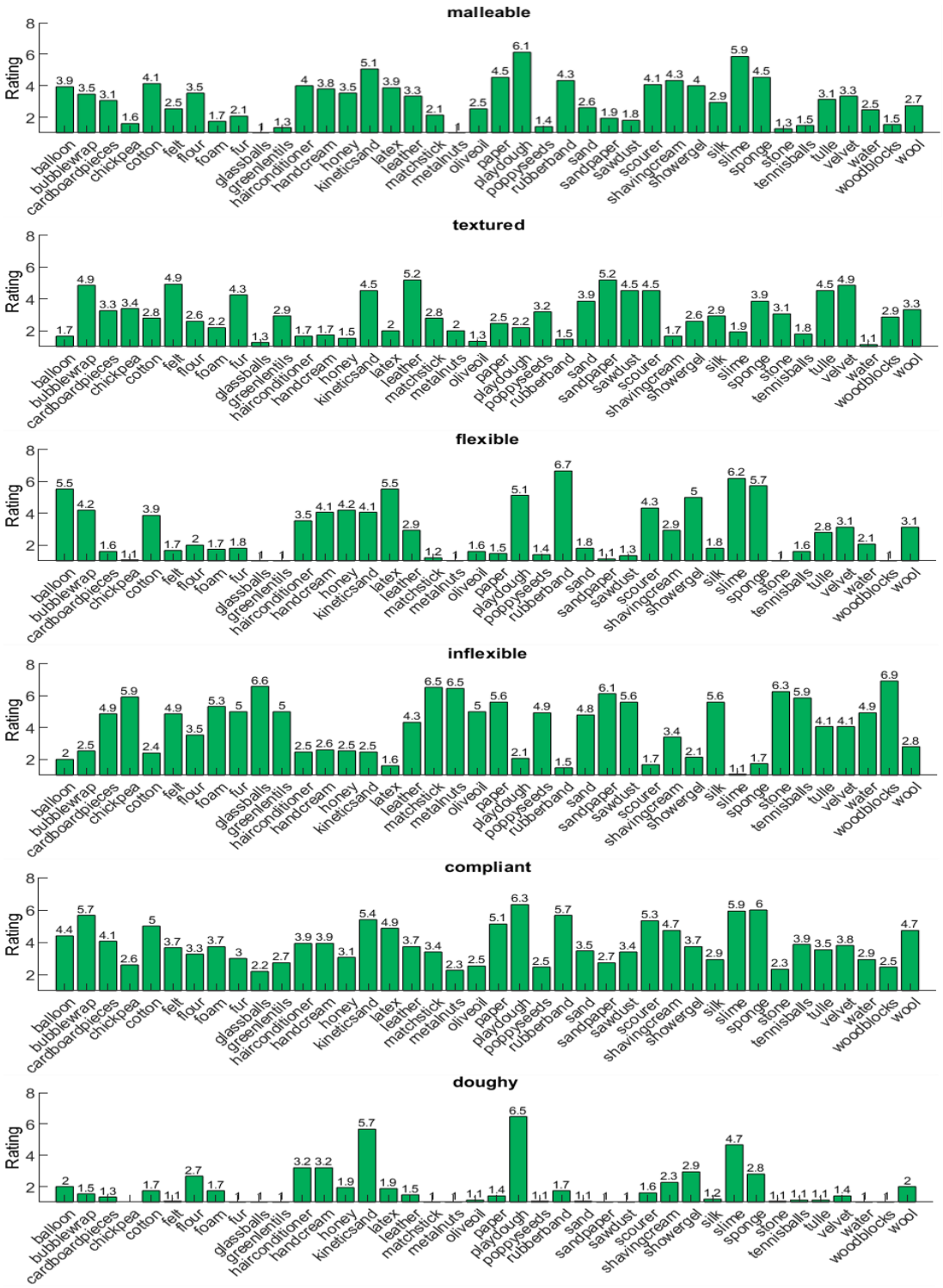

Figure D.1 (continued) The ratings for all adjectives across all materials for Study 2. Each panel shows a separate adjective. The x-axis lists the materials, the y-axis is the ratings obtained for that adjective for each of the materials.

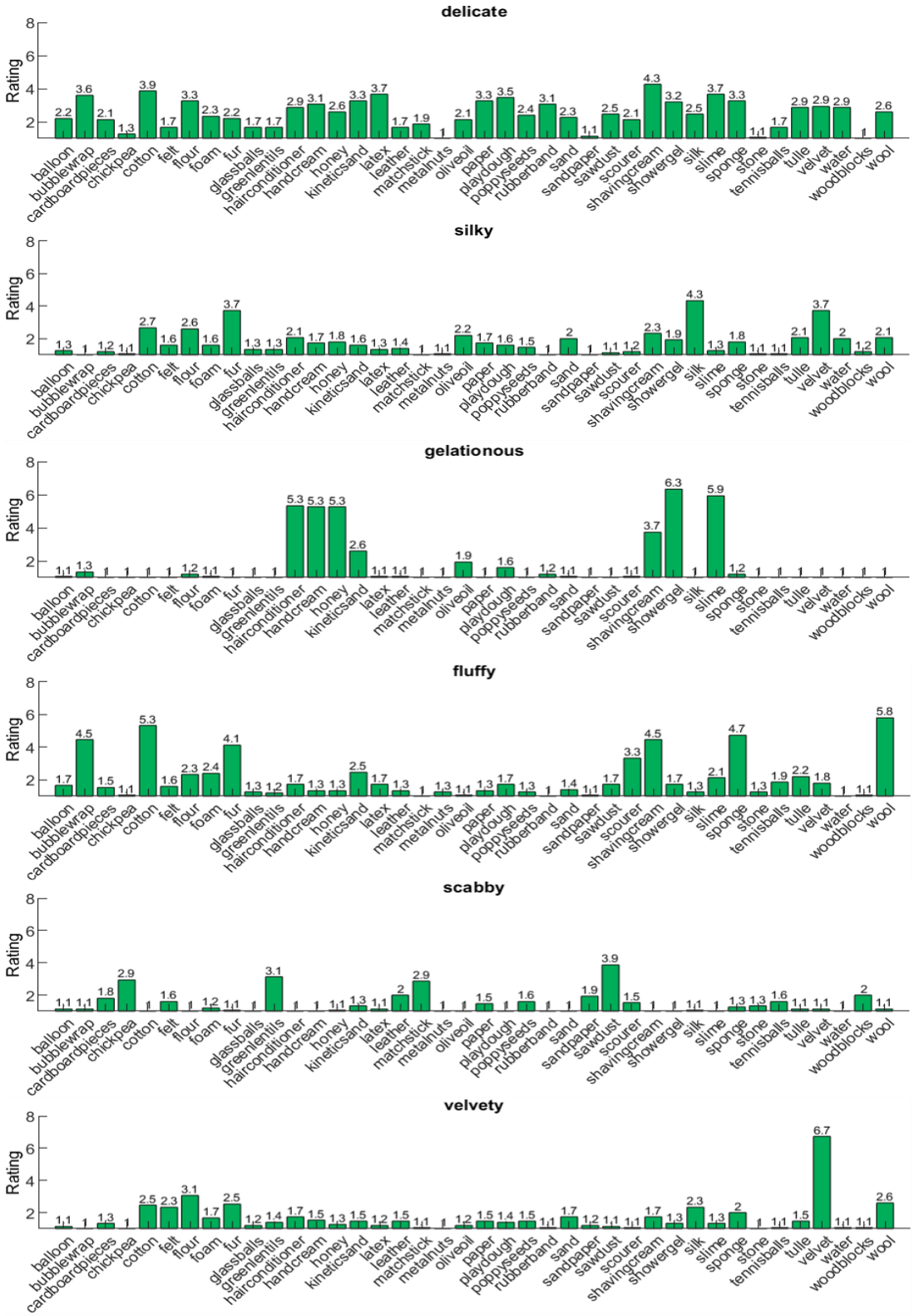

Figure D.1 (continued) The ratings for all adjectives across all materials for Study 2. Each panel shows a separate adjective. The x-axis lists the materials, the y-axis is the ratings obtained for that adjective for each of the materials.

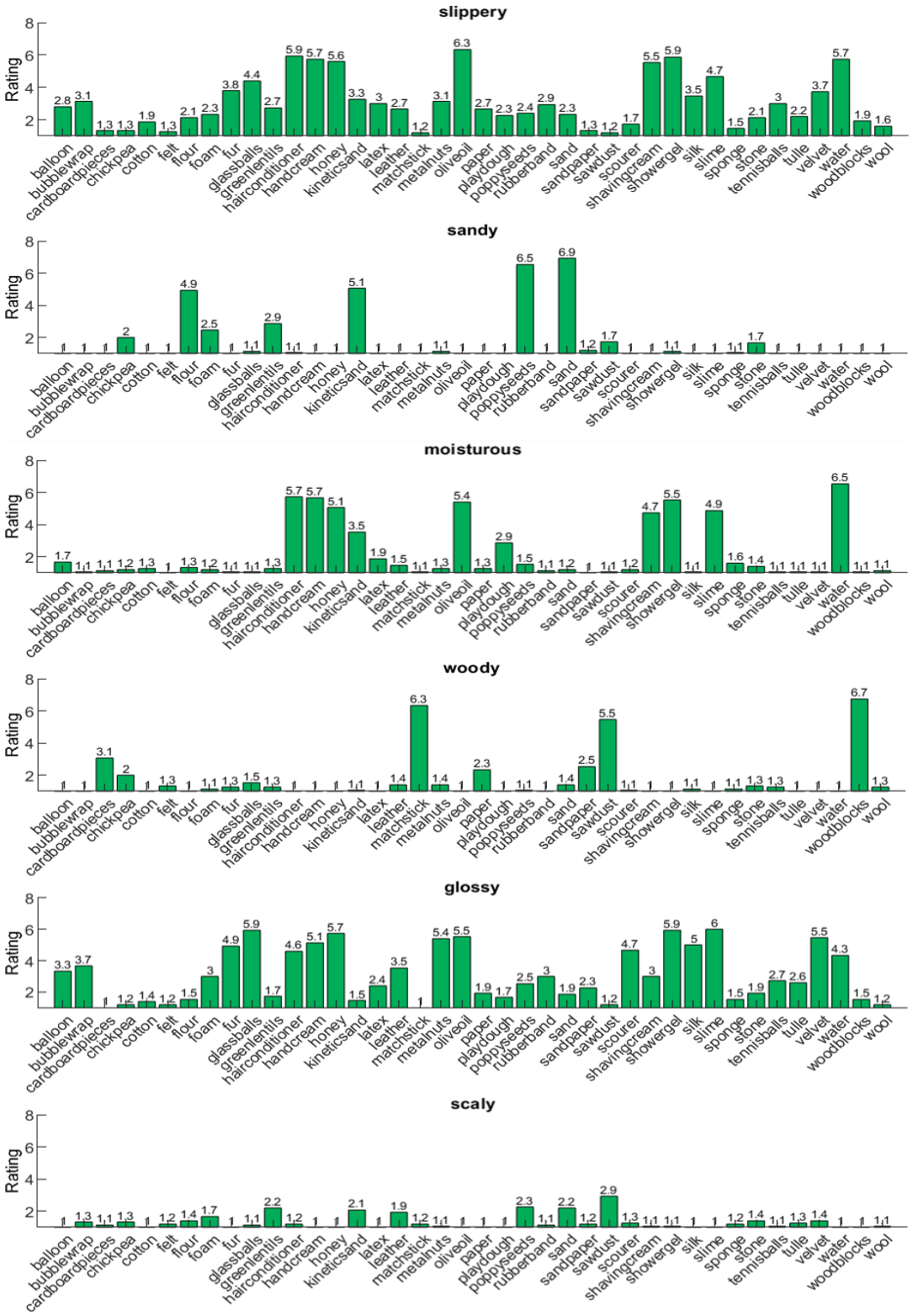

Figure D.1 (continued) The ratings for all adjectives across all materials for Study 2. Each panel shows a separate adjective. The x-axis lists the materials, the y-axis is the ratings obtained for that adjective for each of the materials.

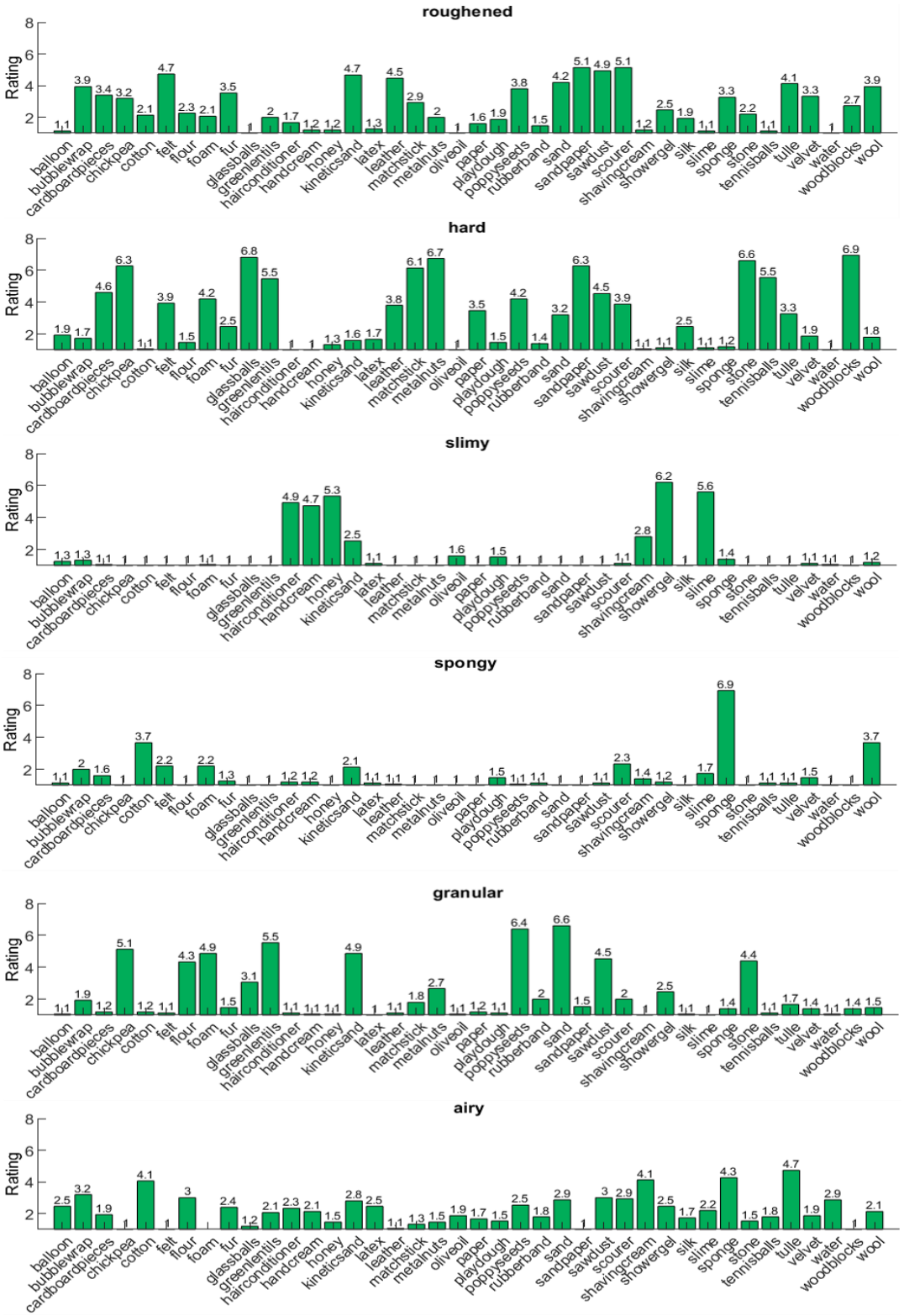

Figure D.1 (continued) The ratings for all adjectives across all materials for Study 2. Each panel shows a separate adjective. The x-axis lists the materials, the y-axis is the ratings obtained for that adjective for each of the materials.

E. GRAPHS FOR EXPERIMENT 1

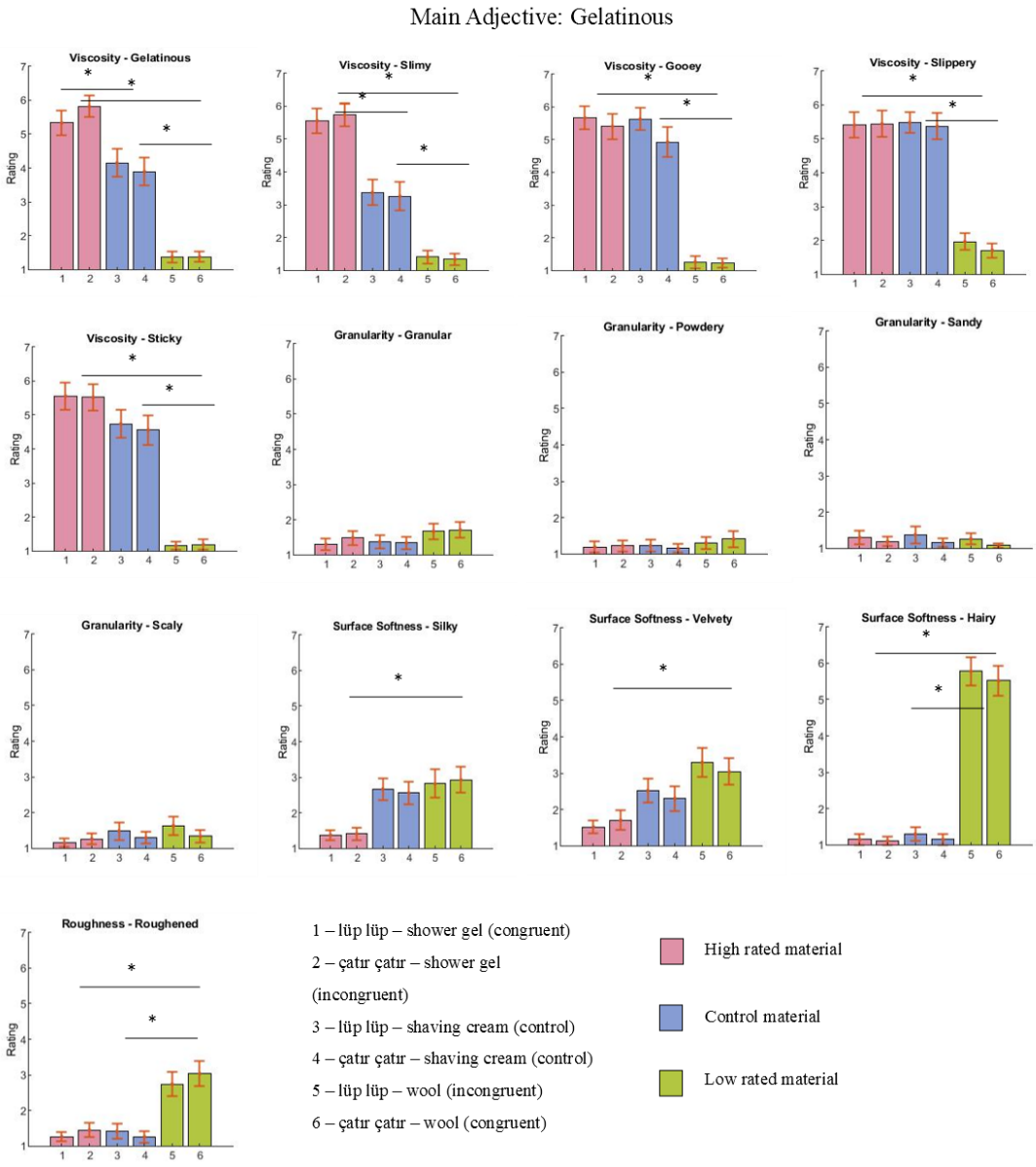

Figure E.1 Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Gelatinous. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

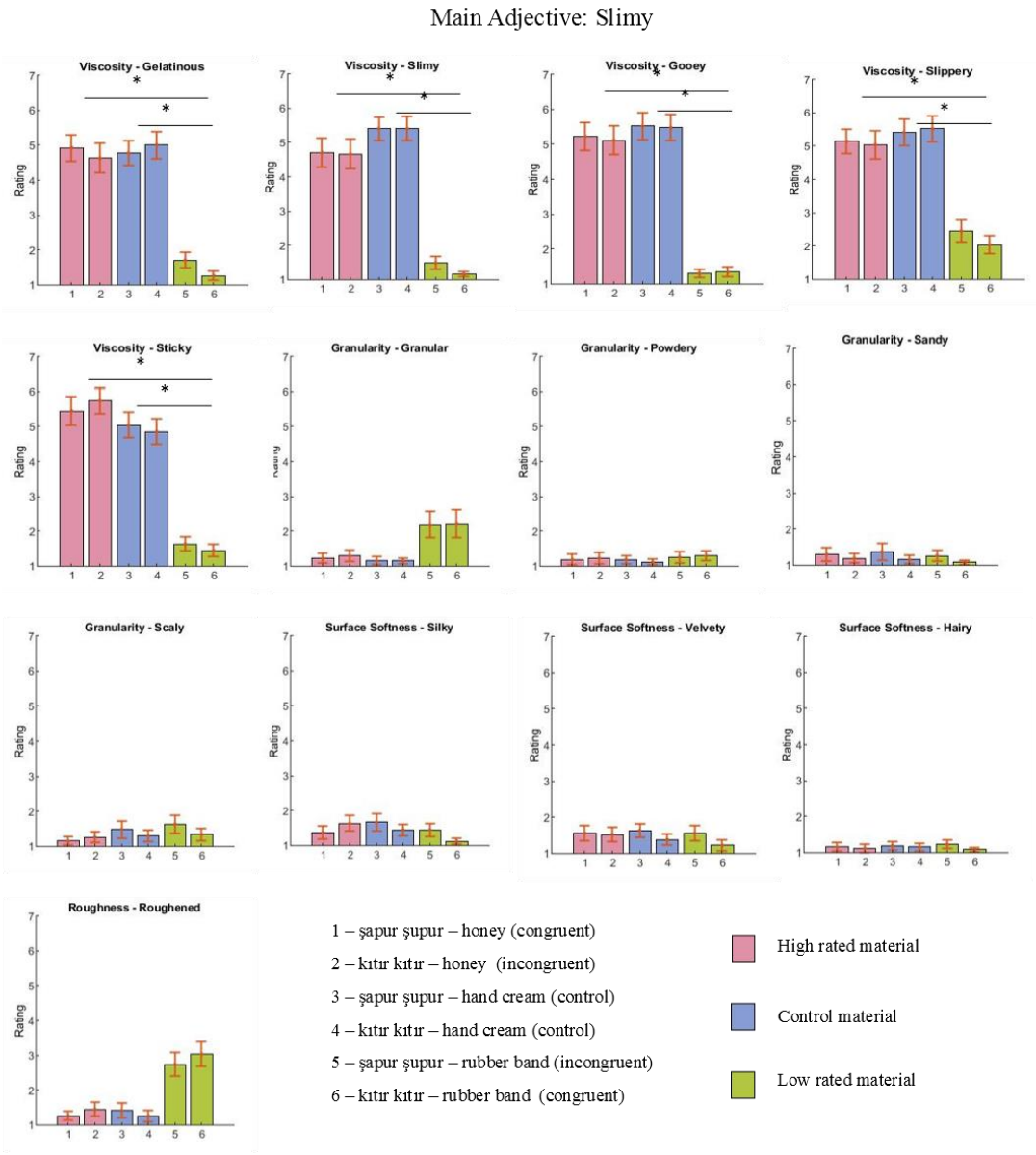

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Slimy. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

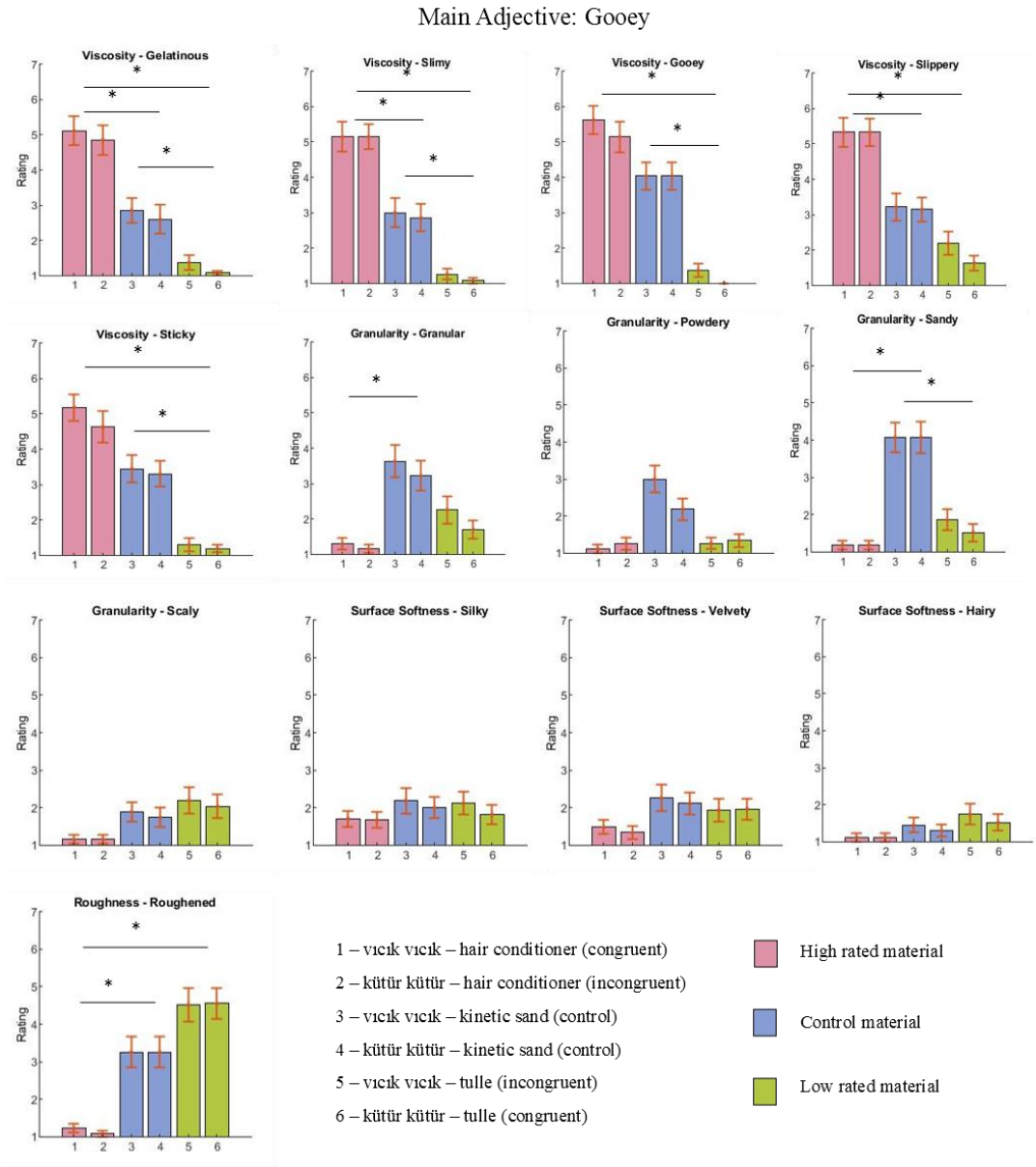

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Gooey. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

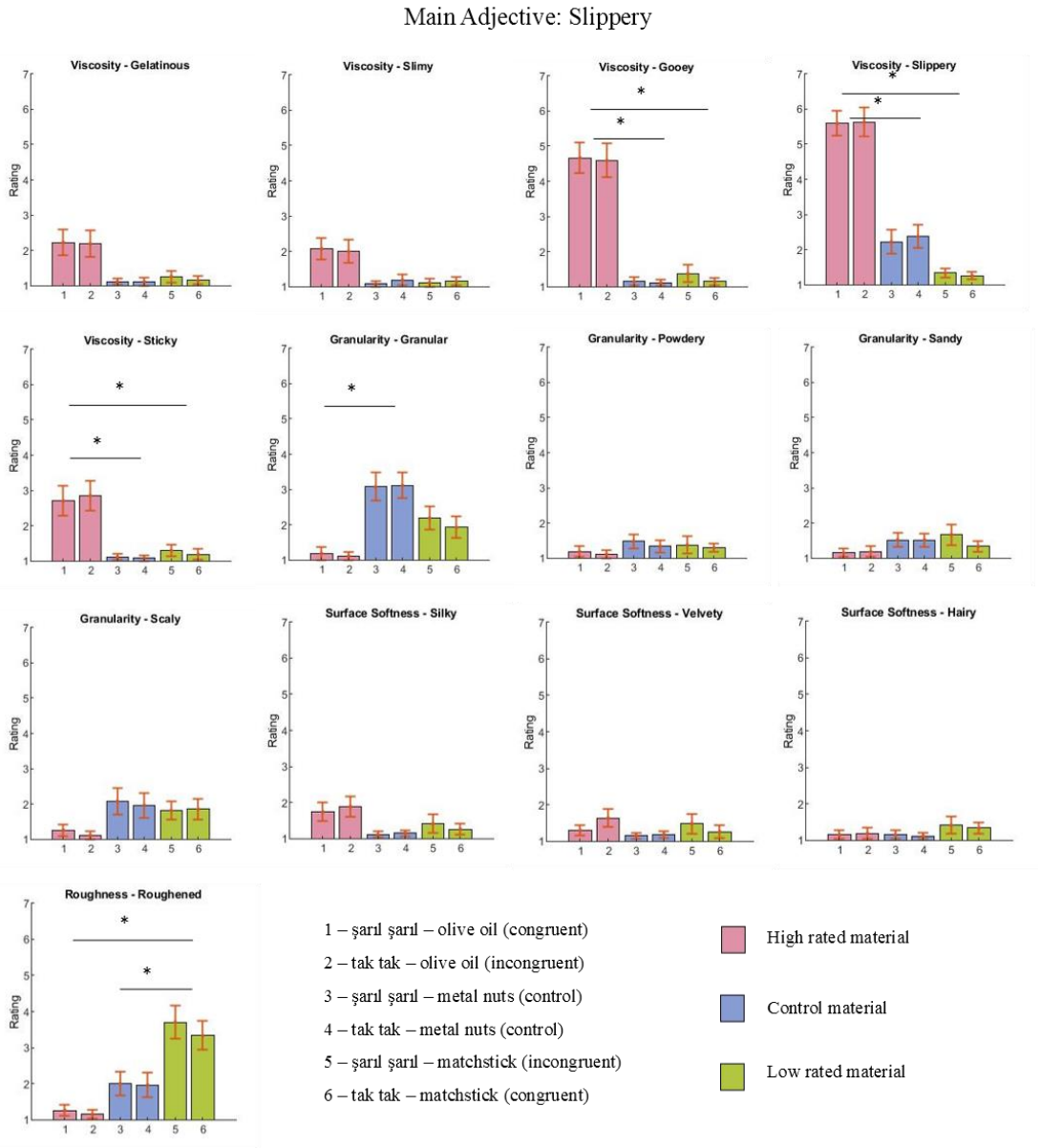

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Slippery. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

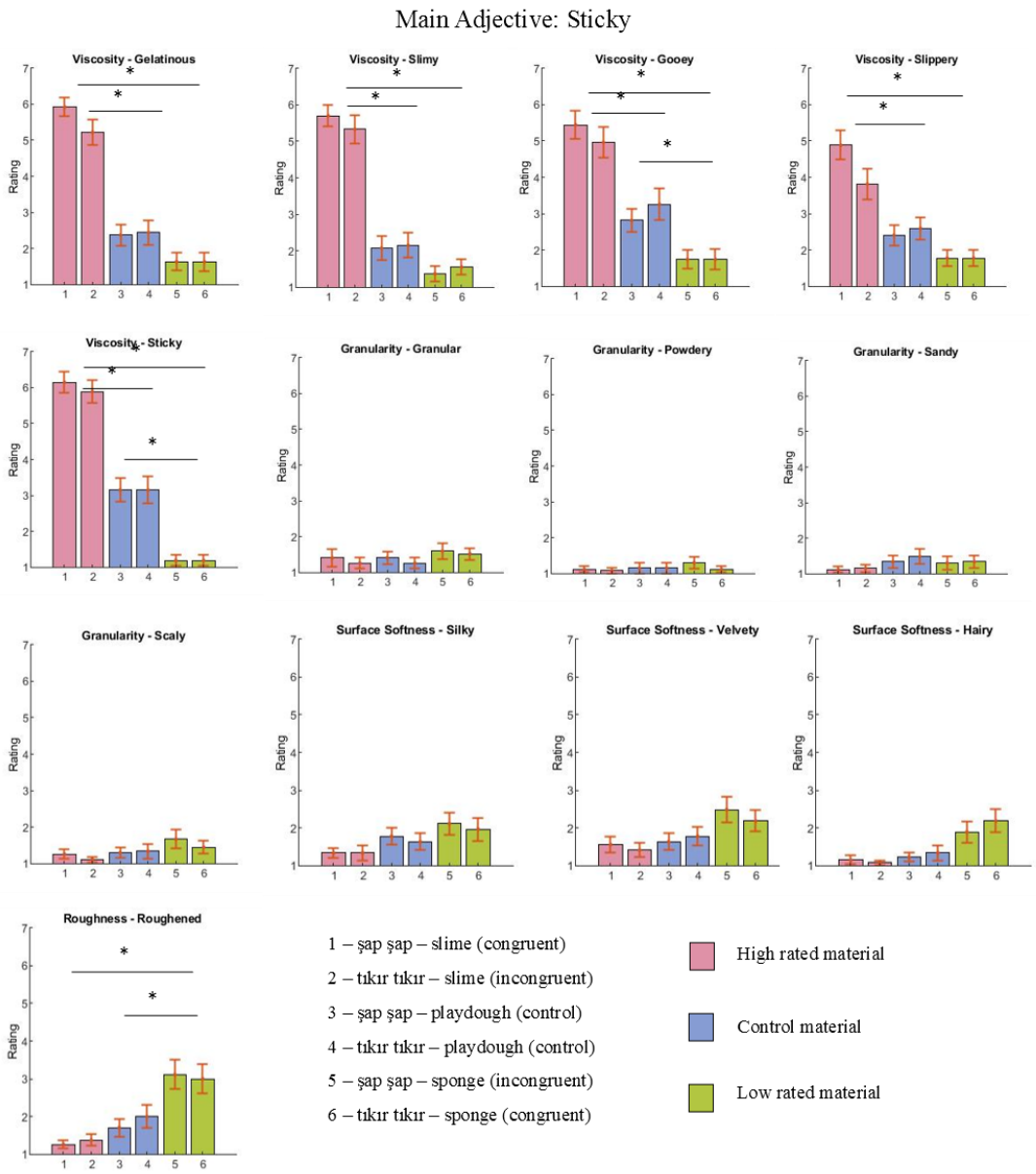

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Sticky. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

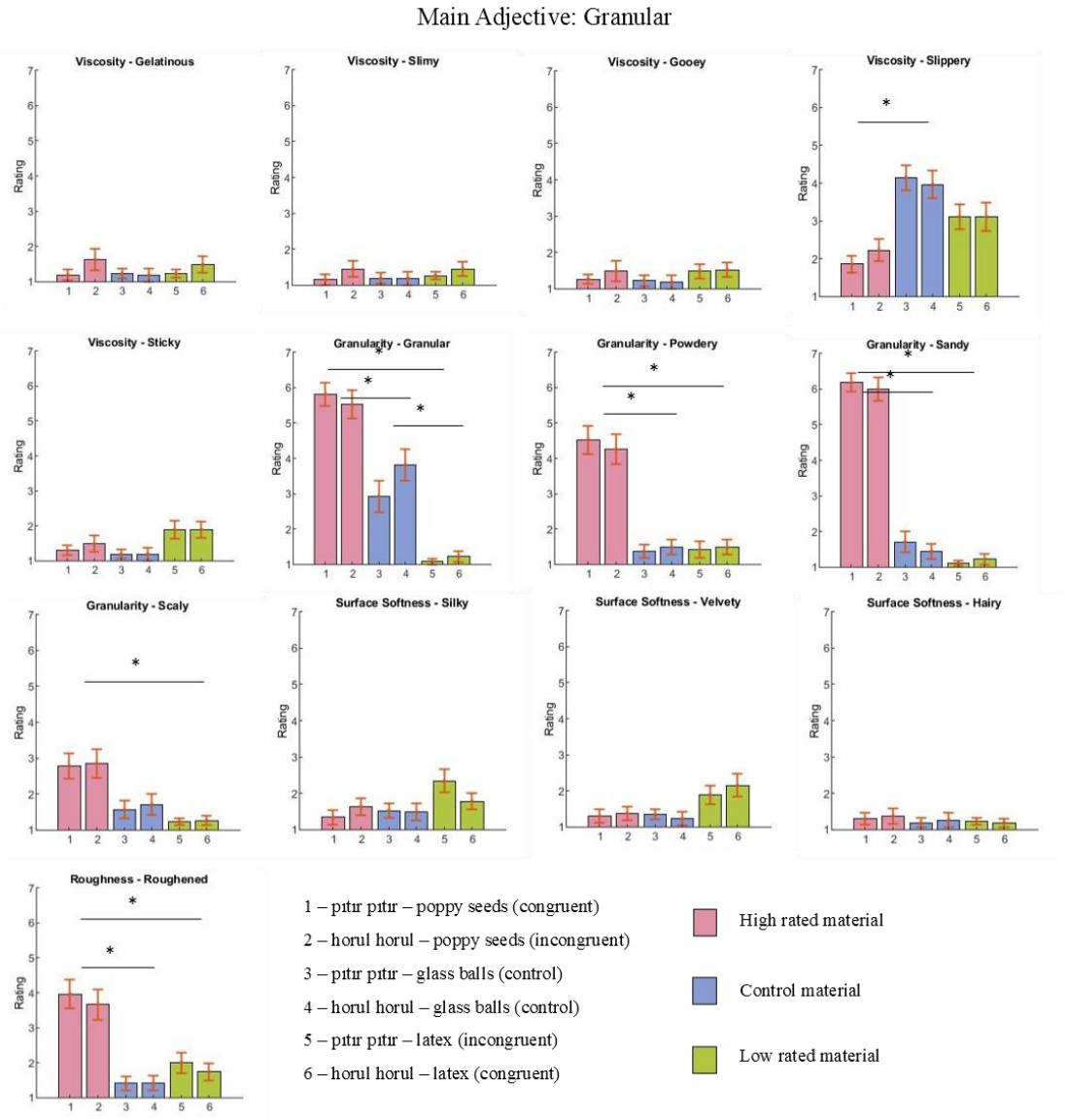

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Granular. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

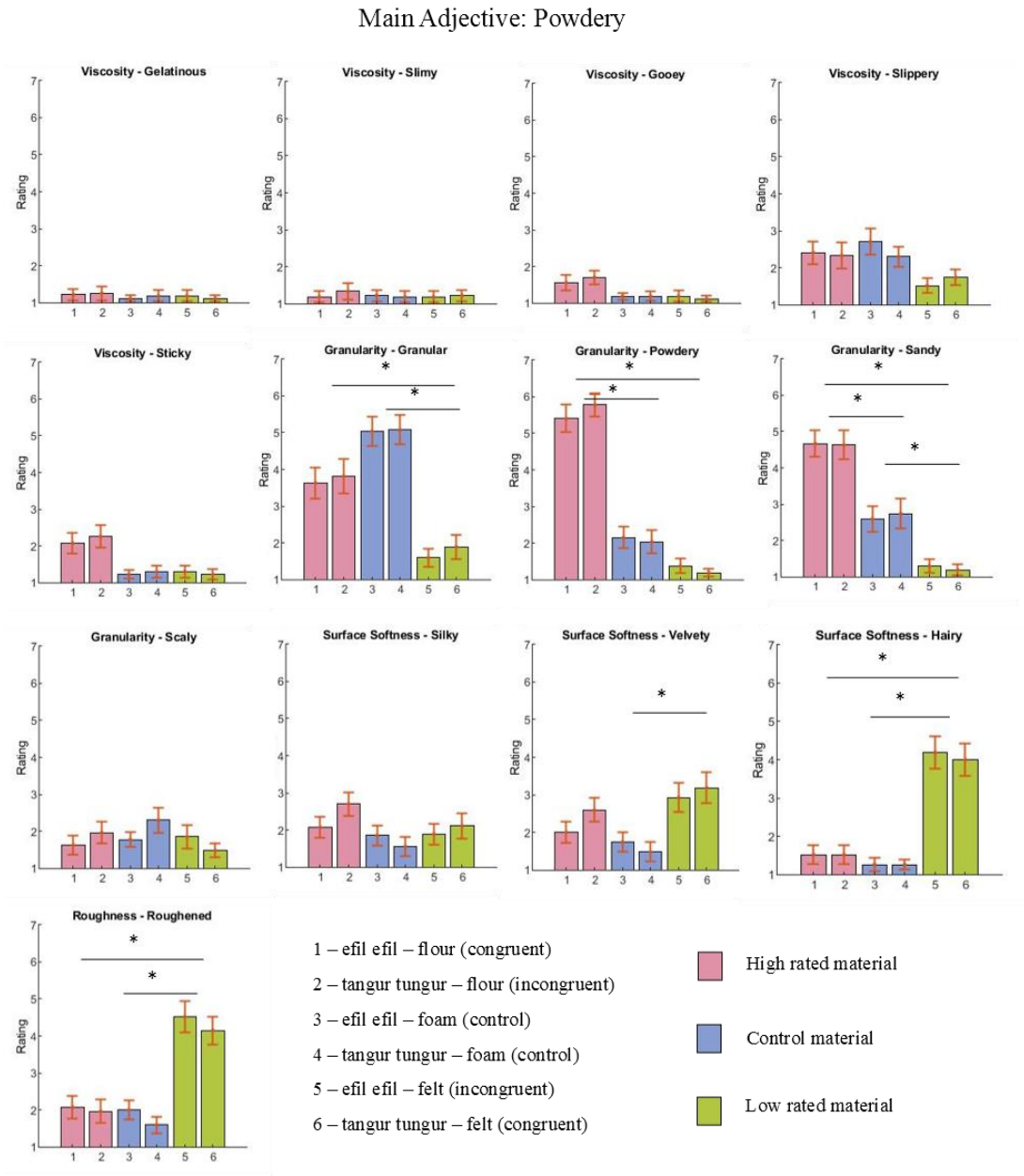

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Powdery. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

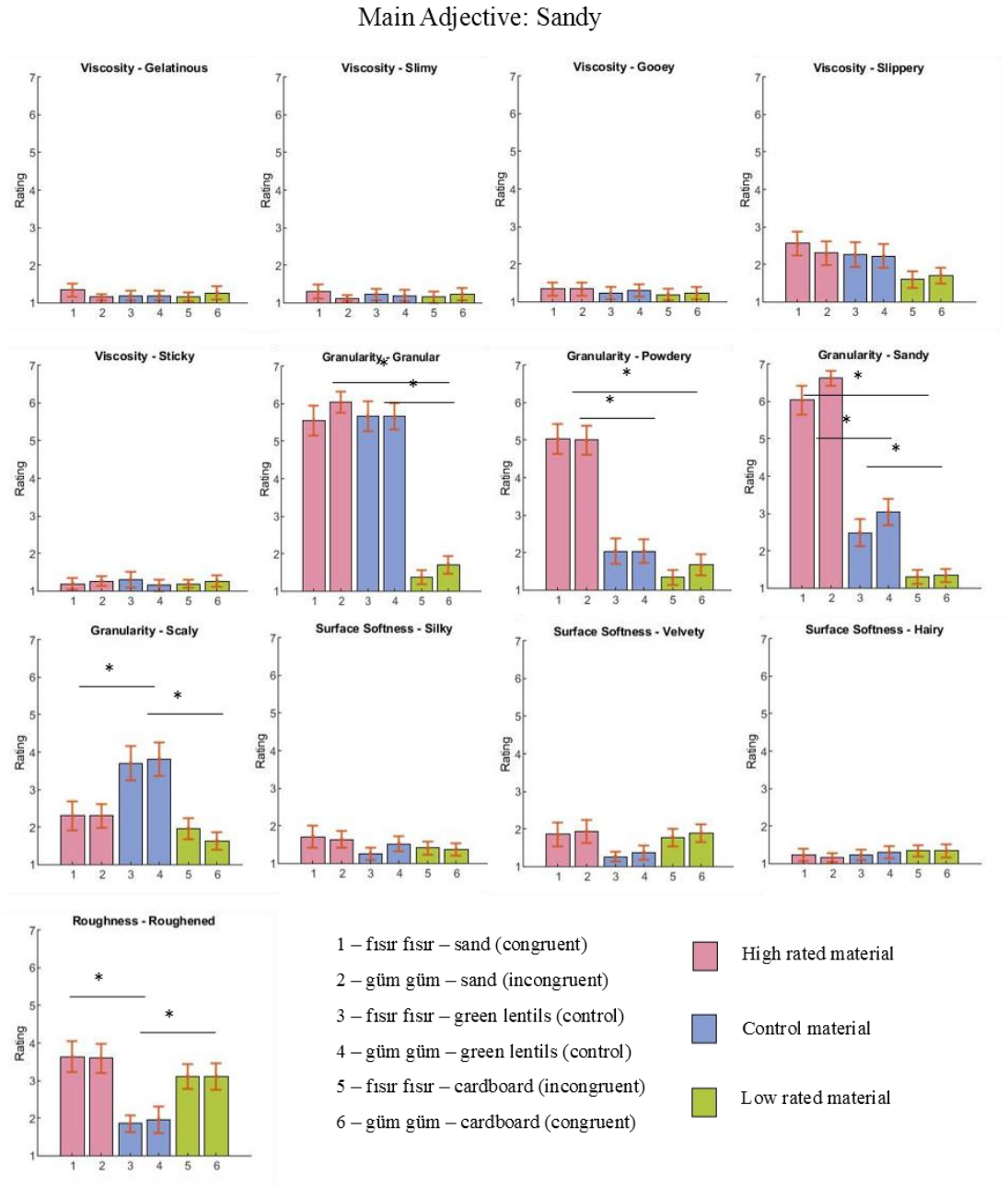

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Sandy. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

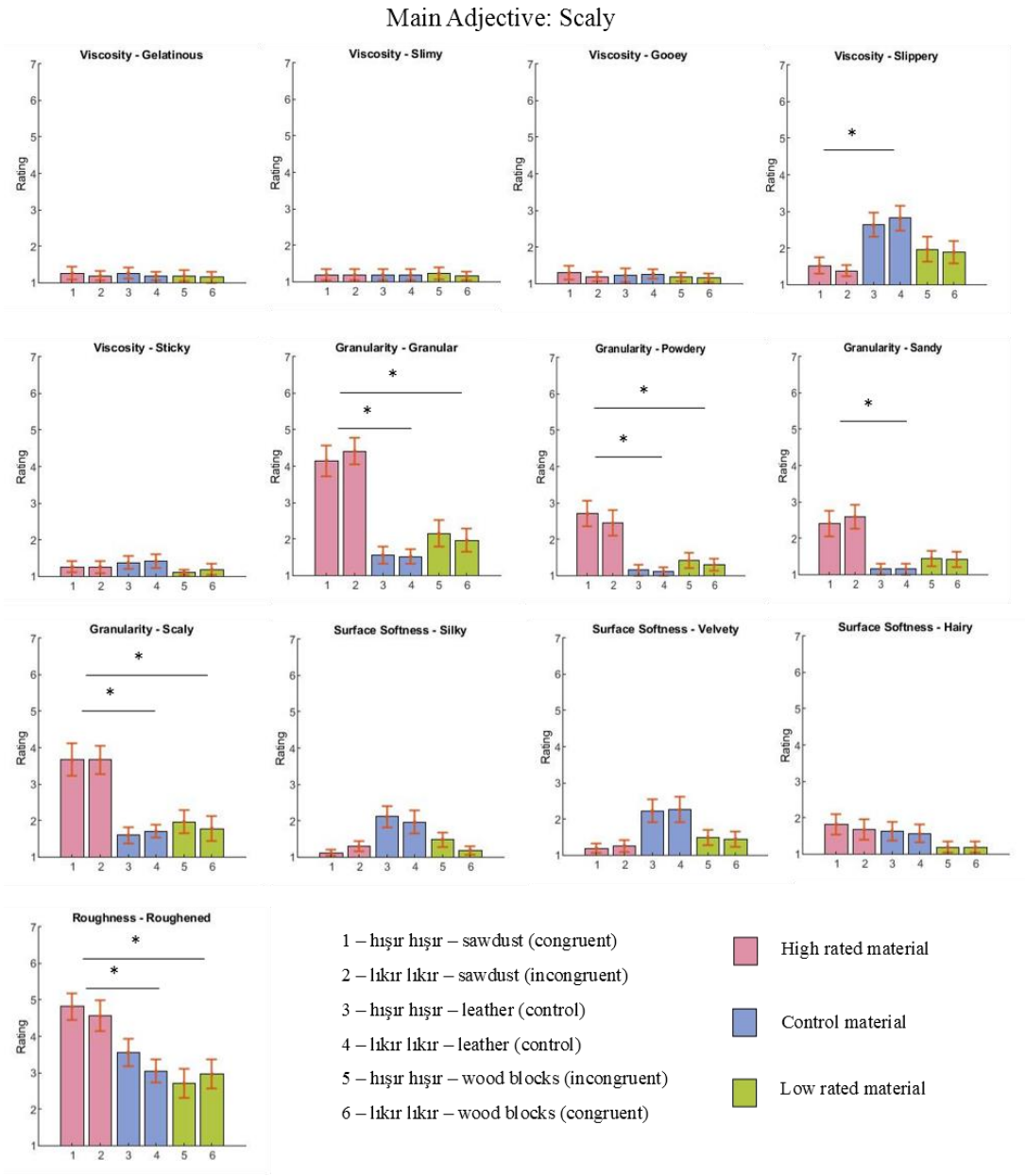

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Scaly. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

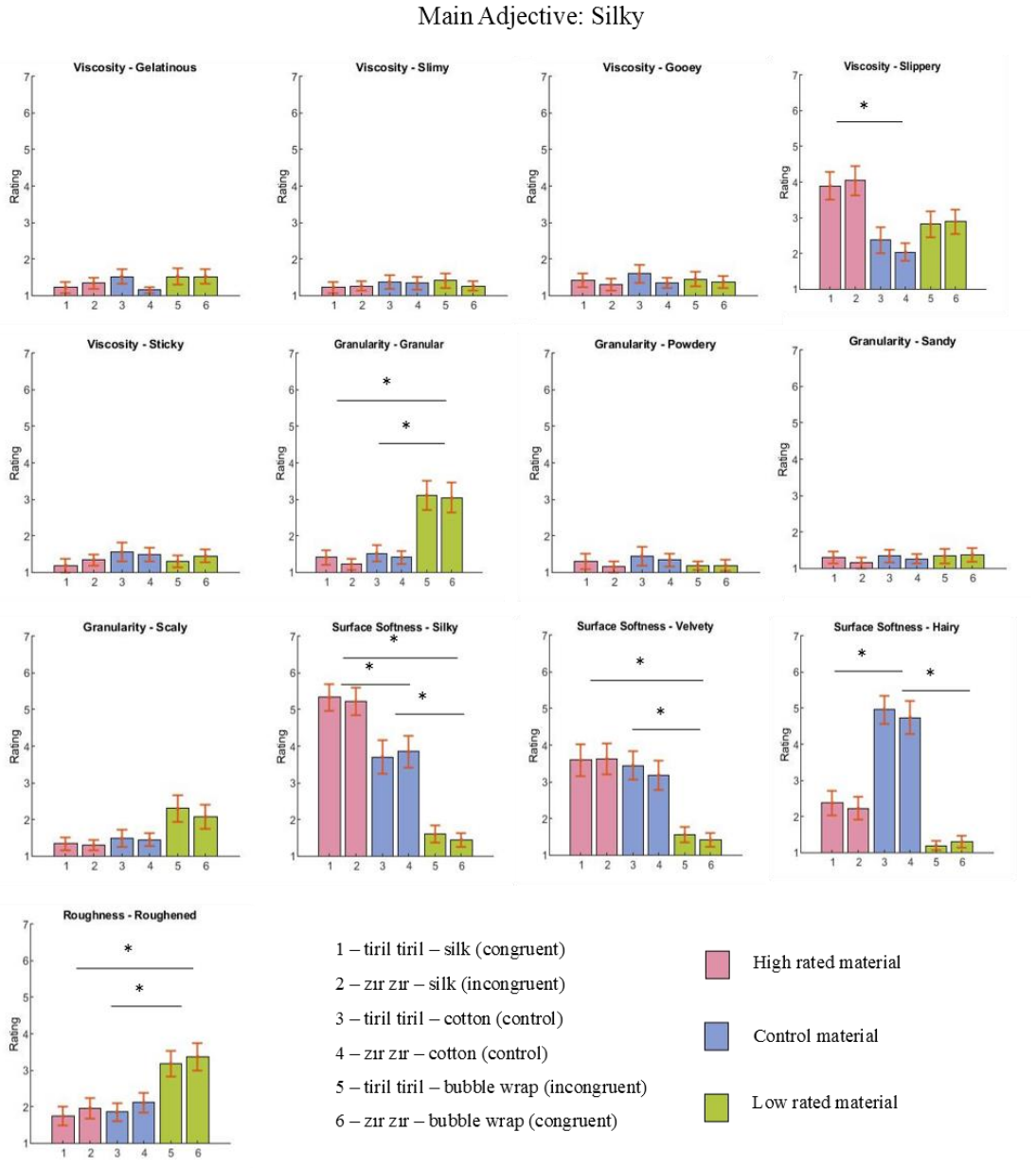

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Silky. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

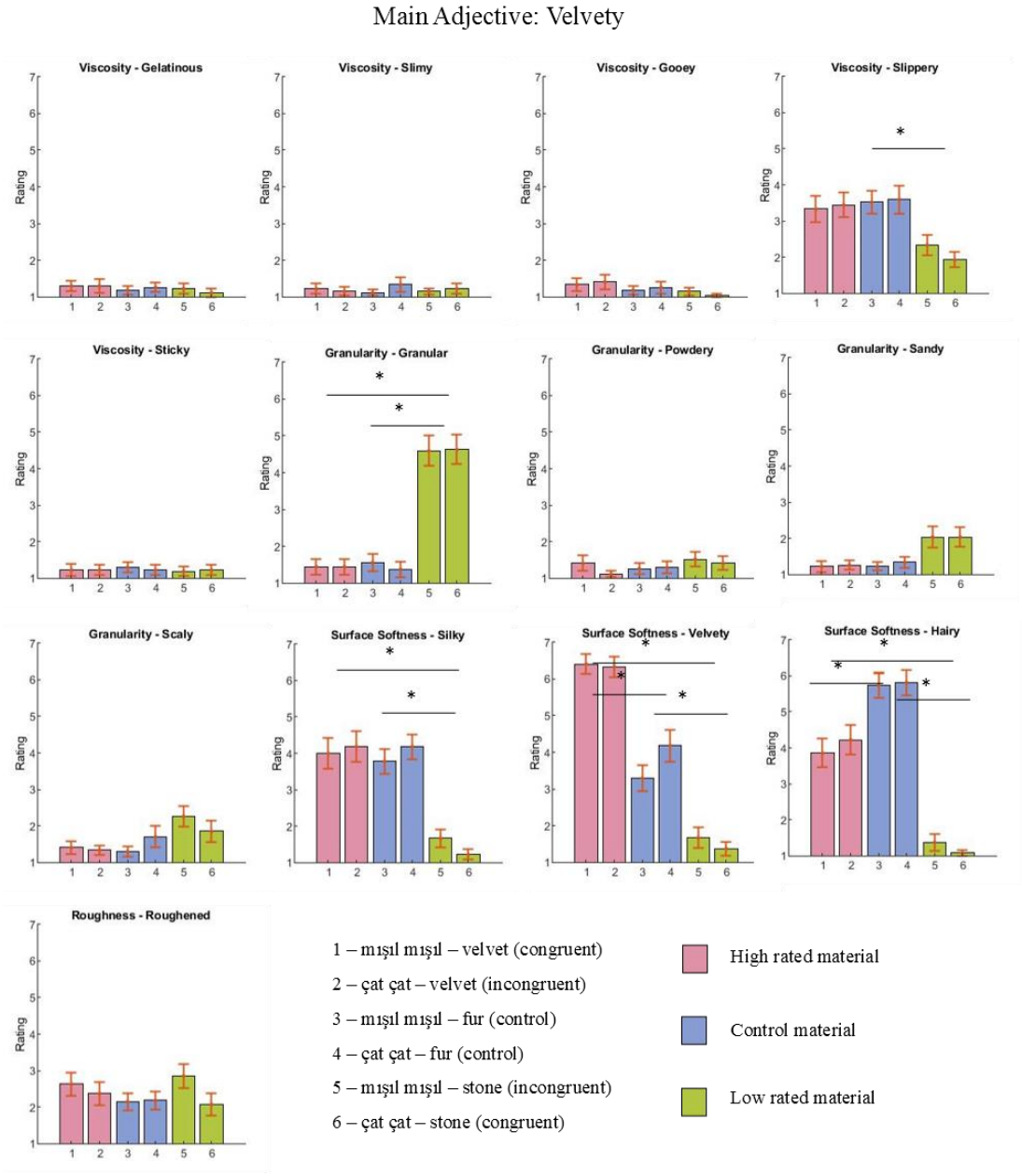

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Velvety. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

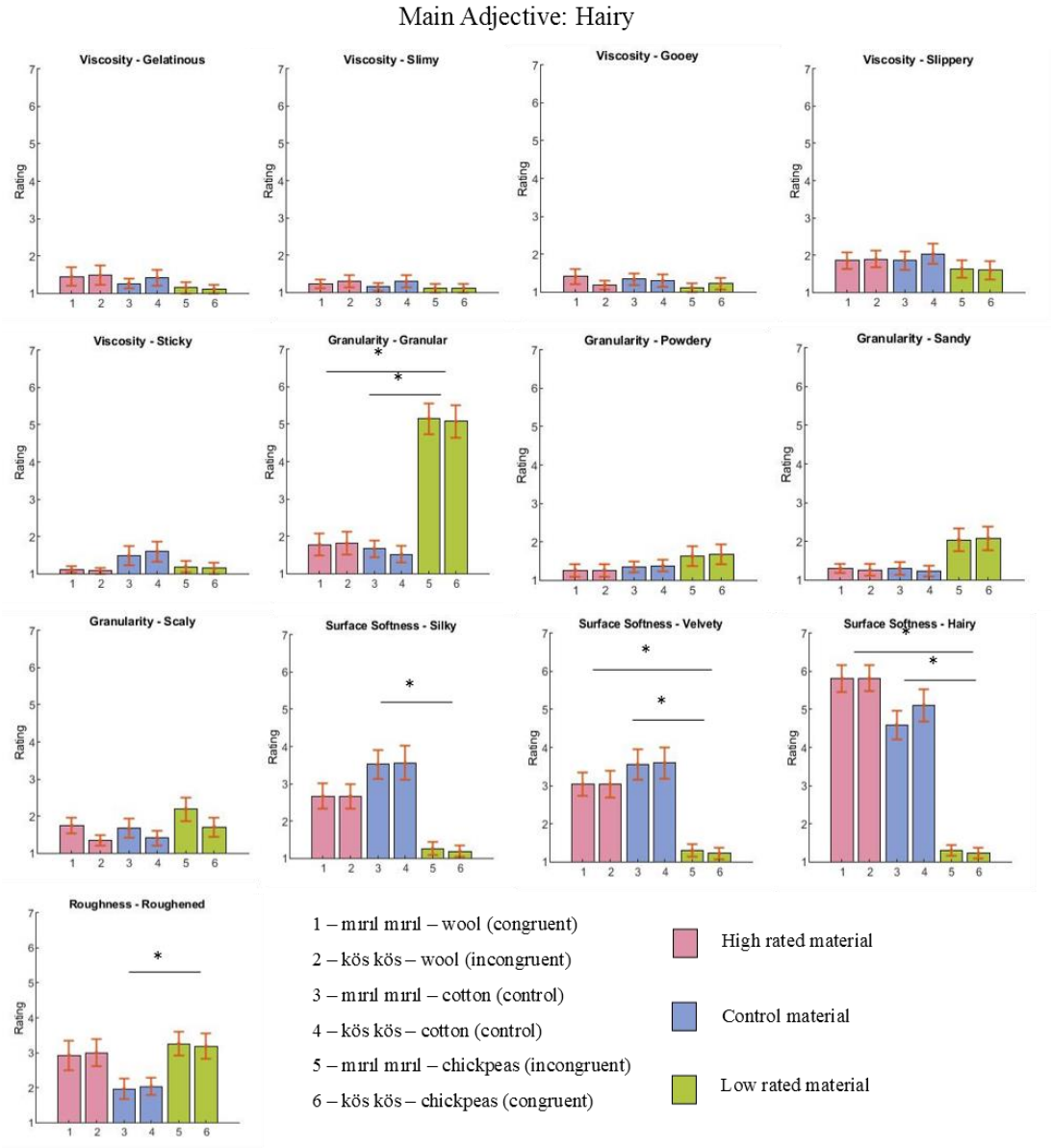

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Hairy. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

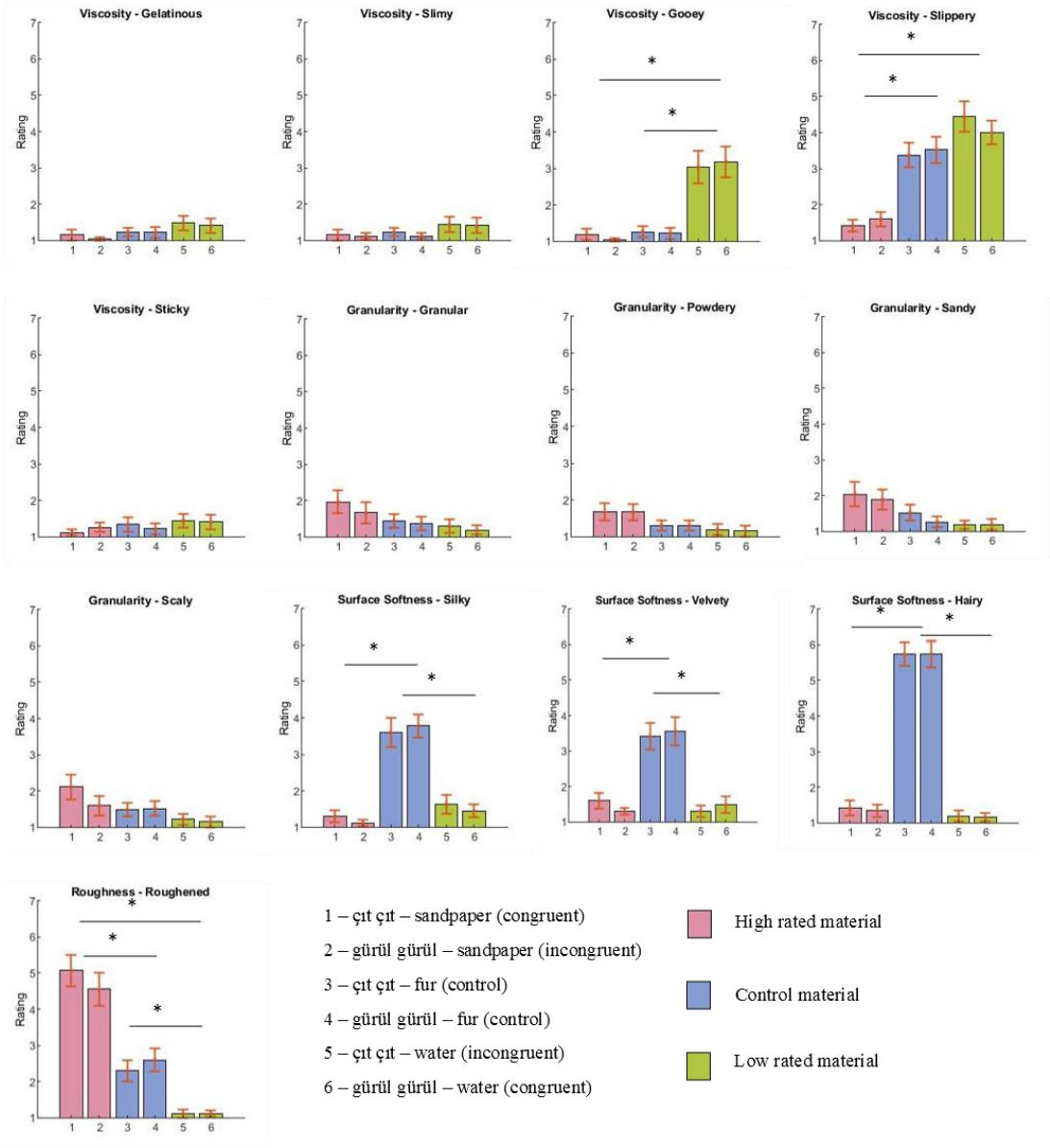

Figure E.1 (continued) Rating differences between conditions across all adjectives in Experiment 1. This plot is for Main Adjective Roughened. Each graph demonstrates the ratings for a different adjective. For each graph, y-axis shows the rating, the x-axis shows the onomatopoeic word-material pairing. Left two bars are for the high rated material, middle two bars are for the control material, the right two bars are the low rated material. The pairing each bar represents is mentioned in the text box within the figure. The significant differences between materials are depicted with a line that has a star above. The longer line represents the significant difference between high and low rated materials. The shorter line represents the significant difference between high and control, or low and control materials, depending on where the line is located.

F. GRAPHS FOR STUDY 3

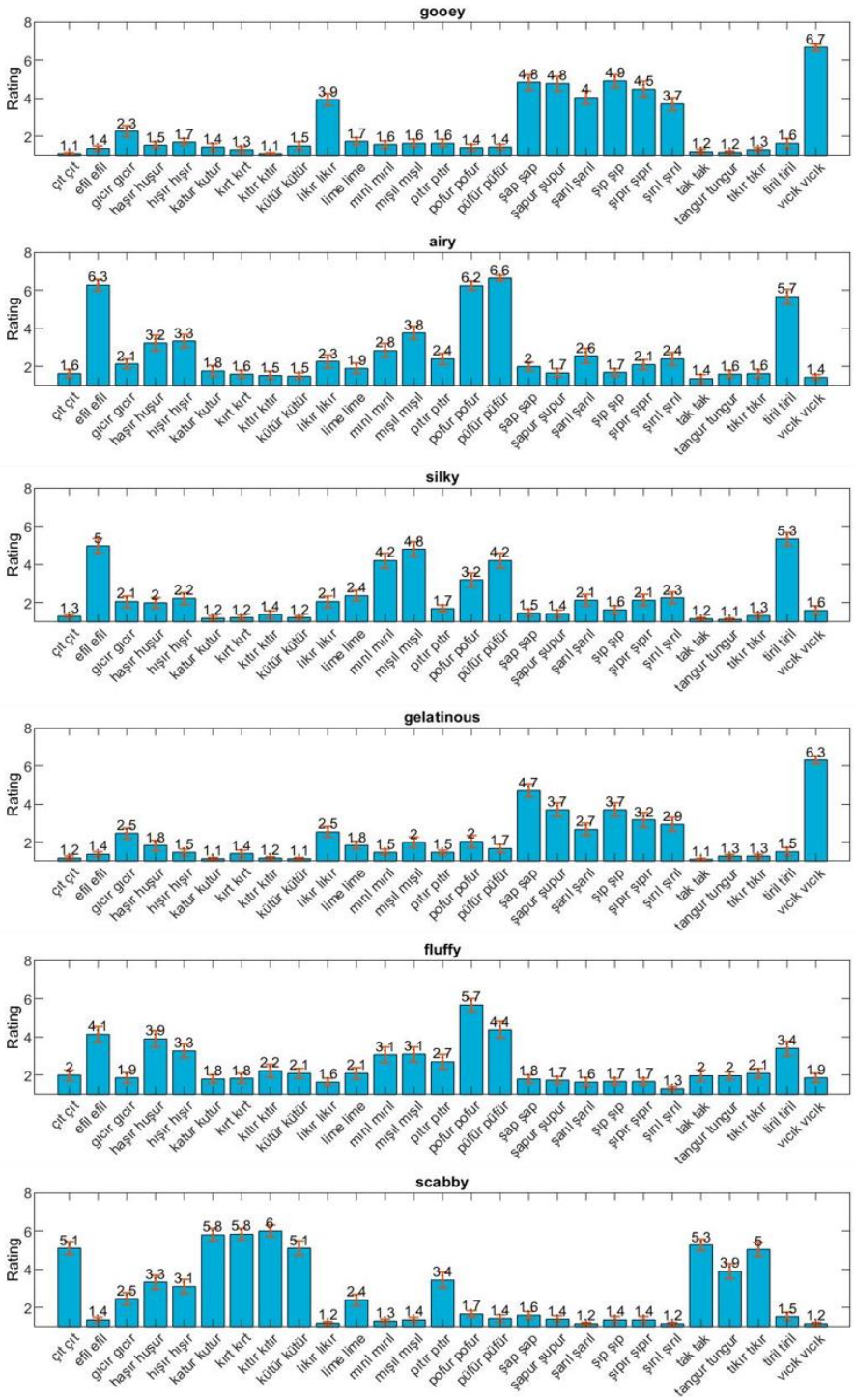

Figure F.1 The ratings of adjectives on all onomatopoeic words for Study 3. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the onomatopoeic word.

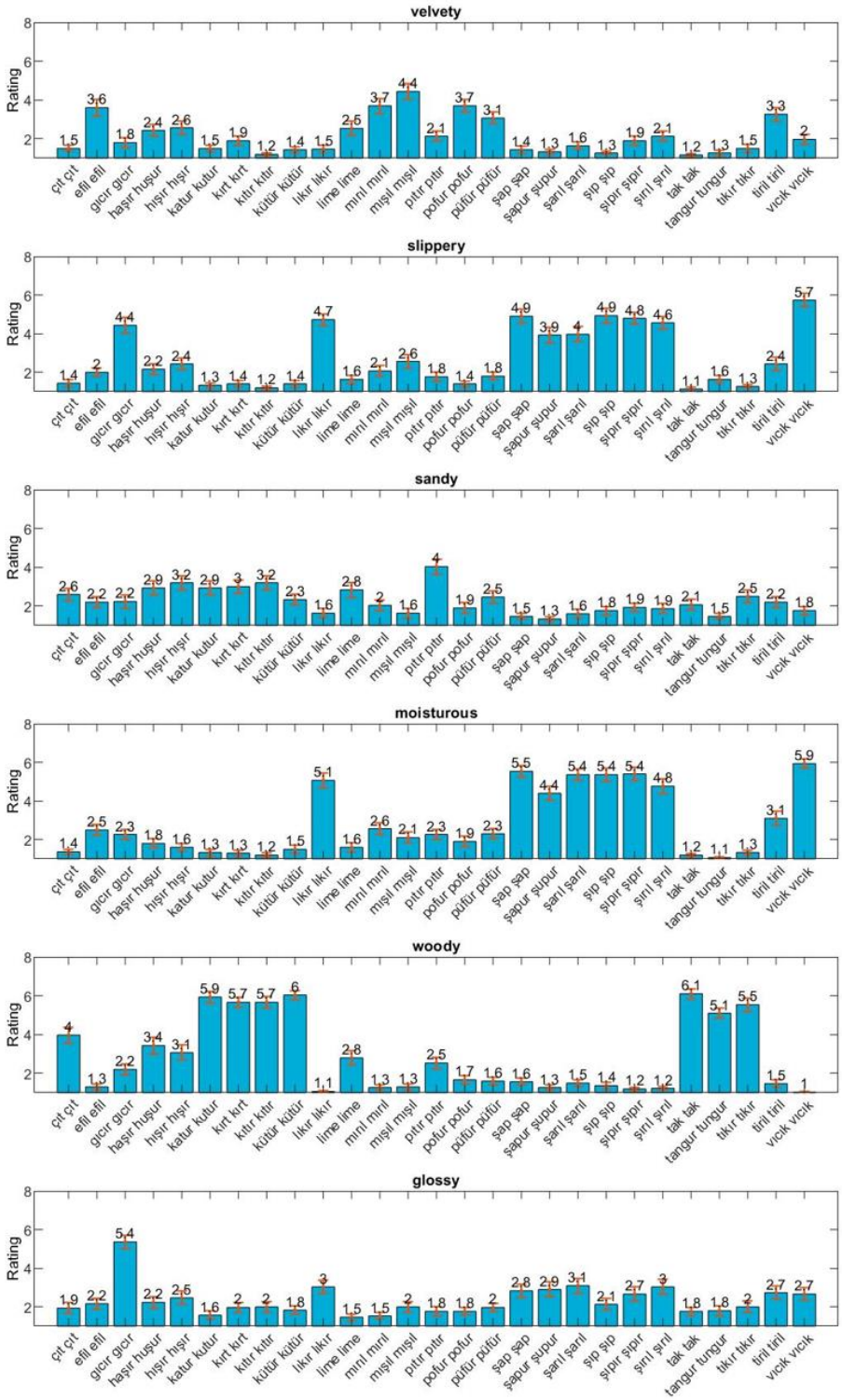

Figure F.1 (continued) The ratings of adjectives on all onomatopoeic words for Study 3. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the onomatopoeic word.

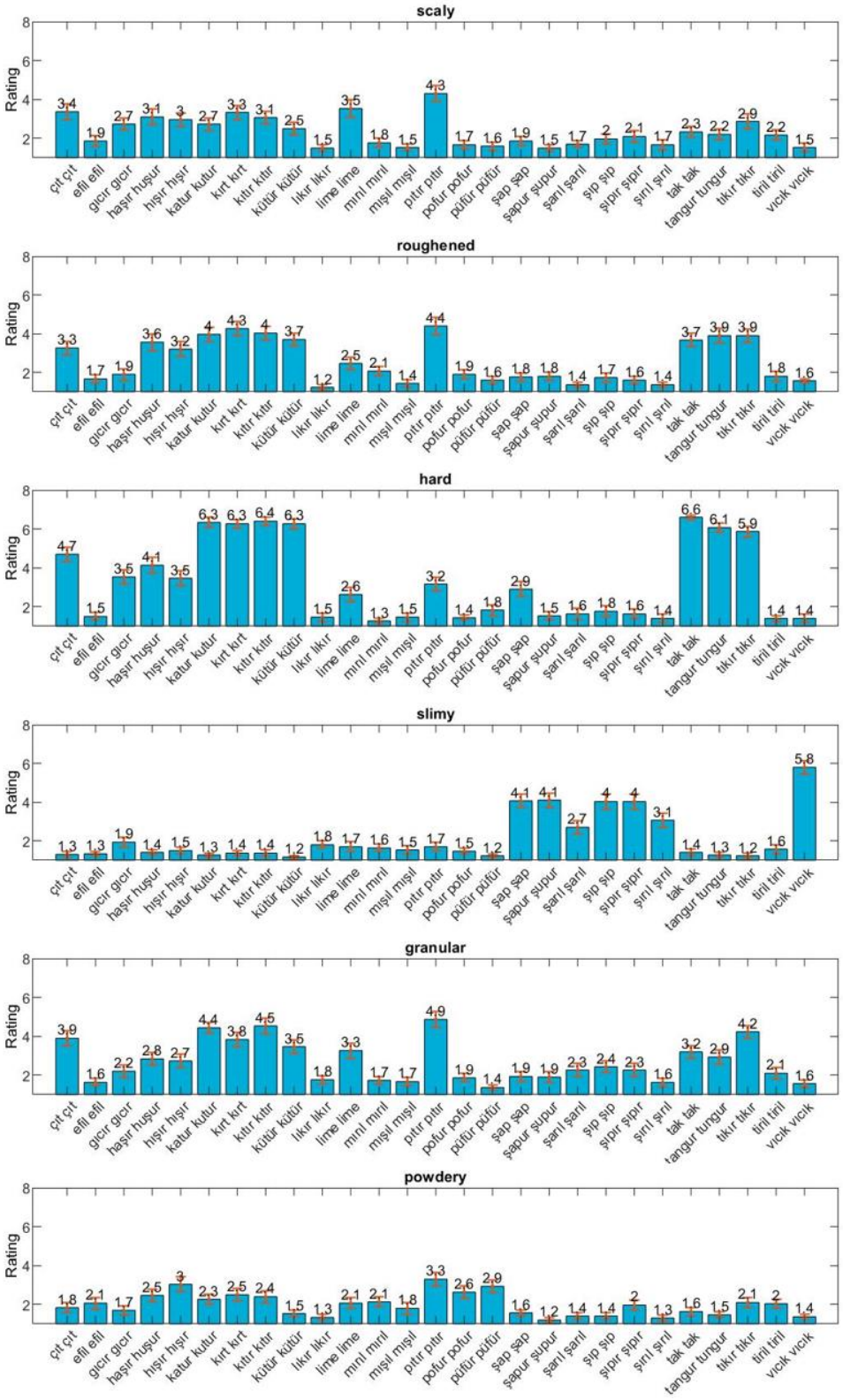

Figure F.1 (continued) The ratings of adjectives on all onomatopoeic words for Study 3. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the onomatopoeic word.

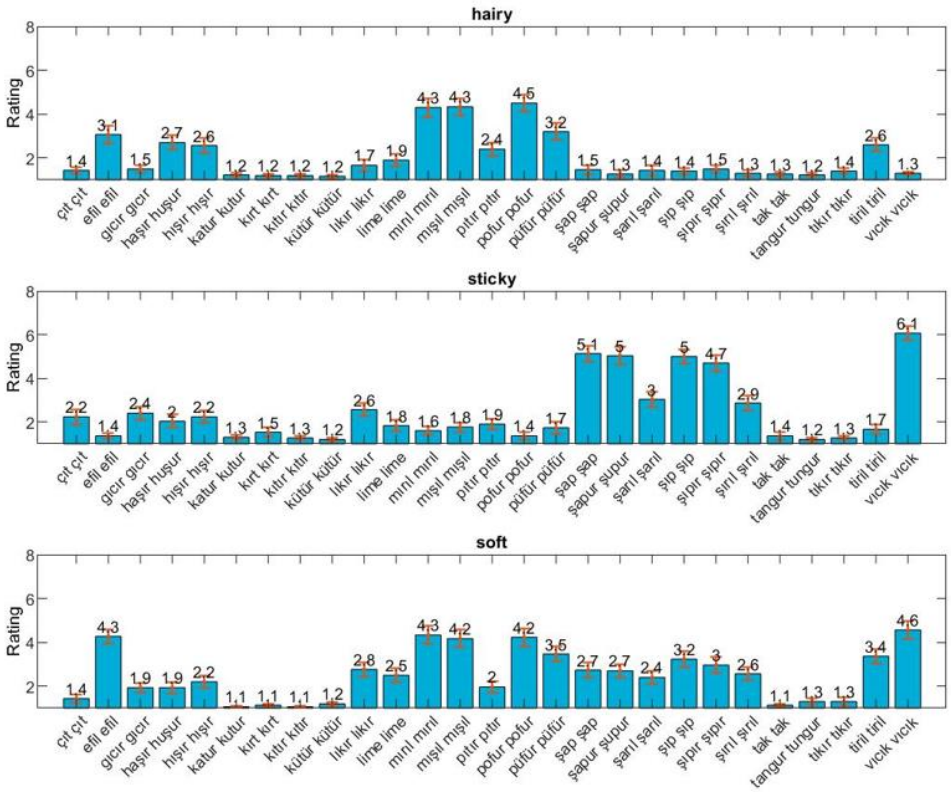

Figure F.1 (continued) The ratings of adjectives on all onomatopoeic words for Study 3. Each panel shows a separate adjective. The x-axis lists the onomatopoeic words, the y-axis is the ratings obtained for that adjective for each of the onomatopoeic word.

G. GRAPHS FOR EXPERIMENT 2

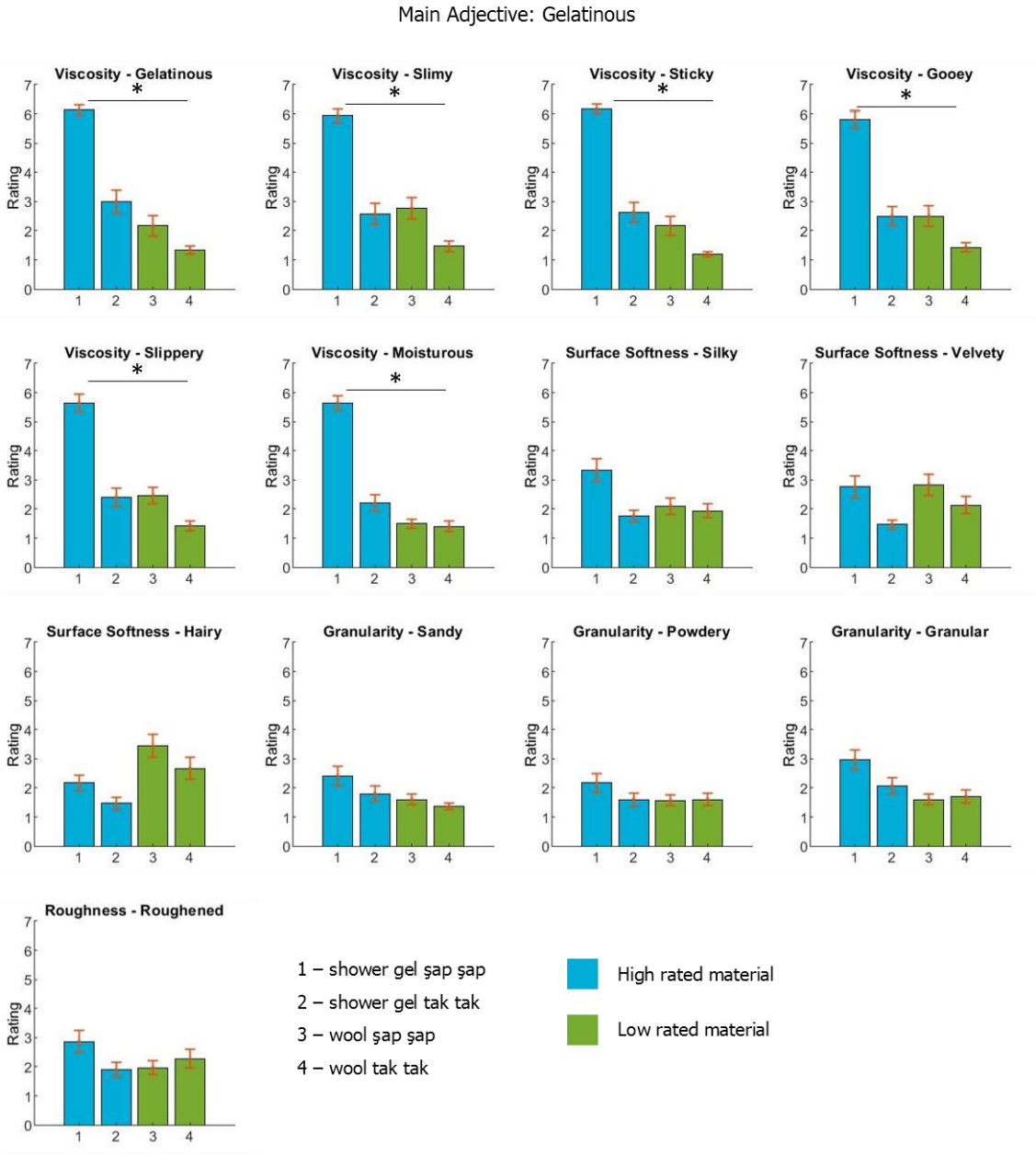

Figure G.1 Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Gelatinous. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

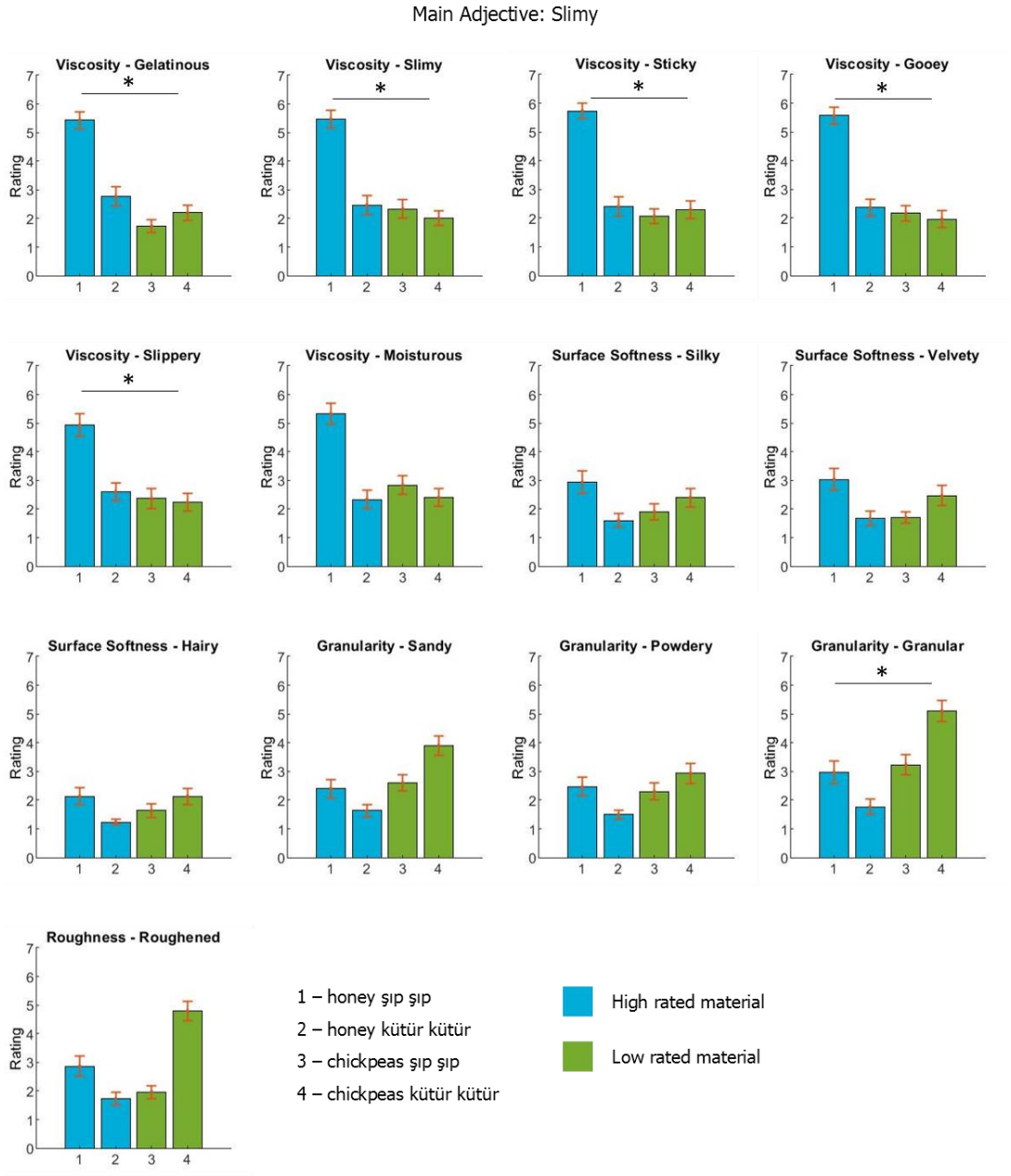

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Slimy. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

Main Adjective: Sticky

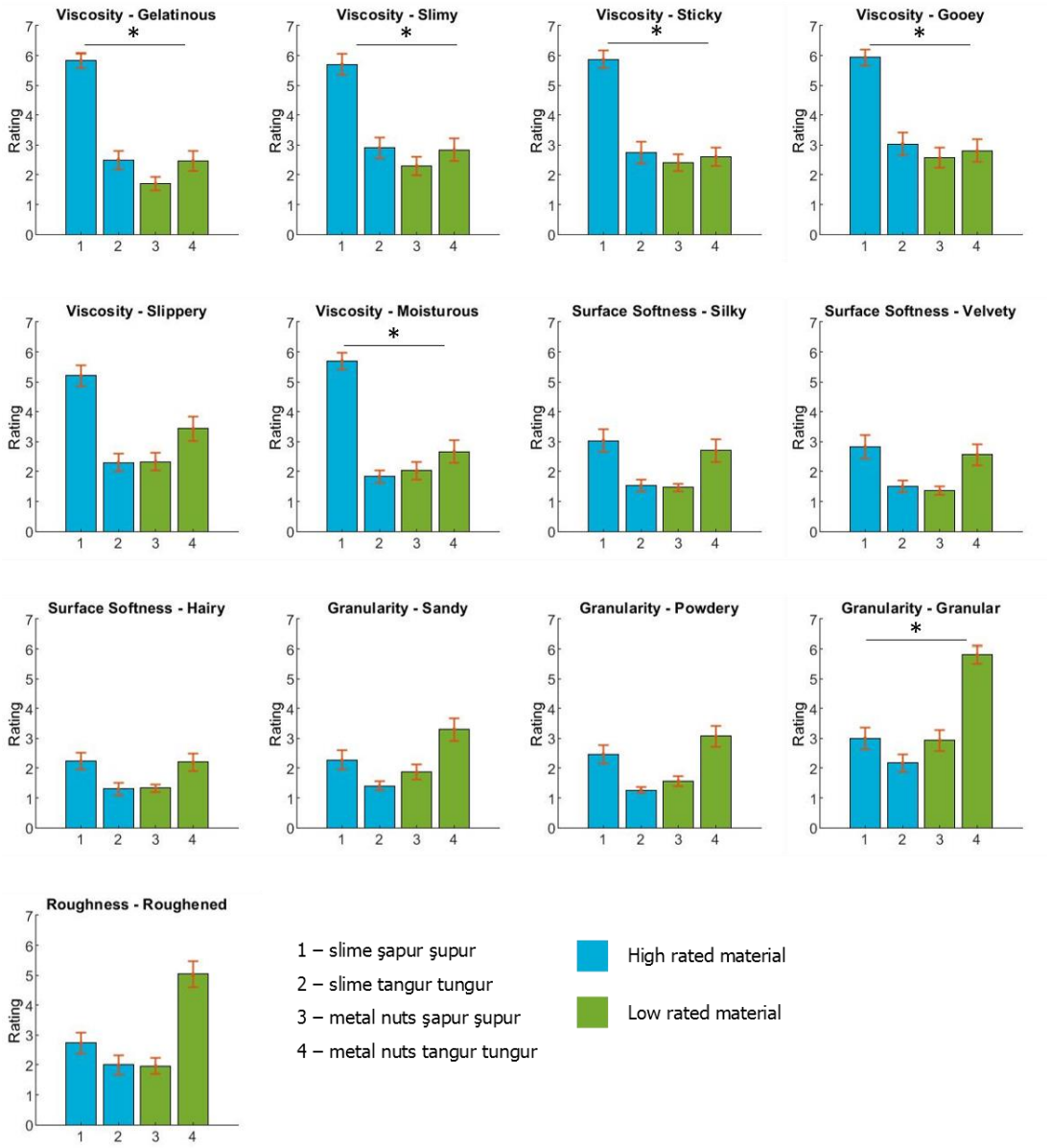

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Sticky. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

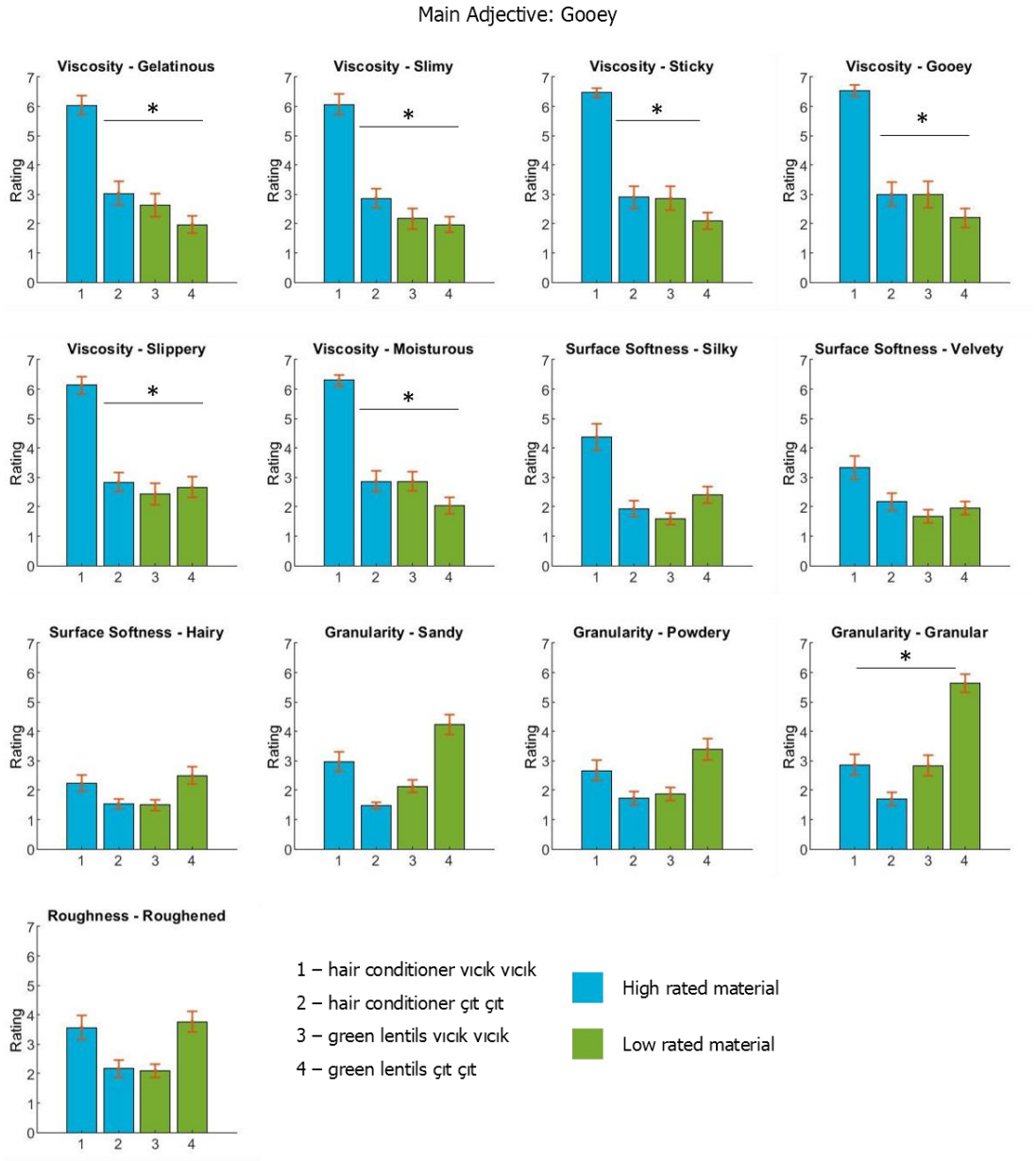

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Gooey. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

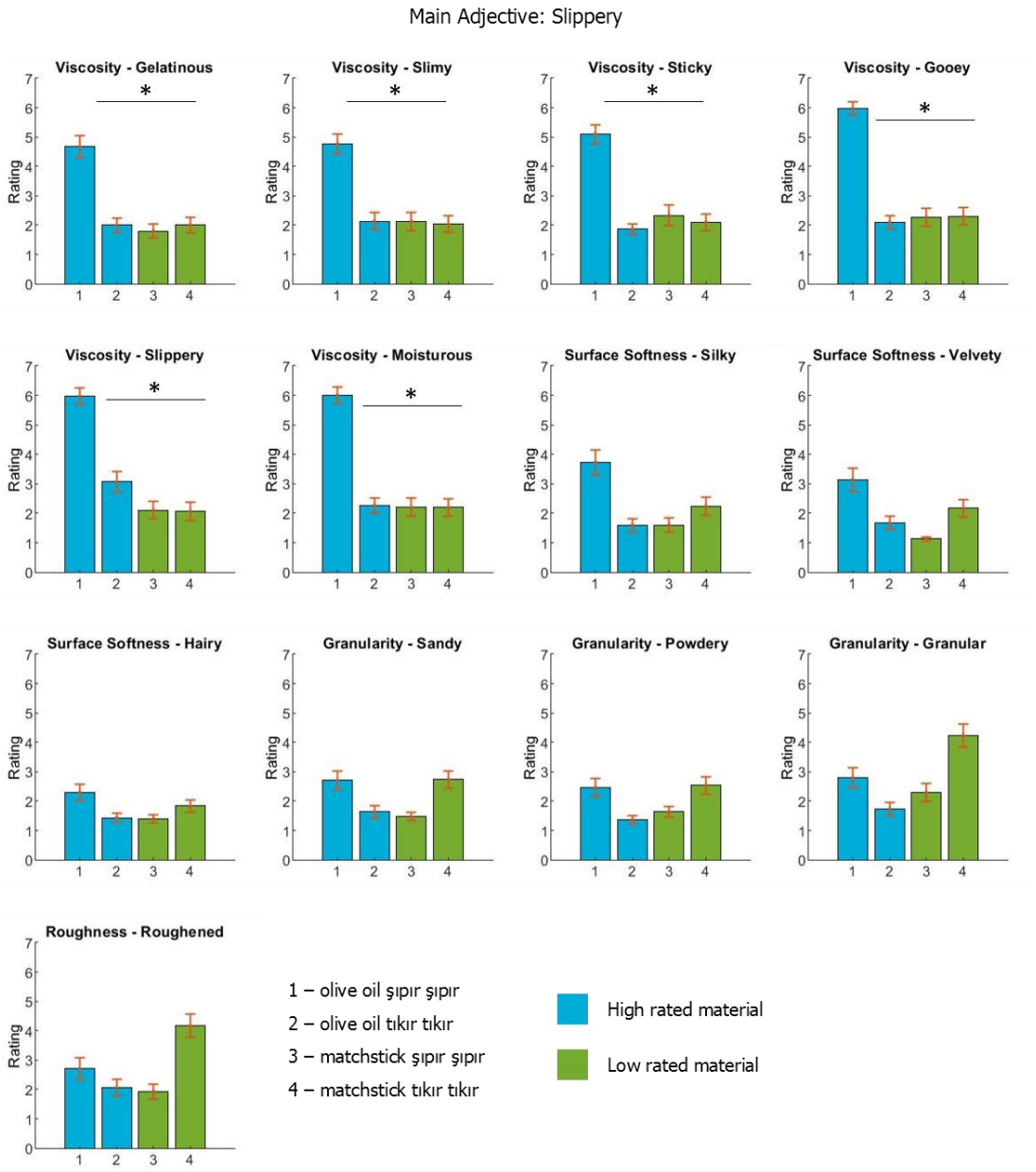

Figure H.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Slippery. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

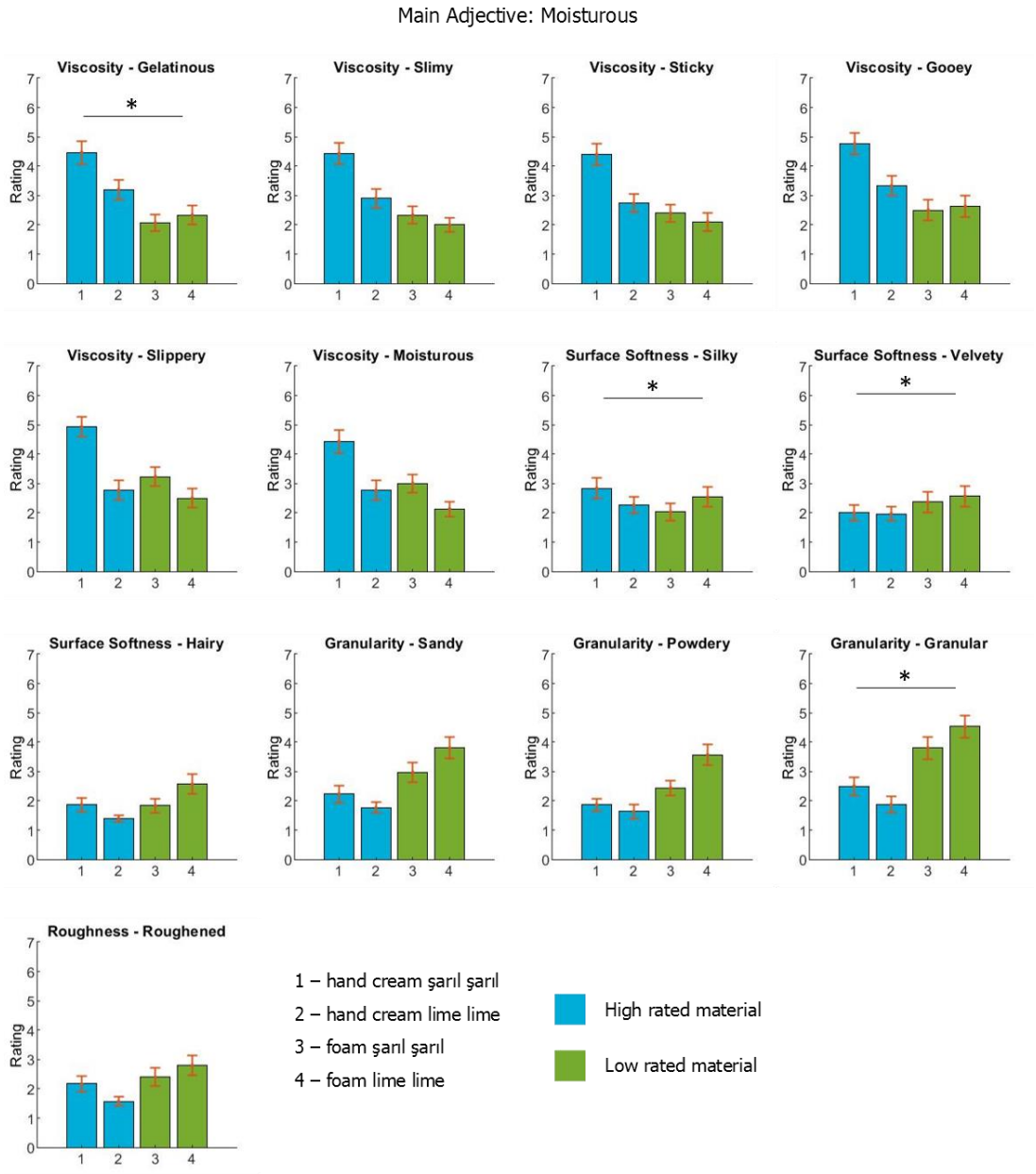

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Moisturous. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

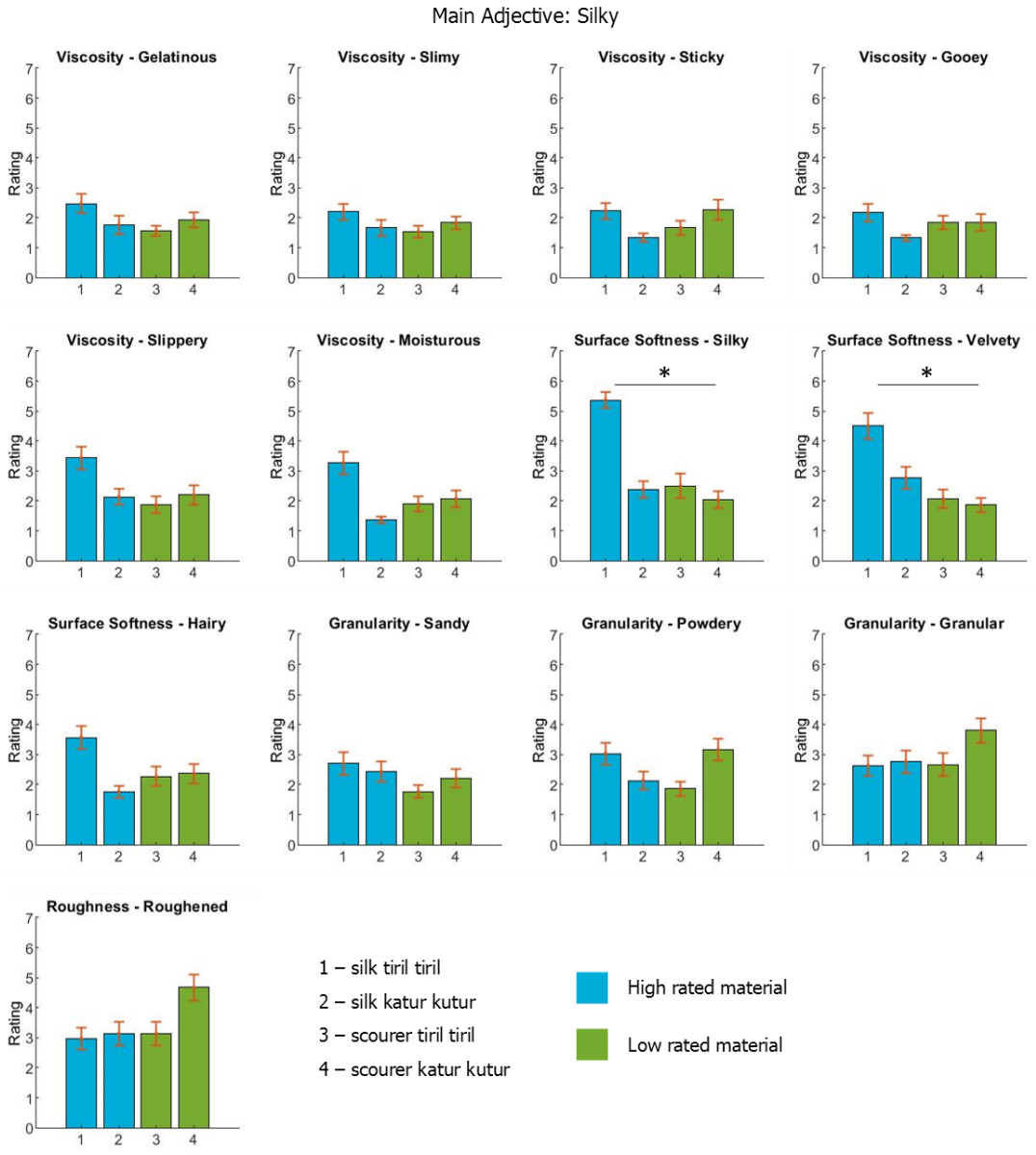

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Silky. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

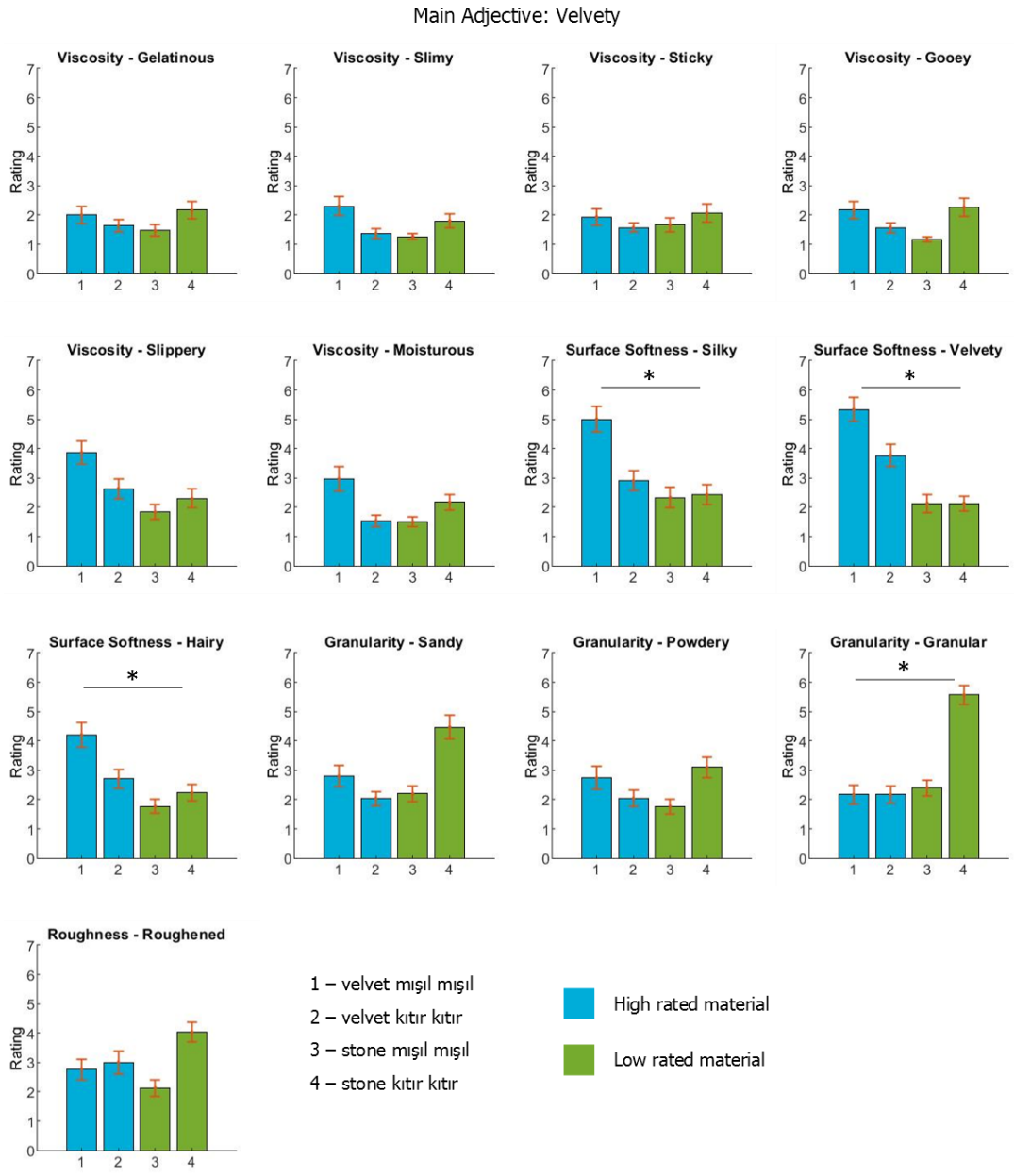

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Velvety. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

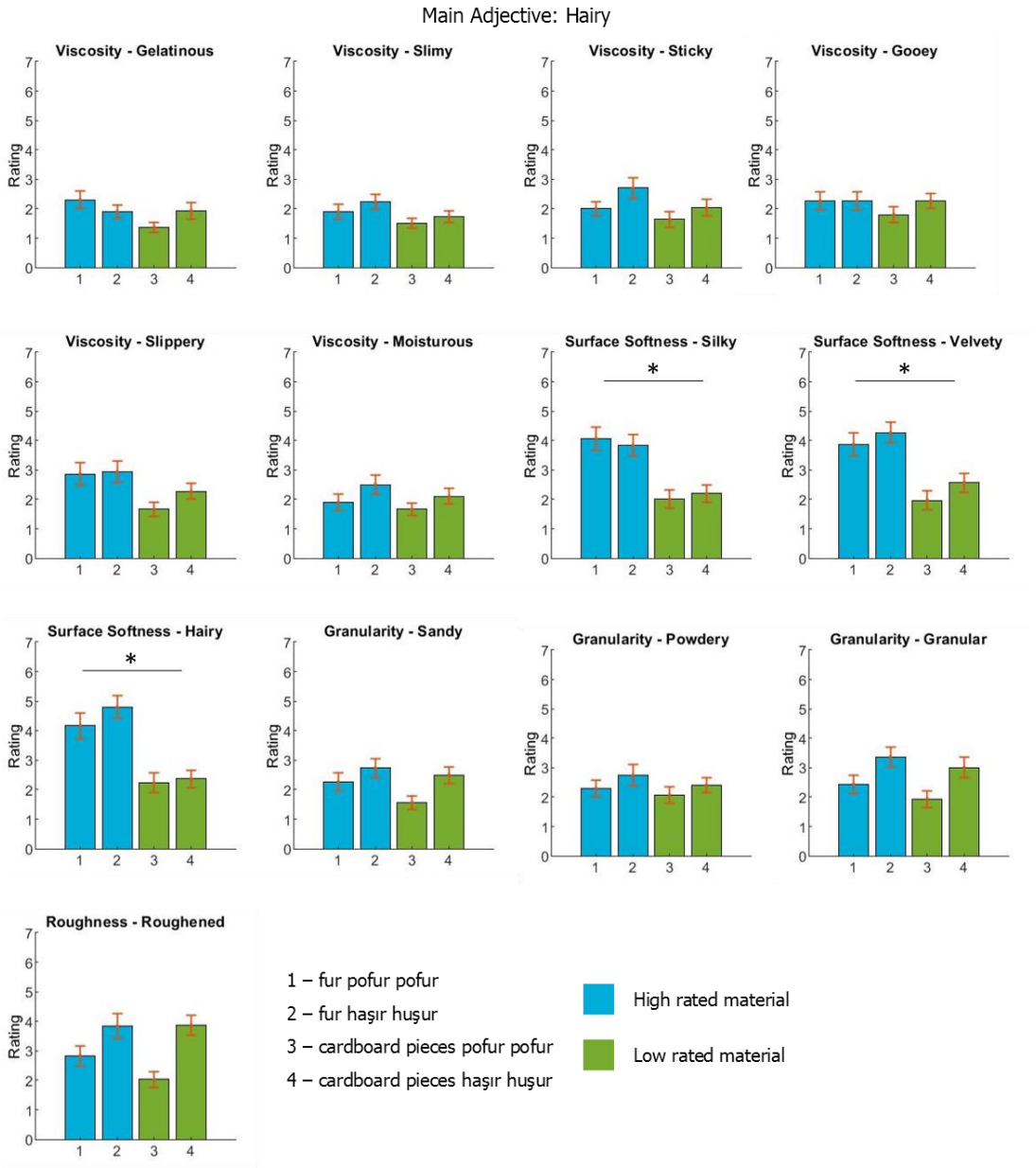

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Hairy. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

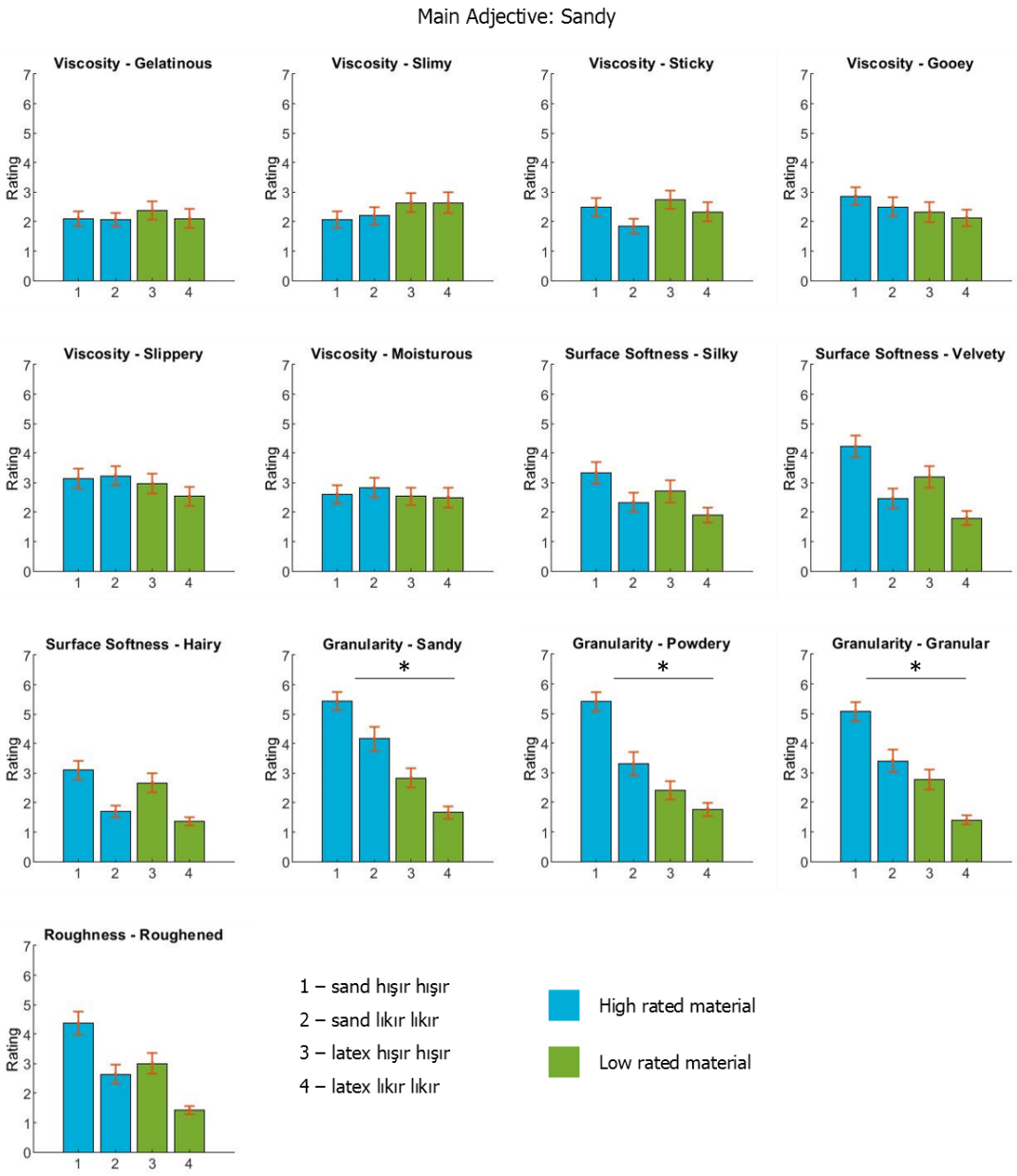

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Sandy. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

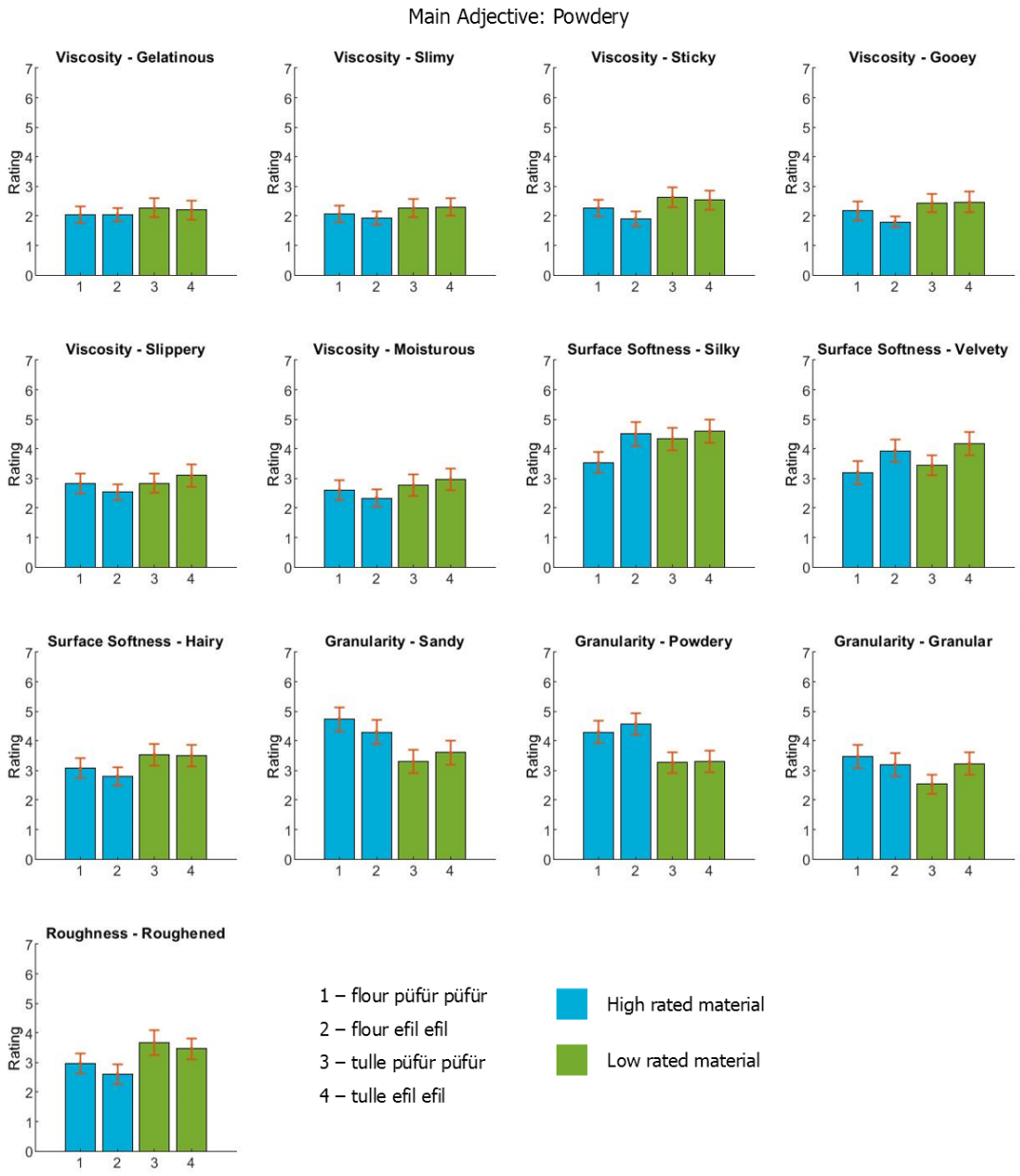

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Powdery. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

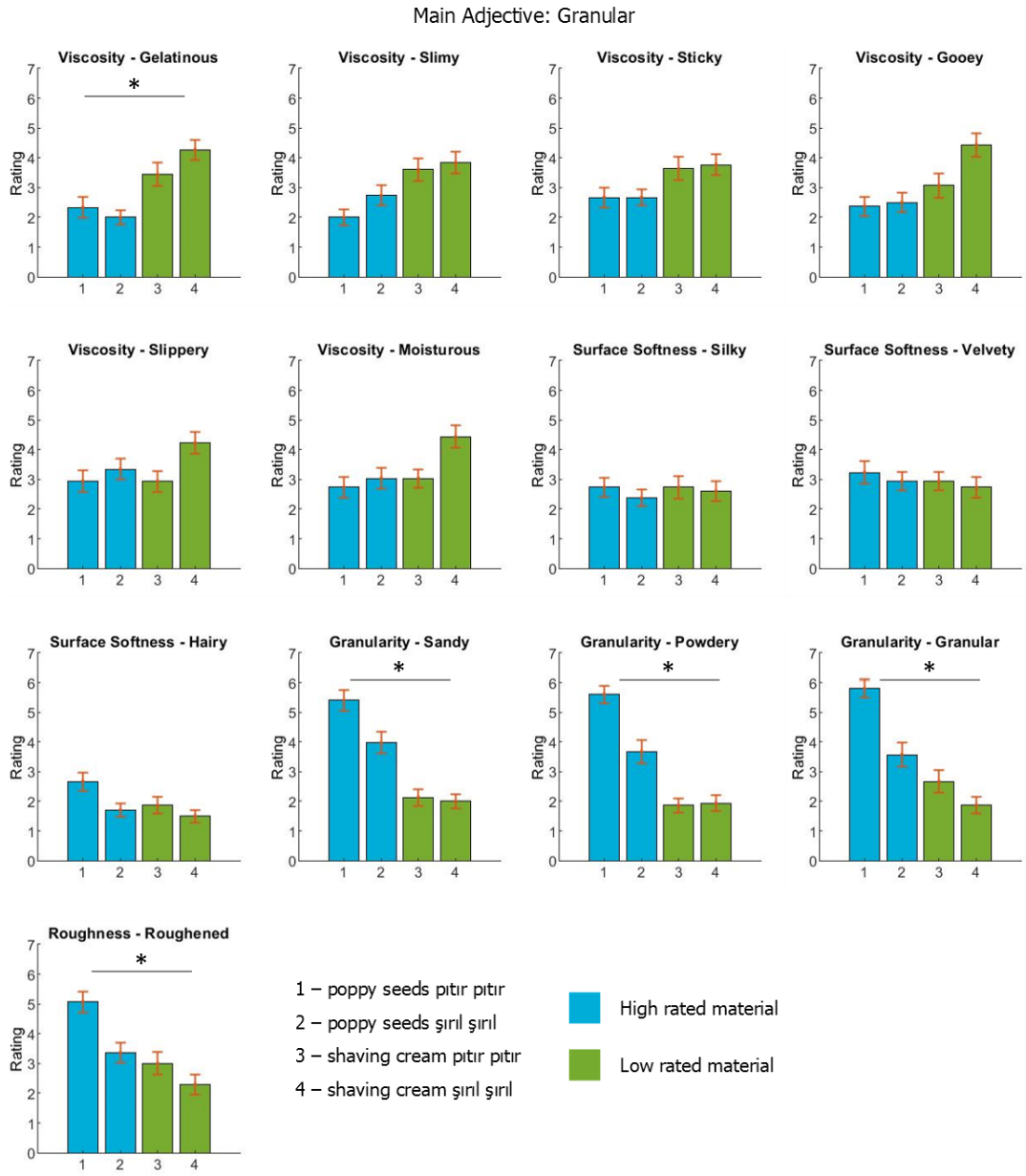

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Granular. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoeic words used for each Main Adjective is written in the figure.

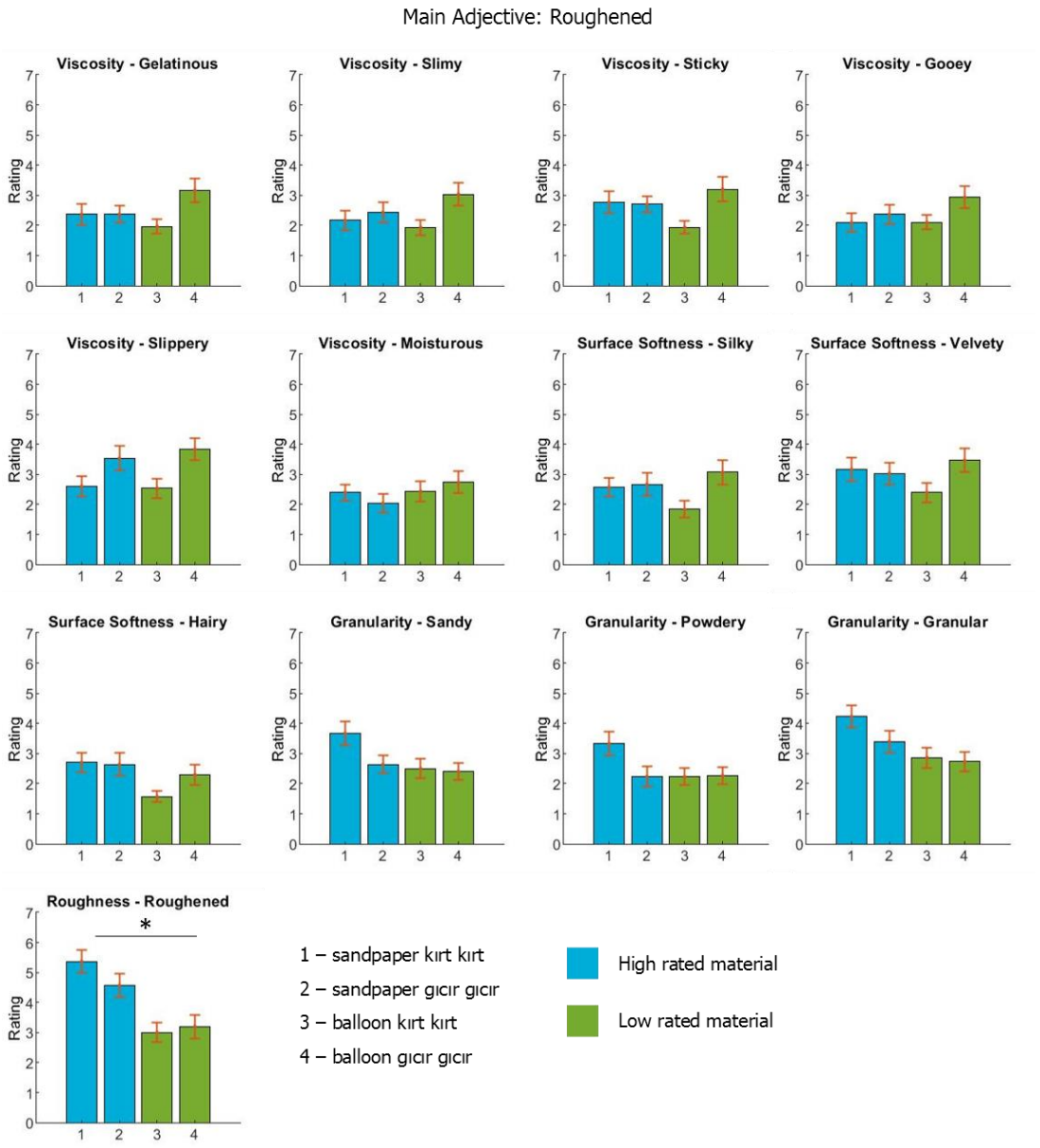

Figure G.1 (continued) Rating differences between conditions across all adjectives in Experiment 2. Above graphs are for Main Adjective Roughened. Each graph represents a separate adjective. For each graph, x-axis shows the material – onomatopoeic word pairings, and the y-axis shows the rating obtained for the respective adjective. Left two bars represent the high rated material and the right two bars represent the low rated material. Details of the materials and onomatopoiec words used for each Main Adjective is written in the figure.

H. GRAPHS FOR EXPERIMENT 3

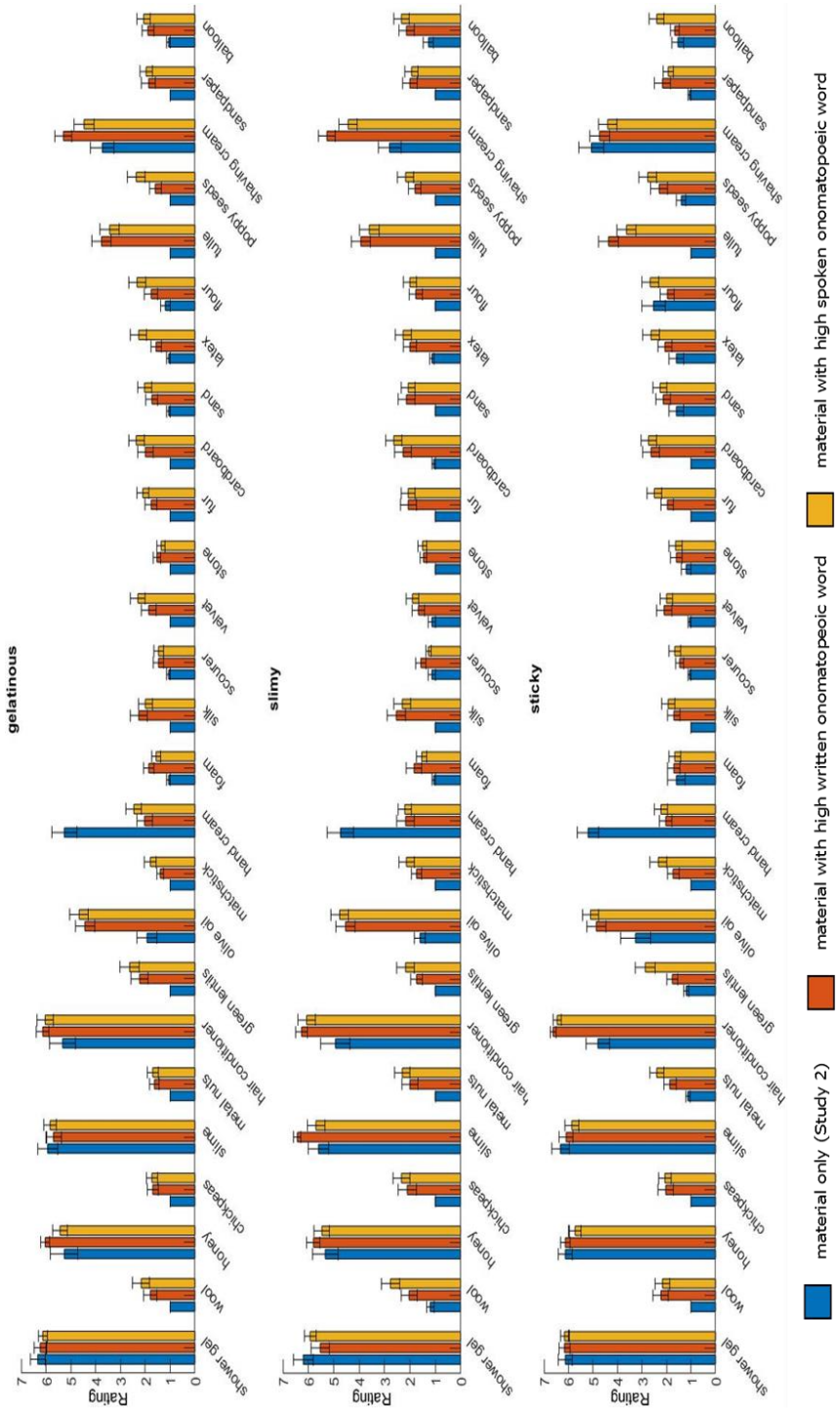

Figure H.1 Ratings obtained for each material for each adjective when presented alone or together with a high-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with high-rated written onomatopoeic word (Experiment 3, red), and when it is presented with a high-rated spoken onomatopoeic word (Experiment 2, orange). Material names are written along the x-axis, the rating range is displayed between 1-7.

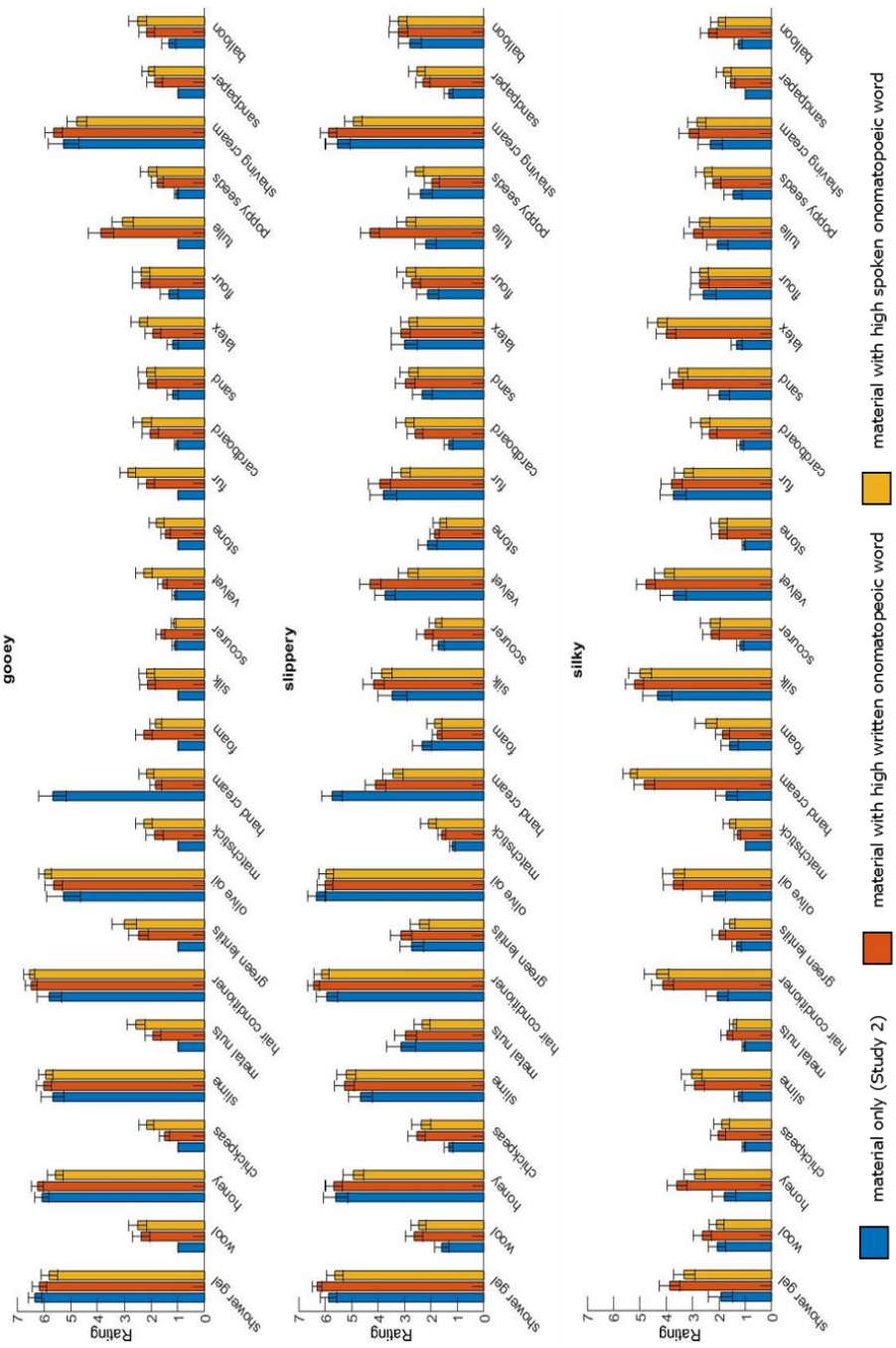

Figure H.1 (continued) Ratings obtained for each material for each adjective when presented alone or together with a high-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with high-rated written onomatopoeic word (Experiment 3, red), and when it is presented with a high-rated spoken onomatopoeic word (Experiment 2, orange). Material names are written along the x-axis, the rating range is displayed between 1-7.

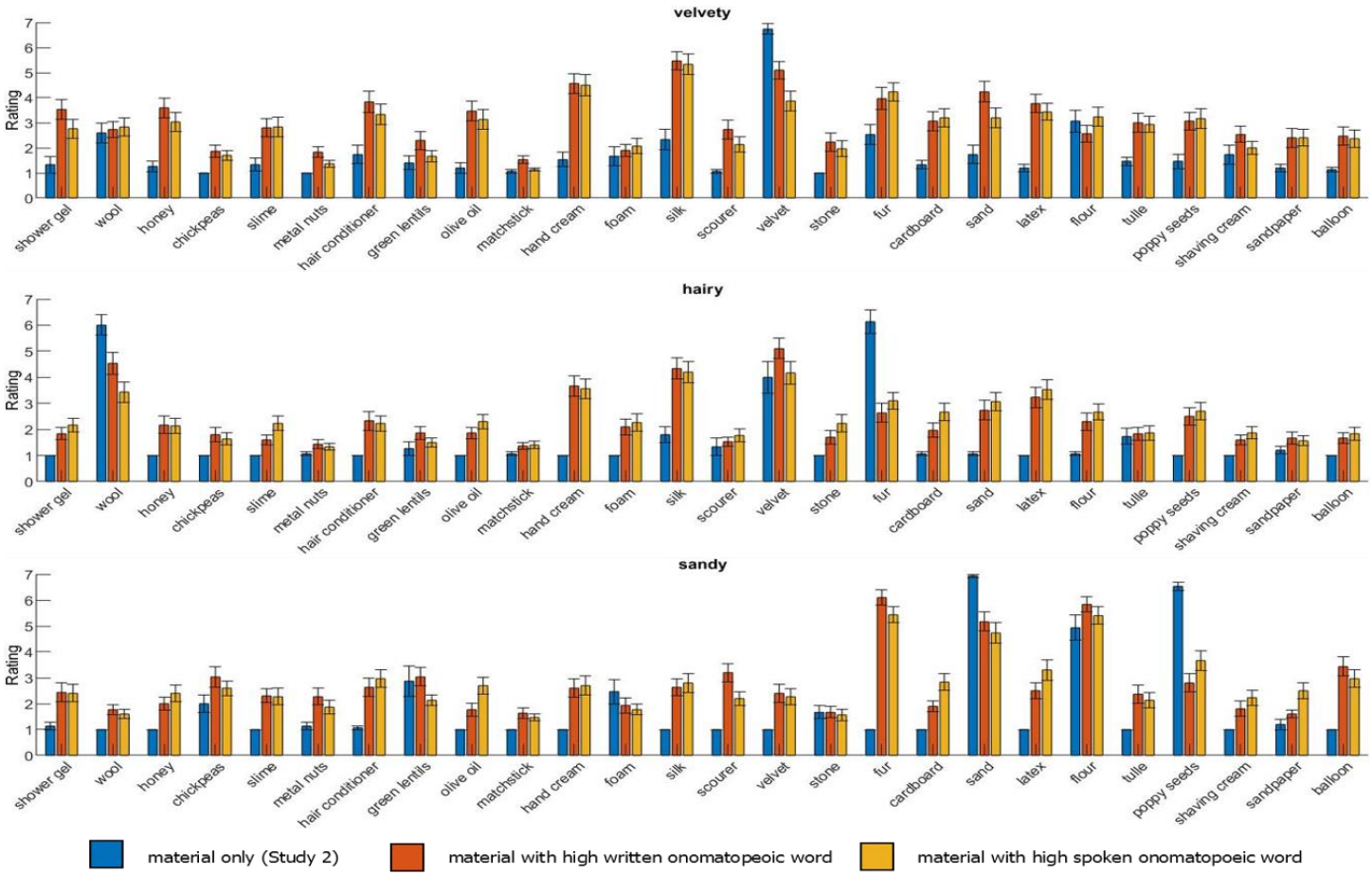

Figure H.1 (continued) Ratings obtained for each material for each adjective when presented alone or together with a high-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with high-rated written onomatopoeic word (Experiment 3, red), and when it is presented with a high-rated spoken onomatopoeic word (Experiment 2, orange). Material names are written along the x-axis, the rating range is displayed between 1-7.

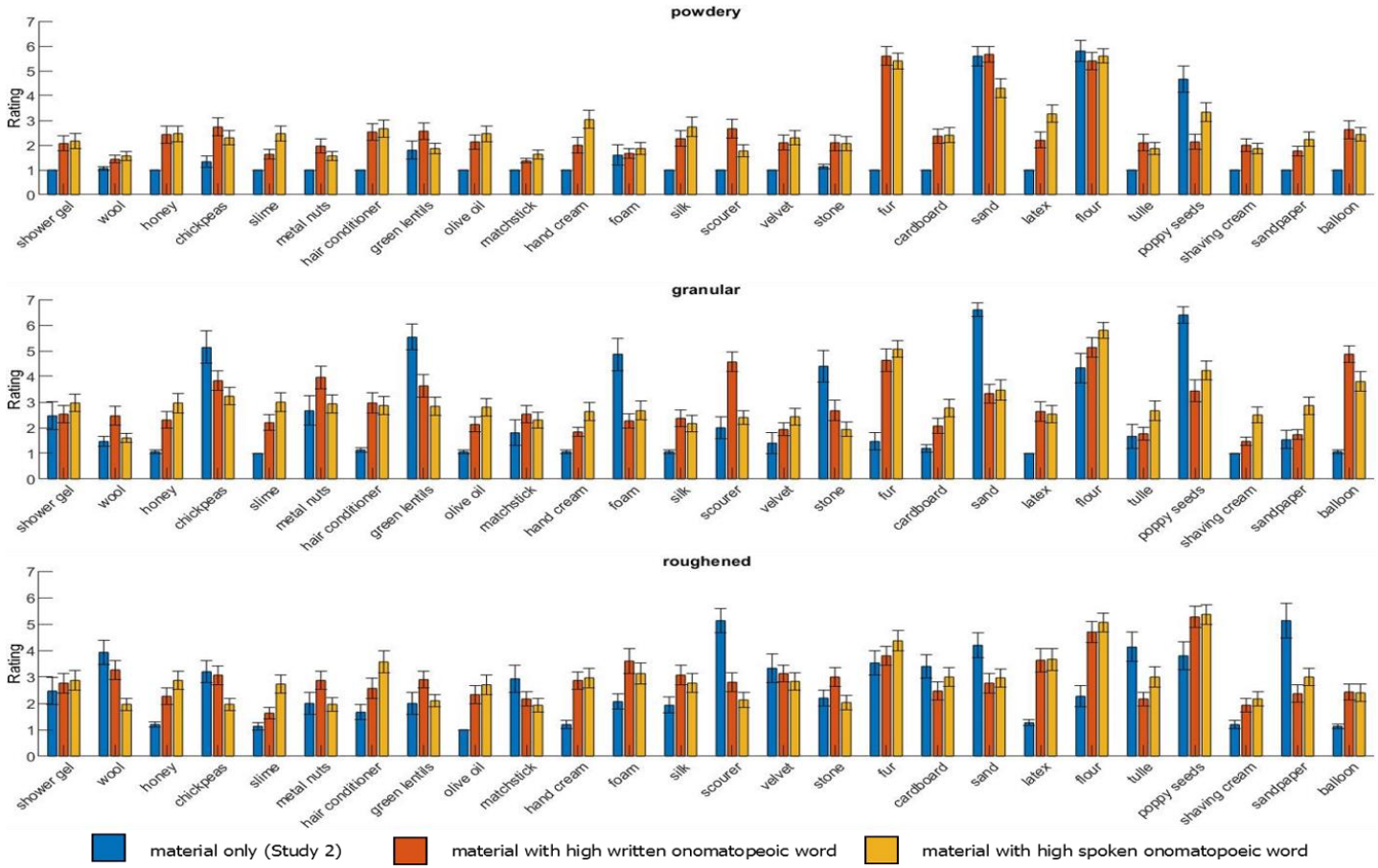

Figure H.1 (continued) Ratings obtained for each material for each adjective when presented alone or together with a high-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with high-rated written onomatopoeic word (Experiment 3, red), and when it is presented with a high-rated spoken onomatopoeic word (Experiment 2, orange). Material names are written along the x-axis, the rating range is displayed between 1-7.

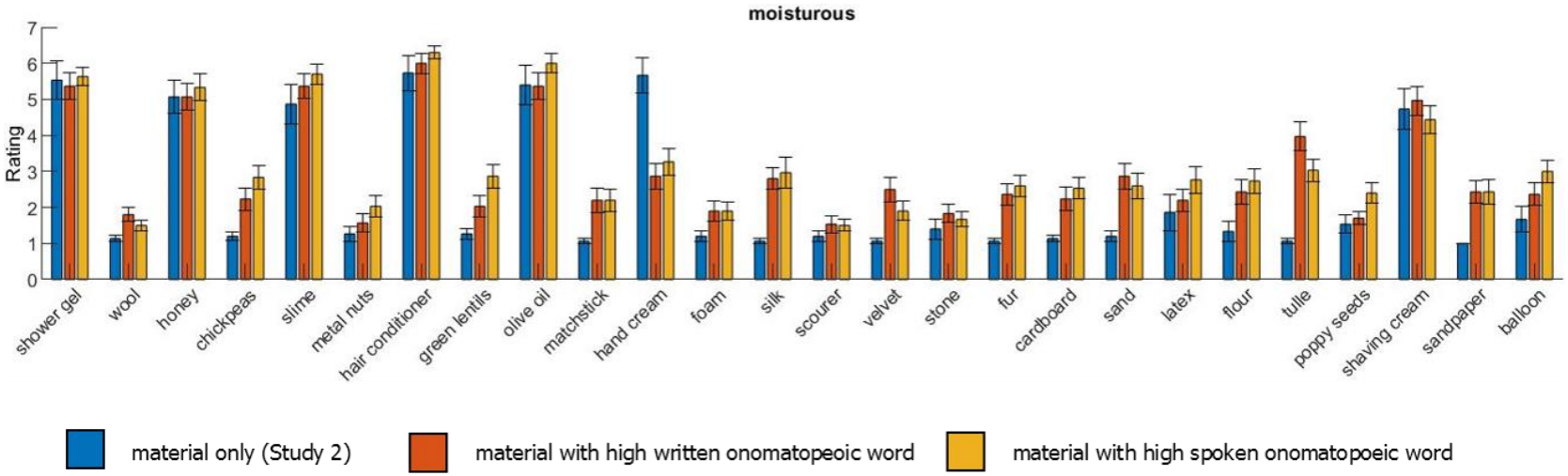

Figure H.1 (continued) Ratings obtained for each material for each adjective when presented alone or together with a high-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with high-rated written onomatopoeic word (Experiment 3, red), and when it is presented with a high-rated spoken onomatopoeic word (Experiment 2, orange). Material names are written along the x-axis, the rating range is displayed between 1-7.

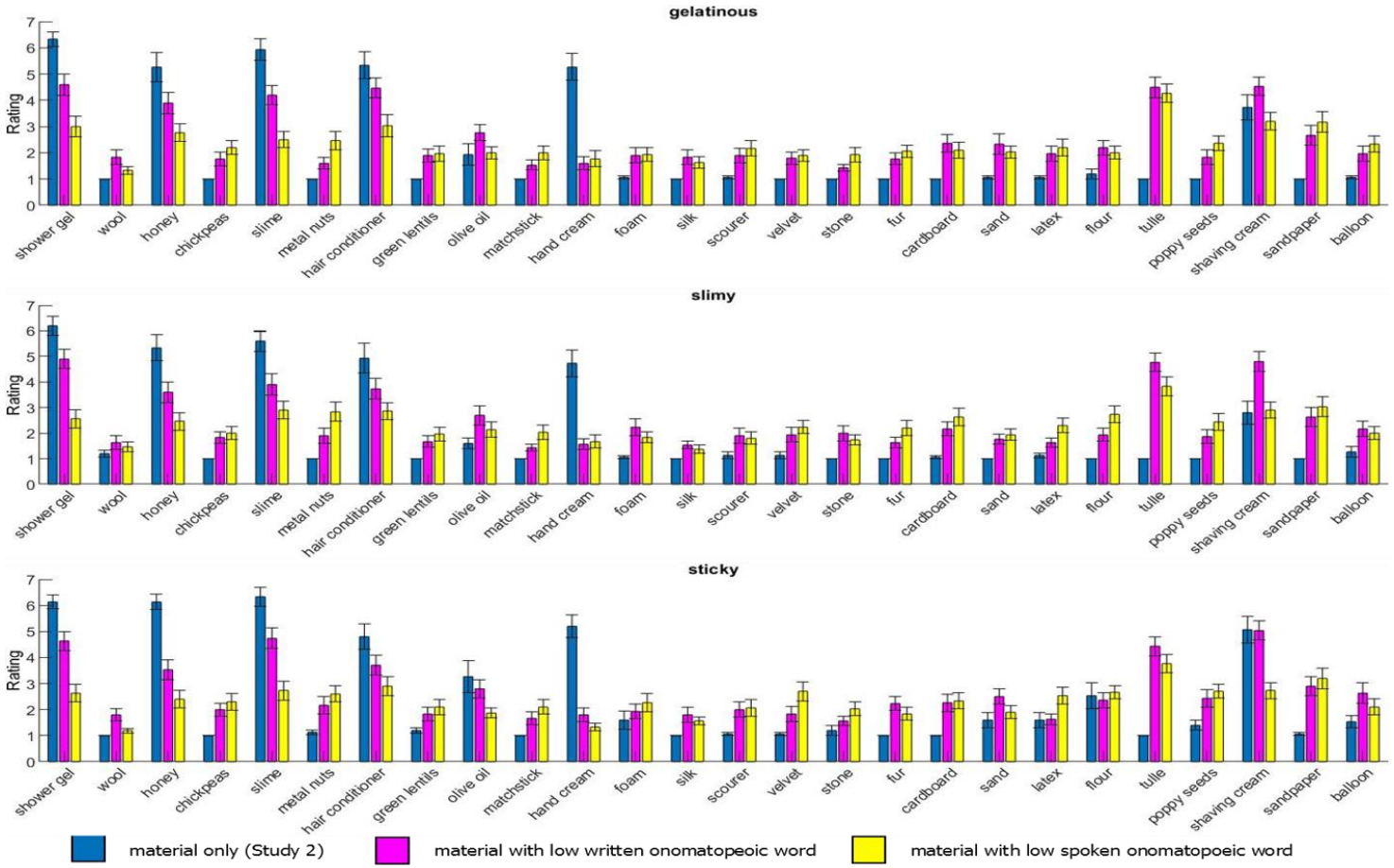

Figure H.2 Ratings obtained for each material for each adjective when presented alone or together with a low-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with low-rated written onomatopoeic word (Experiment 3, purple), and when it is presented with a low-rated spoken onomatopoeic word (Experiment 2, yellow). Material names are written along the x-axis, the rating range is displayed between 1-7.

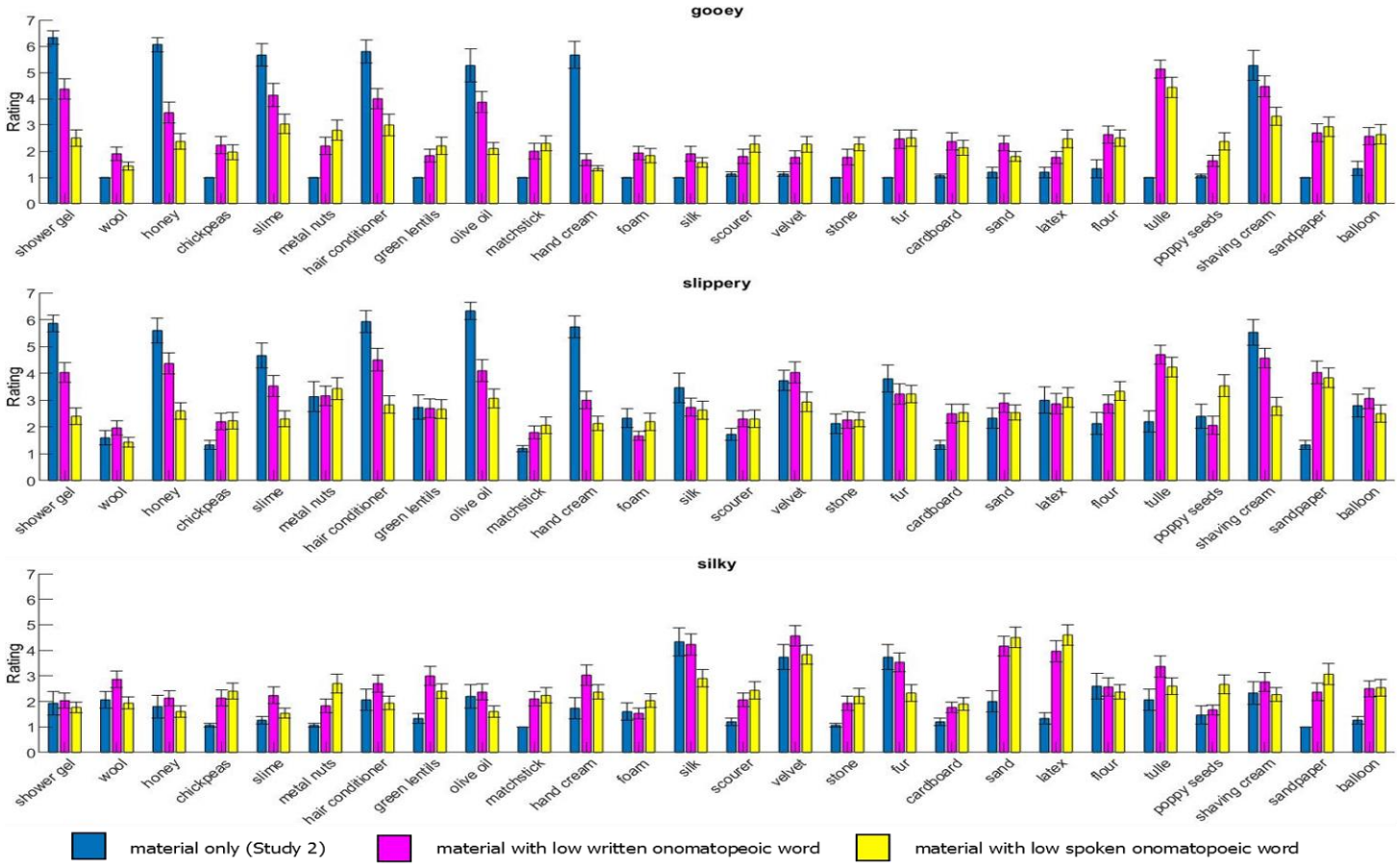

Figure H.2 (continued) Ratings obtained for each material for each adjective when presented alone or together with a low-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with low-rated written onomatopoeic word (Experiment 3, purple), and when it is presented with a low-rated spoken onomatopoeic word (Experiment 2, yellow). Material names are written along the x-axis, the rating range is displayed between 1-7.

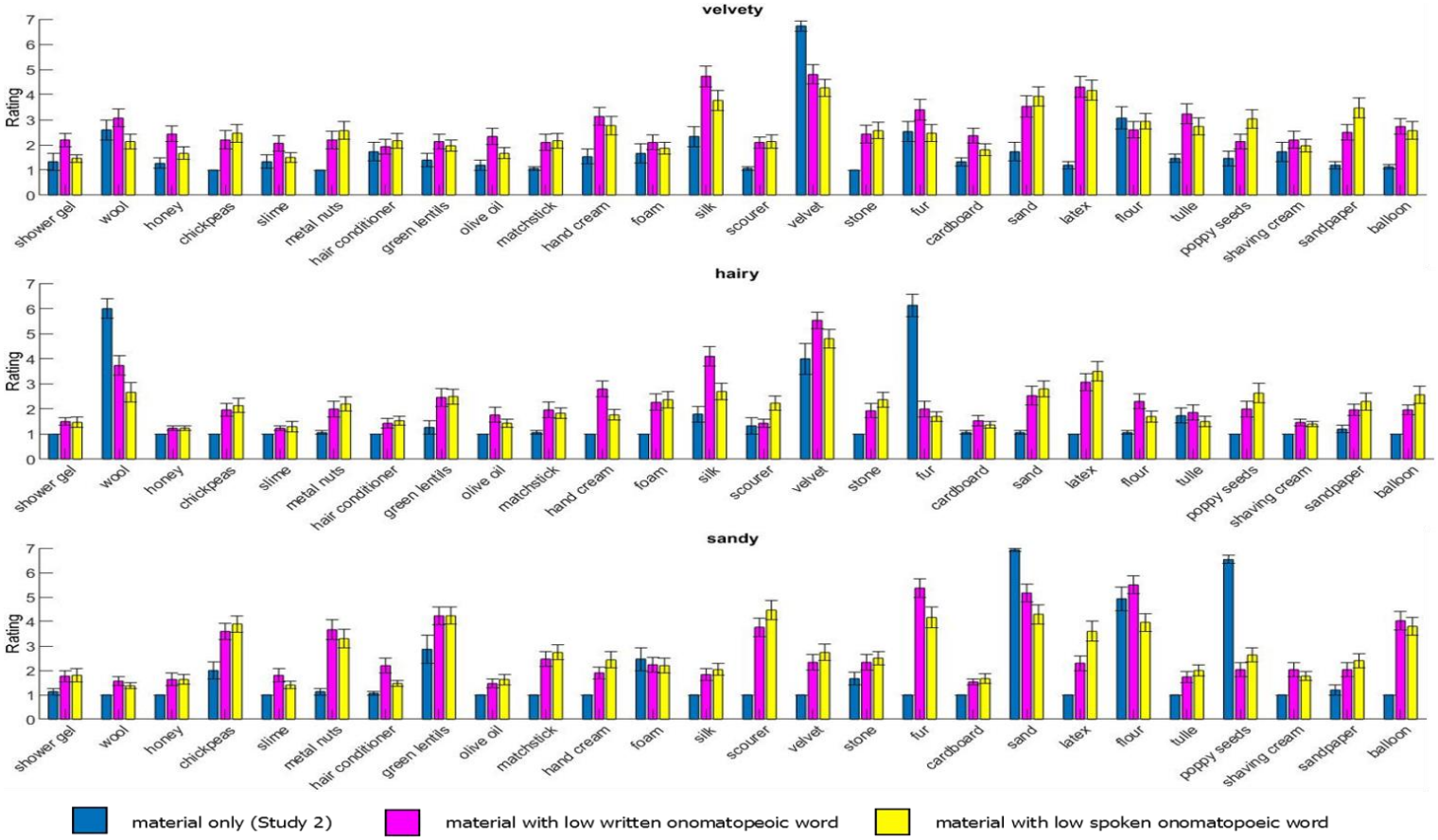

Figure H.2 (continued) Ratings obtained for each material for each adjective when presented alone or together with a low-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with low-rated written onomatopoeic word (Experiment 3, purple), and when it is presented with a low-rated spoken onomatopoeic word (Experiment 2, yellow). Material names are written along the x-axis, the rating range is displayed between 1-7.

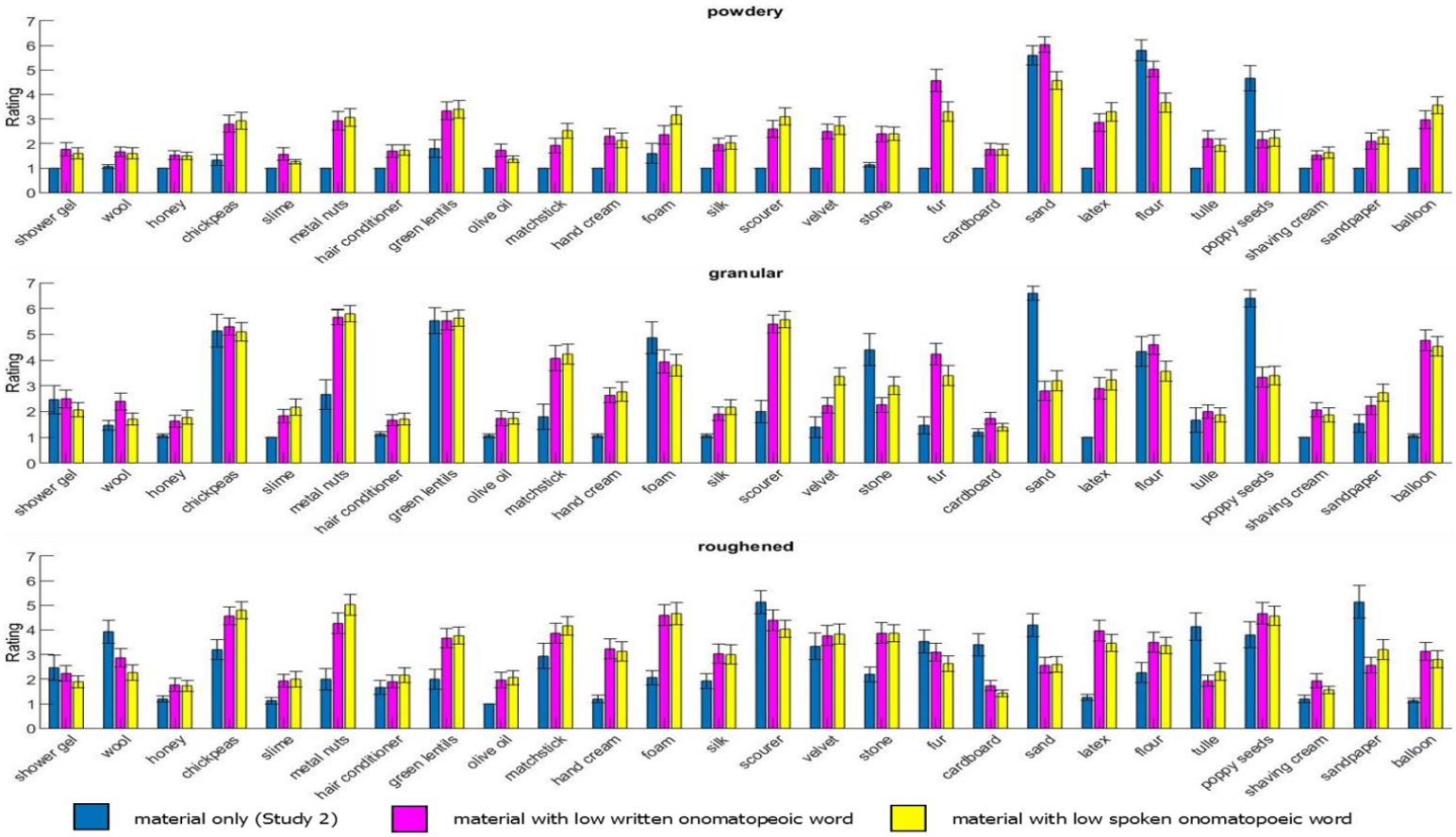

Figure H.2 (continued) Ratings obtained for each material for each adjective when presented alone or together with a low-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with low-rated written onomatopoeic word (Experiment 3, purple), and when it is presented with a low-rated spoken onomatopoeic word (Experiment 2, yellow). Material names are written along the x-axis, the rating range is displayed between 1-7.

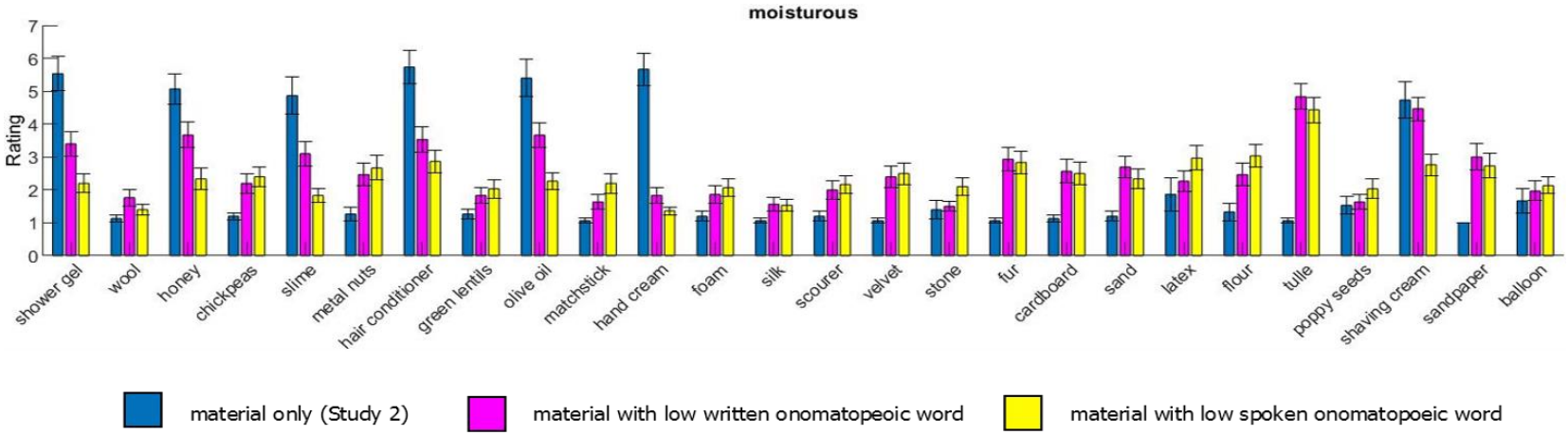

Figure H.2 (continued) Ratings obtained for each material for each adjective when presented alone or together with a low-rated onomatopoeic word. The ratings for each adjective are represented in separate graphs, as noted in graph titles. The material rating is compared with when it is presented alone (Study 2, blue), when it is presented with low-rated written onomatopoeic word (Experiment 3, purple), and when it is presented with a low-rated spoken onomatopoeic word (Experiment 2, yellow). Material names are written along the x-axis, the rating range is displayed between 1-7.

I. MODALITY COMPARISON ANOVA RESULTS FOR EXPERIMENT 3

Table I.1

ANOVA results for Surface Softness Dimension in Experiment 3

	Silky		Velvety		Hairy	
	F	η^2_p	F	η^2_p	F	η^2_p
Modality	0.013	0.0002	0.56	0.01	0.005	0.00
Adjective	27.42*	0.32	45.42*	0.43	40.57*	0.41
Word	9.71*	0.14	0.15	0.003	14.21*	0.19
Material	20.74*	0.26	19.91*	0.25	124.47*	0.68
Modality * Adjective	1.16	0.02	0.89	0.01	3.05*	0.05
Modality * Word	1.99	0.03	1.12	0.02	4.54*	0.07
Modality * Material	0.23	0.004	0.2	0.003	1.25	0.02
Adjective * Word	12.26*	0.17	8.95*	0.13	3.34*	0.05
Adjective * Material	20.36*	0.26	49.68*	0.46	31.66*	0.35
Word * Material	36.72*	0.38	53.22*	0.48	1.90	0.03
Modality * Adjective * Word	0.67	0.01	1.91	0.03	1.32	0.02
Modality * Adjective * Material	1.64	0.02	2.43*	0.04	3.75*	0.06
Modality * Word * Material	2.86	0.04	6.56*	0.1	0.15	0.003
Adjective * Word * Material	1.68	0.02	2.82*	0.04	1.33	0.02
Modality* Adjective * Word * Material	0.81	0.01	1.52	0.02	0.68	0.01

Note. * donates a statistical significant effect for α = .003

Table I.2

ANOVA results for Granularity and Roughness Dimensions in Experiment 3

	Sandy		Powdery		Granular		Roughened	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Modality	0.00	0.00	0.12	0.002	0.32	0.006	2.57	0.04
Adjective	22.34*	0.27	47.24*	0.45	16.47*	0.22	21.75*	0.27
Word	32.19*	0.35	0.29	0.005	0.20	0.003	9.08*	0.13
Material	68.25*	0.54	4.53*	0.07	0.51	0.009	8.69*	0.13
Modality * Adjective	1.08	0.01	0.95	0.02	1.34	0.02	0.57	0.01
Modality * Word	7.07*	0.11	0.12	0.002	5.24*	0.08	0.13	0.002
Modality * Material	2.05	0.03	12.13*	0.17	3.27	0.05	2.42	0.04
Adjective * Word	8.21*	0.12	1.51	0.02	9.30*	0.14	5.23*	0.08
Adjective * Material	33.31*	0.36	17.62*	0.23	71.59*	0.55	18.84*	0.24
Word * Material	0.72	0.01	1.90	0.03	19.37*	0.25	24.35*	0.29
Modality * Adjective * Word	1.47	0.02	1.17	0.02	1.70	0.03	1.83	0.03
Modality * Adjective * Material	1.60	0.02	2.82*	0.04	2.77*	0.05	1.24	0.02
Modality * Word * Material	0.07	0.001	0.49	0.008	2.06	0.03	0.03	0.0005
Adjective * Word * Material	0.82	0.01	1.18	0.02	1.70	0.03	0.39	0.007
Modality* Adjective * Word * Material	0.92	0.01	0.90	0.01	1.20	0.02	0.81	0.01

Note. * donates a statistical significant effect for $\alpha = .003$

Table I.3

ANOVA results for adjectives for Viscosity Dimension in Experiment 3

	Gelatinous		Slimy		Sticky		Gooey		Slippery		Moisturous	
	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p	F	η^2_p
Modality	5.85*	0.09	1.29	0.02	0.15	0.003	0.67	0.01	0.04	0.0006	1.91	0.03
Adjective	37.32*	0.39	26.84*	0.32	50.64*	0.47	31.85*	0.35	31.43*	0.35	30.55*	0.34
Word	180.85*	0.76	80.46*	0.58	12.29*	0.17	67.72*	0.54	72.84*	0.56	9.55*	0.14
Material	230.34*	0.80	67.07*	0.54	36.24*	0.38	114.86*	0.66	96.35*	0.62	12.19*	0.17
Modality * Adjective	1.26	0.02	1.03	0.02	1.08	0.02	1.37	0.02	0.89	0.01	2.04*	0.03
Modality * Word	17.55*	0.23	0.81	0.01	1.18	0.02	1.18	0.02	9.71*	0.14	5.75*	0.09
Modality * Material	0.57	0.01	7.11*	0.11	3.24	0.05	1.23	0.02	3.87	0.06	5.44*	0.09
Adjective * Word	12.11*	0.17	14.59*	0.20	18.37*	0.24	21.42*	0.27	19.56*	0.25	6.49*	0.10
Adjective * Material	62.12*	0.51	69.66*	0.55	74.00*	0.56	75.09*	0.56	43.29*	0.43	63.49*	0.52
Word * Material	74.97*	0.56	78.94*	0.58	98.74*	0.63	121.62*	0.68	92.85*	0.62	38.94*	0.40
Modality * Adjective * Word	2.98*	0.05	1.19	0.02	1.39	0.02	1.78	0.03	0.95	0.02	2.47*	0.04
Modality * Adjective * Material	3.55*	0.06	3.06*	0.05	4.81*	0.08	2.96*	0.05	1.81	0.03	3.89*	0.06
Modality * Word * Material	4.24*	0.07	2.76	0.04	9.92*	0.15	3.48	0.06	6.08*	0.09	4.71*	0.07
Adjective * Word * Material	6.62*	0.10	4.32*	0.07	4.13*	0.07	2.55*	0.04	2.45*	0.04	1.32	0.02
Modality* Adjective * Word * Material	1.77	0.03	0.77	0.01	1.09	0.02	1.08	0.02	0.75	0.01	0.84	0.01

Note. * donates a statistical significant effect for $\alpha = .003$

J. SPEARMAN'S RANK ORDER CORRELATION COEFFICIENT SCORES FOR THE PHONETIC ANALYSIS WITHIN STUDY 1

Table J.1
Spearman's rank order correlation coefficient scores for Study 1 phonetic analysis for component 1

Component	Phonetic Feature	Correlation
Component 1	Vowel /a/	0.173
	Vowel /ɪ/	-0.339
	Vowel /o/	-0.170
	Vowel /ö/	0.028
	Vowel /u/	-0.303
	Vowel /ü/	0.345
	Voiceless consonants	0.165
	Voiced consonants	-0.297
	Fluid	-0.139
	Fricative	-0.568**
	Plosive	0.452*
	Labial	-0.055
	Labio-dental	-0.340
	Post-alveolar	0.582**
	Alveo-palatal	-0.230
	Prevelar	-0.047
	Glottal	-0.427

* p < .05, ** p < .01, *** p < .001

Table J.2
Spearman's rank order correlation coefficient scores for Study 1 phonetic analysis for component 2

Component	Phonetic Feature	Component Loadings
Component 2	Vowel /a/	0.189
	Vowel /ɪ/	0.116
	Vowel /o/	0.051
	Vowel /u/	-0.112
	Vowel /ü/	-0.166
	Voiceless Consonants	-0.021
	Voiced Consonants	0.080
	Fluid	0.439
	Fricative	0.093
	Plosive	-0.446
	Labial	-0.113
	Labio-dental	-0.368
	Post-alveolar	0.204
	Alveo-palatal	0.192
	Prevelar	0.399

* p < .05, ** p < .01, *** p < .001

Table J.3

Spearman's rank order correlation coefficient scores for Study 1 phonetic analysis for component 3

Component	Phonetic Parameter	Correlation
Component 3	Vowel /a/	-0.070
	Vowel /e/	0.274
	Vowel /ɪ/	-0.634
	Vowel /i/	0.274
	Vowel /u/	-0.277
	Vowel /ü/	0.548
	Voiceless Consonants	-0.563
	Voiced Consonants	0.055
	Fluid	0.000
	Fricative	-0.686*
	Plosive	0.258
	Labial	0.520
	Labio-dental	-0.414
	Alveo-palatal	-0.183
	Prevelar	-0.209
	Glottal	-0.411

* p < .05, ** p < .01, *** p < .001

Table J.4

Spearman's rank order correlation coefficient scores for Study 1 phonetic analysis for component 4

Component	Phonetic Parameter	Component Loadings
Component 4	Vowel /e/	0.393
	Vowel /ɪ/	-0.414
	Vowel /i/	0.372
	Voiceless Consonants	-0.802
	Voiced Consonants	0.494
	Fluid	0.339
	Fricative	0.247
	Plosive	-0.507
	Labial	-0.098
	Labio-dental	0.000
	Post-alveolar	0.131
	Alveo-palatal	0.655
	Prevelar	-0.488

* p < .05, ** p < .01, *** p < .001

Table J.5

Spearman's rank order correlation coefficient scores for Study 1 phonetic analysis for component 5

Component	Phonetic Parameter	Correlations
Component 5	Vowel /a/	-0.574
	Vowel /ɪ/	0.519
	Vowel /i/	-0.247
	Vowel /u/	-0.209
	Voiceless Consonants	-0.489
	Voiced Consonants	0.489
	Fluid	-0.247
	Fricative	-0.077
	Plosive	-0.330
	Post-alveolar	-0.252
	Alveo-palatal	0.247
	Prevelar	-0.282
	Glottal	0.378

* p < .05, ** p < .01, *** p < .001

Table J.6

Spearman's rank order correlation coefficient scores for Study 1 phonetic analysis for component 6

Component	Phonetic Parameter	Correlation
Component 6	Vowel /a/	0.775
	Vowel /ɪ/	-0.775
	Voiceless Consonants	-0.775
	Voiced Consonants	0.775
	Fricative	-0.738
	Plosive	0.738
	Labial	0.894
	Labio-dental	-0.258
	Post-alveolar	0.894
	Alveo-palatal	-0.775
	Glottal	-0.775

* p < .05, ** p < .01, *** p < .001

Table J.7

Spearman's rank order correlation coefficient scores for Study 1 phonetic analysis for component 7

Component	Phonetic Parameter	Correlations
Component 7	Vowel /a/	-0.655
	Vowel /e/	-0.393
	Vowel /ɪ/	-0.304
	Vowel /i/	-0.393
	Vowel /o/	0.828*
	Vowel /u/	0.293
	Vowel /ü/	-0.131
	Voiceless Consonants	0.123
	Voiced Consonants	0.304
	Fluid	0.414
	Fricative	-0.338
	Plosive	0.293
	Labio-dental	0.098
	Alveo-palatal	-0.655
	Prevelar	0.828*
	Glottal	0.000

* p < .05, ** p < .01, *** p < .001

K. FREQUENCY TABLES FOR PHONETIC PARAMETERS

Table K.1

Frequency scores for onomatopoeic words in component 1

Onomatopoeic Word	Component Loadings	Vowel /a/	Vowel /e/	Vowel /i/	Vowel /ɨ/	Vowel /o/	Vowel /ö/	Vowel /u/	Vowel /ü/	Voiceless	Voiced	Fluid	Fricative	Plosive	Labial	Labio-Dental	Post-Alveolar	Alveo-Palatal	Prevelar	Velar	Glottal
küt küt	0.971	0	0	0	0	0	0	0	2	4	0	0	0	4	0	0	2	0	2	0	0
çat pat	0.965	2	0	0	0	0	0	0	0	4	0	0	0	4	1	0	2	1	0	0	0
tangır tungur	0.965	1	0	1	0	0	0	2	0	2	6	4	0	4	0	0	2	0	4	0	0
çatır çatır	0.962	2	0	2	0	0	0	0	0	4	2	2	0	4	0	0	2	2	2	0	0
kıtır kıtır	0.960	0	0	4	0	0	0	0	0	4	2	2	0	4	0	0	2	0	4	0	0
tıkır tıkır	0.955	0	0	4	0	0	0	0	0	4	2	2	0	4	0	0	2	0	4	0	0
tak tak	0.955	2	0	0	0	0	0	0	0	4	0	0	0	4	0	0	2	0	2	0	0
kütür kütür	0.953	0	0	0	0	0	0	0	4	4	2	2	0	4	0	0	2	0	4	0	0
güm güm	0.952	0	0	0	0	0	0	0	2	0	4	2	0	2	0	0	0	0	2	0	0
çıt çıt	0.950	0	0	2	0	0	0	0	0	4	0	0	0	4	0	0	2	2	0	0	0
paldır küldür	0.943	1	0	1	0	0	0	0	2	2	6	4	0	4	1	0	2	0	4	0	0
kös kös	0.932	0	0	0	0	0	2	0	0	4	0	0	2	2	0	0	2	0	2	0	0
zangır zangır	0.918	2	0	2	0	0	0	0	0	0	8	4	2	0	0	0	4	0	4	0	0
tın tın	0.869	0	0	2		0	0	0	0	2	2	2	0	2	0	0	2	0	0	0	0
zır zır	0.862	0	0	2	0	0	0	0	0	0	2	2	2	0	0	0	2	0	2	0	0
patır patır	0.861	2	0	2	0	0	0	0	0	4	2	2	0	4	2	0	2	0	2	0	0
cart curt	0.759	1	0	0	0	0	0	1	0	2	4	2	0	4	0	0	2	2	2	0	0
kıkır kıkır	0.717	0	0	4	0	0	0	0	0	4	2	2	0	4	0	0	0	0	6	0	0
horul horul	0.712	0	0	0	0	2	0	2	0	2	4	4	2	0	0	0	0	0	4	0	2
gacır gucur	0.665	1	0	1	0	0	0	2	0	0	6	2	0	2	0	0	0	2	4	0	0
şakır şukur	0.590	1	0	1	0	0	0	2	0	4	2	2	2	2	0	0	0	2	4	0	0
vıcık vıcık	-0.326	0	0	4	0	0	0	0	0	2	4	0	2	4	0	2	0	0	2	0	0
hışır hışır	0.413	0	0	4	0	0	0	0	0	4	2	2	4	0	0	0	0	2	2	0	2
haşır huşur	0.528	1	0	1	0	0	0	2	0	4	2	2	4	0	0	0	0	2	2	0	2
pıtır pıtır	0.408	0	0	4	0	0	0	0	0	4	2	2	0	4	2	0	2	0	2	0	0

Table K.2

Frequency scores for onomatopoeic words in component 2

Onomatopoeic Word	Component Loadings	Vowel /a/	Vowel /e/	Vowel /ı/	Vowel /i/	Vowel /o/	Vowel /ö/	Vowel /u/	Vowel /ü/	Voiceless	Voiced	Fluid	Fricative	Plosive	Labial	Labio-Dental	Post-Alveolar	Alveo-Palatal	Prevelar	Velar	Glottal
şarıl şarıl	0.969	2	0	2	0	0	0	0	0	2	4	4	2	0	0	0	0	2	4	0	0
şırıl şırıl	0.956	0	0	4	0	0	0	0	0	2	4	4	2	0	0	0	0	2	4	0	0
şıp şıp	0.932	0	0	2	0	0	0	0	0	4	0	0	2	2	2	0	0	2	0	0	0
lıkır lıkır	0.907	0	0	4	0	0	0	0	0	2	4	4	0	2	0	0	0	0	6	0	0
zırıl zırıl	0.872	0	0	4	0	0	0	0	0	0	6	4	2	0	0	0	2	0	4	0	0
şakır şakır	0.830	2	0	2	0	0	0	0	0	4	2	2	2	2	0	0	0	2	2	0	0
gürül gürül	0.802	0	0	0	0	0	0	0	4	0	6	4	0	2	0	0	0	0	4	0	0
fokur fokur	0.780	0	0	0	0	2	0	2	0	4	2	2	2	2	0	2	0	0	4	0	0
şapur şupur	0.745	1	0	0	0	0	0	3	0	4	2	2	2	2	2	0	0	2	2	0	0
fıkır fıkır	0.737	0	0	4	0	0	0	0	0	4	2	2	2	2	0	2	0	0	4	0	0
şakır şukur	0.649	1	0	1	0	0	0	0	0	4	2	2	2	2	0	0	0	2	4	0	0
lüp lüp	0.343	0	0	0	0	0	0	0	2	2	2	2	0	2	2	0	0	0	2	0	0
şap şap	0.564	2	0	0	0	0	0	0	0	4	0	0	2	2	2	0	0	2	0	0	0
gurul gurul	0.521	0	0	0	0	0	0	4	0	0	6	4	0	2	0	0	0	0	4	0	0
vıcık vıcık	0.515	0	0	4	0	0	0	0	0	2	4	0	2	4	0	2	0	2	2	0	0
fısır fısır	0.330	0	0	4	0	0	0	0	0	4	2	2	4	0	0	2	0	0	2	0	0
gıcır gıcır	0.357	0	0	4	0	0	0	0	0	0	6	2	0	4	0	0	0	2	2	0	0

Table K.3

Frequency scores for onomatopoeic words in component 3

Onomatopoeic Word	Component Loadings	Vowel /a/	Vowel /e/	Vowel /ı/	Vowel /i/	Vowel /o/	Vowel /ö/	Vowel /u/	Vowel /ü/	Voiceless	Voiced	Fluid	Fricative	Plosive	Labial	Labio-Dental	Post-Alveolar	Alveo-Palatal	Prevelar	Velar	Glottal
şapur şupur	0.480	1	0	0	0	0	0	3	0	4	2	2	2	2	2	0	0	2	2	0	0
lüp lüp	0.848	0	0	0	0	0	0	0	2	2	2	2	0	2	2	0	0	0	2	0	0
şap şap	0.726	2	0	0	0	0	0	0	0	4	0	0	2	2	2	0	0	2	0	0	0
lime lime	0.712	0	2	0	2	0	0	0	0	0	4	4	0	0	2	0	0	0	2	0	0
gurul gurul	0.659	0	0	0	0	0	0	4	0	0	6	4	0	2	0	0	0	0	4	0	0
vıcık vıcık	0.645	0	0	4	0	0	0	0	0	2	4	0	2	4	0	2	0	0	2	0	0
kıpır kıpır	0.615	0	0	4	0	0	0	0	0	4	2	2	0	4	2	0	0	0	4	0	0
fısır fısır	-0.330	0	0	4	0	0	0	0	0	4	2	2	4	0	0	2	0	0	2	0	0
haşır huşur	0.306	1	0	1	0	0	0	2	0	4	2	2	4	0	0	0	0	2	2	0	2

Table K.4

Frequency scores for onomatopoeic words in component 4

Onomatopoeic Word	Component Loadings	Vowel /a/	Vowel /e/	Vowel /i/	Vowel /ı/	Vowel /o/	Vowel /ö/	Vowel /u/	Vowel /ü/	Voiceless	Voiced	Fluid	Fricative	Plosive	Labial	Labio-Dental	Post-Alveolar	Alveo-Palatal	Prevelar	Velar	Glottal
kıpır kıpır	0.444	0	0	4	0	0	0	0	0	4	2	2	0	4	2	0	0	0	4	0	0
mışıl mışıl	0.880	0	0	4	0	0	0	0	0	0	6	4	2	0	2	0	0	2	2	0	0
efil efil	0.818	0	2	0	2	0	0	0	0	0	2	2	2	0	0	2	0	0	2	0	0
tiril tiril	0.809	0	0	0	4	0	0	0	0	2	4	4	0	2	0	0	2	0	4	0	0
mırıl mırıl	0.807	0	0	4	0	0	0	0	0	0	6	6	0	0	2	0	0	0	4	0	0
fısır fısır	0.688	0	0	4	0	0	0	0	0	4	2	2	4	0	0	2	0	0	2	0	0

Table K.5

Frequency scores for onomatopoeic words in component 5

Onomatopoeic Word	Component Loadings	Vowel /a/	Vowel /e/	Vowel /i/	Vowel /ı/	Vowel /o/	Vowel /ö/	Vowel /u/	Vowel /ü/	Voiceless	Voiced	Fluid	Fricative	Plosive	Labial	Labio-Dental	Post-Alveolar	Alveo-Palatal	Prevelar	Velar	Glottal
cart curt	0.434	1	0	0	0	0	0	1	0	2	4	2	0	4	0	0	2	2	2	0	0
gacır gucur	0.611	1	0	1	0	0	0	2	0	0	6	2	0	2	0	0	0	2	4	0	0
şakır şakır	0.337	2	0	2	0	0	0	0	0	4	2	2	2	2	0	0	0	2	4	0	0
şakır şukur	0.332	1	0	1	0	0	0	2	0	4	2	2	2	2	0	0	0	2	4	0	0
tiril tiril	0.404	0	0	0	4	0	0	0	0	2	4	4	0	2	0	0	2	0	4	0	0
gıcır gıcır	0.780	0	0	4	0	0	0	0	0	0	6	2	0	2	0	0	0	2	4	0	0
hışır hışır	0.746	0	0	4	0	0	0	0	0	4	2	2	4	0	0	0	0	2	2	0	2
haşır huşur	0.548	1	0	1	0	0	0	2	0	4	2	2	4	0	0	0	0	2	2	0	2

Table K.6

Frequency scores for onomatopoeic words in component 6

Onomatopoeic Word	Component Loadings	Vowel /a/	Vowel /e/	Vowel /ı/	Vowel /i/	Vowel /o/	Vowel /ö/	Vowel /u/	Vowel /ü/	Voiceless	Voiced	Fluid	Fricative	Plosive	Labial	Labio-Dental	Post-Alveolar	Alveo-Palatal	Prevelar	Velar	Glottal
fısır fısır	0.335	0	0	4	0	0	0	0	0	4	2	2	4	0	0	2	0	0	2	0	0
hışır hışır	0.312	0	0	4	0	0	0	0	0	4	2	2	4	0	0	0	0	2	2	0	2
sapır sapır	0.921	2	0	2	0	0	0	0	0	2	4	2	2	2	2	0	2	0	2	0	0
pıtır pıtır	0.852	0	0	4	0	0	0	0	0	4	2	2	0	4	2	0	2	0	2	0	0

Table K.7

Frequency scores for onomatopoeic words in component 7

Onomatopoeic Word	Component Loadings	Vowel /a/	Vowel /e/	Vowel /ı/	Vowel /i/	Vowel /o/	Vowel /ö/	Vowel /u/	Vowel /ü/	Voiceless	Voiced	Fluid	Fricative	Plosive	Labial	Labio-Dental	Post-Alveolar	Alveo-Palatal	Prevelar	Velar	Glottal
horul horul	0.459	0	0	0	0	2	0	2	0	2	4	4	2	0	0	0	0	0	4	0	2
gürül gürül	0.408	0	0	0	0	0	0	0	4	0	6	4	0	2	0	0	0	0	4	0	0
fokur fokur	0.445	0	0	0	0	2	0	2	0	4	2	2	2	2	0	2	0	0	4	0	0
fıkır fıkır	0.427	0	0	4	0	0	0	0	0	4	2	2	2	2	0	2	0	0	4	0	0
efil efil	0.317	0	2	0	2	0	0	0	0	0	2	2	2	0	0	2	0	0	2	0	0
haşır huşur	0.308	1	0	1	0	0	0	2	0	4	2	2	4	0	0	0	0	2	2	0	2

L. TURKISH SUMMARY / TÜRKÇE ÖZET

BÖLÜM BİR

GİRİŞ

Algı, bilişsel psikolojide en çok araştırılan alanlardan biridir. Fizyolojik ölçüm araçlarının yanı sıra görselleştirme cihazlarındaki gelişmelerle bu alan son derece gelişmiştir. Popüler bir araştırma alanı olan görsel algı literatürü her zaman dokunma gibi diğer duyusal yöntemlerden daha yaygın olmuştur (Katz, 1925/1989). Daha önce daha az popüler olan bir araştırma konusu olan dokunsal algı, son zamanlarda bu alanda yeni yöntemlerle yürütülen çalışmalarla artan bir ilgi kazanmıştır. Bununla birlikte, bu gelişmeler alana ne kadar katkıda bulunmuş olsa da, dokunsal algının temelleri ve diğer algısal ve bilişsel bileşenlerle ilişkisi hala araştırmaya açıktır.

Dokunsal algı, nesnelerin dokunarak aktif olarak keşfedilmesi olarak tanımlanır. Alanın öncülerinden biri olan Gibson (1962), aktif ve pasif dokunma arasındaki farkı vurgulayarak, aktif dokunmanın, söz konusu nesnenin belirli niteliklerini keşfetmek için gerçekleştirilen hareketler olan keşif eylemini içerdiğini, pasif dokunmanın ise performans hareketlerini içerdiğini belirtti. Farklı dokunma biçimleri arasındaki bu ayrım, pek çok çalışmanın yapılmaya başlandığı dokunsal algı literatürünün önemli ölçüde gelişmesine yol açmıştır. Ancak yakın zamana kadar, çalışmaların çoğu ahşap, taş, cam ve benzeri sert materyallerin dokunsal algısına odaklanmış (DiFranco ve ark. 1997; Avanzini ve Crosato 2006) ve kumaşlar (örneğin kadife ve pamuk) ve bazı durumlarda sıvılar (örneğin su ve yağlar) gibi (Picard ve ark., 2003; Soufflet, Calonnier ve Dacremont 2004; Tanaka, Tanaka ve Chonan, 2006; Guest ve ark., 2011) yumuşak materyalleri dahil etmiştir. Fakat yumuşak materyallerin dahil edilmesi, kendi başına

yumuşaklığı incelemek için değil, 'sert' materyalleri tek bir kategoriyle karşılaştırabilmek içindi.

Yumuşaklık algısı incelenirken, yumuşaklık tek bir boyut ve uyumluluğun eşdeğeri olarak kabul edilmiş (Lederman & Klatzky, 1987; Drewing ve ark., 2017) ve bir materyalin deforme olabilirlik derecesi olarak tanımlanmıştır (Di Luca, 2014). Tekstil materyallerinin çok boyutluluğuyla ilgili en kapsamlı çalışmalardan biri Okamoto ve arkadaşları tarafından yapılmıştır (2013). Kumaşlar, kağıtlar, sıvılar ve sert materyaller dahil olmak üzere çeşitli materyalleri kullanan 18 çalışmanın incelenmesinde, dokunsal doku algısı için beş genel boyut bildirdiler: Pürüzlülük/Yumuşaklık, Sıcaklık, İnce Pürüzlülük, Makro Pürüzlülük ve Sürtünme. Benzer şekilde, Tiest (2010) materyal özelliklerinin dokunsal algısına ilişkin bir incelemede, çeşitli çalışmalarda bulunan ortak noktalara dayalı olarak dört kategori bildirmiştir: Pürüzlülük, Uyum, Soğukluk ve Kayganlık. Ancak bu açıklama, şu anda yalnızca "yumuşak" kategorisinde tanımlanan tüm nesneleri içermek için çok belirsiz kalmaktadır.

1.1. Materyal Algısı

Son zamanlarda, genellikle yalnızca "yumuşak" olarak sınıflandırılan materyallerde bulunabilecek daha tanımlayıcı olan farklı yumuşaklık kategorilerinin olup olmadığını incelemek için çalışmalar yapılmıştır. Dövencioğlu ve ark. (2018, 2019, 2022) yumuşaklık algısının birden fazla boyuttan oluştuğunu göstermiştir. Çalışmaları (Dövencioğlu ve ark., 2022) 5 farklı kategoriye (elastik, tekstil, deforme olabilen, tanecikli ve sert) karşılık gelen 50 materyal ile gerçekleştirilmiştir. Bu çalışmada Guest ve arkadaşlarının (2011) kapsamlı bir dokunsal sözlüğünden Türkçeye uyarlanan, dokunmanın yumuşaklık ve pürüzlülük yönleriyle ilgili 31 sıfattan oluşan bir liste kullanılmıştır. Sonuçlar, materyal algısı için beş boyutun varlığını göstermiştir: Şekil Değiştirebilirlik, Akışkanlık, Yüzey Yumuşaklığı, Taneciklilik ve Pürüzlülük (kontrol). Bu, önceden bilinen yumuşak nesneler arasında böyle bir ayrımı tanımlayan ilk çalışmalardan biridir. Sonraki bir çalışmada Cavdan, Doerschner ve Drewing (2019), yumuşaklığın farklı algısal boyutlarının dokunsal keşif prosedürlerini nasıl etkilediğini

araştırdı ve bunun sonucunda beş boyut buldu: Taneciklilik, Kürklülük, Visko-Elastiklik, Şekil Değiştirebilirlik ve Pürüzlülük

1.1.1. Görsel Uyaranlarla Dokunsal Algı Çalışması

Bazı çalışmalarda dokunsal algı boyutlarını keşfetmek için görsel uyaranlar kullanılırken (Dövencioğlu ve ark., 2019, 2022; Cavdan ve ark., 2019; Picada, 2006; Yoshida, 1968), Okamoto ve ark. (2013), dokunsal doku algısı için dokunsal ve görsel modaliteler arasında belirli farklılıklar olup olmadığını inceledi. Parlaklık gibi yalnızca görsel algı için var olan ve sıcaklık gibi yalnızca dokunsal algı için var olan bazı farklı boyutlar dışında, iki modalitenin yüzey özelliklerinde benzer olduğunu buldular. Benzer şekilde, hem görsel hem de dokunsal yargı için aynı 84 materyal seti ile yapılan bir çalışmada Baumgartner ve ark. (2013), materyal algısı için görsel alanın dokunsal alana benzer olduğunu göstermiştir. Bu nedenle, dokunsal algıyı incelemek için görsel uyaranların kullanılması yaygındır ve bir yöntemle çıkarılan benzer boyutların diğer modalitede gözlemlenmesini bekleyebiliriz.

1.2. Ses Sembolizmi

Ses sembolizmi, konuşma seslerinin fonetik özelliklerinin anlamsal bilgi taşıdığı kavramını ifade eder (Hinton, Nichols, & Ohala, 2006). Dilbilim çerçevesinde, ses sembolizmi fonemlerle incelenmiş ve sonuçlar, /i/ ve /k/ gibi daha yüksek frekanslı sesli ve ünsüzlerin küçük ve keskin göndergelerle ilişkili olduğunu, buna karşın /u/ ve /b/ gibi daha düşük frekansta seslerin büyük ve ağır göndergelerle ilişkilendirildiğini göstermiştir (Hinton ve ark., 1994). Sapir (1929) ve Köhler'in (1929) erken dönem çalışmaları ile başlayan ses sembolizmi üzerine çok sayıda çalışma vardır. Sapir, 500 katılımcının birden fazla deneyde "a" sesli harfini ("mal"deki gibi) içeren sözde sözcükleri daha büyük şekillerle ve "i" sesli harfini ("mil"deki gibi) içeren sözde sözcükleri daha küçük nesnelerle ilişkilendirdiği bir çalışma yürüttü. Köhler, 'maluma' sözde kelimesinin yuvarlak şekillerle ve 'takete'nin köşeli şekillerle ilişkilendirildiği benzer bir çalışma yaptı. Daha sonra aynı fikir, Ramachandran ve Hubbard'ın (2001) çalışmasından türeyen 'Bouba/Kiki Etkisi' olarak adını bulmuştur. Deneylerinde iki şekil

kullanmışlardır; 'bouba' veya 'kiki' sözde sözcükleri ile ilişkilendirilecek yuvarlak bir şekil ve sivri bir şekil. Elde ettikleri sonuçlar, katılımcıların "bouba" sözde kelimesini yuvarlak şekillerle ve "kiki" kelimesini sivri şekillerle ilişkilendirdiğini gösterdi. Sonuçları, kültürler arası başka çalışmalarla ve kelimeler ve/veya şekiller için kullanılan farklı uyaranlarla desteklenmiştir (Westbury, 2005; Parise & Spence, 2012) ve genel sonuçlar bu etkinin evrensel olduğunu göstermektedir.

1.2.1. Yansıma Kelimeler

Dillerin içindeki çoğu kelime, yalnızca kelimenin biçimlerini inceleyerek herhangi bir anlam çıkarılamayacak şekildedir. Bunun belirli bir istisnası vardır: Bu kelimeler, tanımladıkları sesi taklit eden kelimeler olan yansıma kelimelerdir (örneğin; şırıl, patır, çatır). Bu kelimeler, kelimelerin anlamlarının atıfta bulunduğu seslerle doğrudan ikonik çağrışımlarla oluşturulmuştur.

Ses sembolizminin materyal algımıza ne ölçüde ulaştığını anlamak için yansıma kelimeler ile materyal algısı arasındaki ilişkiyi araştıran birçok çalışma yapılmıştır. Bu çalışmaların önemli bir kısmı Japoncadır, çünkü Japonca diğer dillere kıyasla en yüksek sayıda yansıma kelimeye sahiptir (Yamaguchi'nin (2015) bir sözlüğünde 2000 Japonca yansıma kelime listelenir). Doizaki, Watanabe ve Sakamoto (2017), bir Japonca ses sembolik kelimeden dokunmanın çok boyutlu derecelendirmelerini otomatik olarak tahmin eden bir sistem önermek için bir çalışma yürüttüler. Daha sonra Sakamoto ve Watanabe (2017), dokunsal algı boyutlarını incelemek için Japon yansıma kelimeleriyle ile ilişkili materyalleri kullanarak bir çalışma yürütmüştür. Bir yansıma kelime listesine dayanarak çalışmaya dahil edilecek materyalleri seçtiler. Katılımcılardan kapalı bir kutudaki materyallerin yüzeyinde aktif olarak parmaklarını gezdirirken derecelendirmelerini topladılar. Sonuçları altı boyut gösterdi: Duygusal değerlendirme ve Sürtünme, Uyum, Yüzey, Hacim, Sıcaklık ve Doğallık.

Hanada (2016), katılımcılardan kendilerine sunulan materyali tanımlamaya uygun olduğunu düşündükleri bir yansımayı adlandırmalarının istendiği serbest çağrışım yöntemini kullanarak görsel materyal özelliklerinin algısal boyutlarını keşfetmek için

Japon yansımalarını kullanmıştır. Üç anlamlı algısal boyut elde etmişlerdir: ıslaklık/yapışkanlık, kabarıklık/yumuşaklık ve pürüzsüzlük-pürüzlülük/parlaklık-matlık. Boyutları, bu bölümün başlarında Okamoto (2013) tarafından açıklanan ana beşten üçünü içerir. Ayrıca Hanada (2019), gıda/doku boyutlarını incelemek için aynı serbest çağrışım yöntemini kullandı ve 15 anlamlı boyut elde etti.

Yansıma kelimeler ses sembolik kelimeler olduğundan, bir dizi çalışma bu kelimelerin fonetik özelliklerine odaklanarak nasıl bir rol oynadıklarını anlamaya çalışmıştır. Fujisawa, Iwamiya & Takada (2004) tarafından yapılan bir araştırma, işitsel olarak sunulan Japonca yansıma kelimelerle ilişkilendirilen işitsel imgeleri araştırdı. Semantik farklılaştırma yöntemini kullanarak, katılımcılardan tipik ve tipik olmayan yansıma kelimeler tarafından uyandırılan işitsel imgelerin ifadelerini derecelendirmelerini istediler. Toplanan derecelendirmeler üzerinde bir temel bileşen analizi yaptılar ve üç boyut raporladılar: güzellik, etki ve keskinlik. Ayrıca dilin fonetik parametrelerinin kelimelerdeki sıklığı ile tipik ve tipik olmayan yansıma sözcüklerin temel bileşen puanları arasındaki korelasyonları hesaplayarak, sesli ünsüzler içeren yansıma sözcüklerin 'kirli' bir izlenim ile ilişkili olma olasılığının daha yüksek olduğunu buldular. Ses sembolizmi araştırmalarına benzer şekilde, /i/ sesli harfini içeren yansıma kelimelerin 'keskin' bir izlenimle ve /u/ veya /o/ ünlü harfini içeren kelimelerin 'donuk' bir izlenimle ilişkilendirildiğini bildirdiler. Bu sonuç, uyaran olarak yansıma kelime kullanarak ses sembolizmi çalışmak için daha fazla destek sağlamaktadır.

Son olarak bu tez kapsamında yansıma sözcükler üzerinde fonetik bir inceleme yapılacaktır; bu nedenle Türkçe ses birimlerinin dil özelliklerini kısaca ele almak önemlidir. Bir fonem, herhangi bir dildeki en küçük ses sınıfını ifade eder. Türkçe için her bir harf bir fonem oluşturur. Türk alfabesi 29 harften oluşur ve 8 ünlü vardır: /a/, /e/, /ı/, /i/, /o/, /ö/, /u/ ve /u/. Kalan 21 harf ünsüzdür ve bu ses birimlerinin fonetik özelliklerine dayalı kriterlerle ayrı kategorilere ayrılabilirler. Burada ele alınacak 3 ortak kategori vardır: 1) ses tellerinin durumuna göre; 2) çıkış yerlerine göre; ve 3) söyleniş sürelerine göre (Dursunoğlu, 2017).

Ünsüzler ses tellerinin durumuna göre i) sert (sessiz) ünsüzler ve ii) yumuşak (sesli) ünsüzler olmak üzere iki kategoriye ayrılmıştır. Sessiz ünsüzler şunlardır: /ç/f/h/k/p/s/ş/t/. Sesli ünsüzler şunlardır: /b/c/d/g/ğ/j/l/m/n/r/v/y/z/. Sesin çıkış yeri için yedi alt kategori vardır: dudak, diş-dudak, dil ucu/diş, diş eti/damak, ön damak, art damak, gırtlak. Ve son olarak, söyleniş türleri için iki alt kategori vardır: sürekli ve süreksiz (patlayıcı). Sürekli ünsüzler ayrıca akıcı ve sızıcı olarak iki kategoriye ayrılır. Birlikte ele alındığında, fonetik bir analizde Türkçede dikkate alınması gereken 20 parametre vardır. Bunlar: 8 sesli harf, 2 ses tellerinin durumu, 7 sesin çıkış yeri ve 3 söyleniş türüdür.

1.3. Amaç ve Hipotez

Türkçe yansıma kelimelerin dokunsal materyallerin yumuşaklık algısı üzerindeki etkisini inceleyen bugüne kadar bir çalışma bulunmamaktadır. Yansıma kelimeler, Japon diline benzer şekilde Türk dilinin değerli bir bölümünü oluşturmaktadır (Zülfikar, 1995). Bu tür kelimelerin kullanım sıklığı açısından bu benzerlik, dilin dokunsal algı üzerindeki etkisine ilişkin ilk çalışma için umut verici bir açıklık sunmaktadır. Bu nedenle, ses sembolik kelimeler ile dokunsal algısal alan arasında benzer çağrışımlar önermek makuldür.

Bu çalışmada, Türkçe yansıma kelimeler ile materyaller arasındaki ilişki, karşılık gelen eşleşmeleri açısından altı çalışmada incelenmiştir. Tezin cevaplamayı amaçladığı araştırma sorusu, dilin, özellikle yansıma kelimelerin, materyallerin algılanan yumuşaklığı üzerinde bir etkisinin olup olmadığıdır. Deney seti ile ilgili iki ana hipotez aşağıdaki gibidir: (1) Yansıma kelimeler, materyallerde gözlemlenene benzer bir yumuşaklık boyut dağılımı gösterecektir. (2) Yansıma kelimeler, materyal yumuşaklığı algısı üzerinde etkili olacaktır. Çalışmalar yansıma kelimeleri iki farklı biçimde içerecektir: Yazılı (Çalışma 1, Deney 1 ve Deney 3) ve sesli (Çalışma 3 ve Deney 2). Hipotezler, yansıma sözcüklerin hem yazılı hem de sesli biçimleri kullanılarak araştırılmıştır.

BÖLÜM 2

YAZILI YANSIMA KELİMELERİN YUMUŞAKLIK ALGISINA ETKİLERİ

2.1. Katılımcılar

Bütün deneylerde katılımcılar, Orta Doğu Teknik Üniversitesi'nin araştırmaya katılım sistemi olan SONA aracılığıyla alınmıştır. Katılımcılar, bilgilendirilmiş onay formunu imzalayarak onay verdiler ve katılımları karşılığında ders kredileri aldılar. Bütün katılımcıların anadili Türkçedir.

Birinci çalışmaya deney için 59 katılımcı alındı. Bunlardan 12'si deneyi zamanında tamamlamadı ve kısmi verileri analizden çıkarıldı. Kalan 47 yanıttan 8'i, deneyi tamamlamaları için geçen süreye bağlı olarak analizden çıkarıldı. Sonuçlanan katılımcı sayısı 39'dur (O yaş = 21.1, SD yaş = 1.44, 6 Erkek). İkinci çalışmaya toplam 15 katılımcı katılmıştır (O yaş = 23.8, SD yaş = 4.5, 2 Erkek, 1 solak). Deney 1'e toplam 27 katılımcı (O yaş = 24.9, SD yaş = 8.17, 8 Erkek, 6 solak) katılmıştır.

2.2. Birinci çalışma

2.2.1. Uyaranlar ve Prosedür

Birinci çalışma çevrimiçi olarak Qualtrics üzerinde yürütülmüştür. Çalışmada Türkçe yansıma kelimeler yazılı olarak kullanılmıştır. Türkçedeki yansıma sözcüklerin tamamının aranacağı tek bir kaynak olmadığından, Türkçe dilbilim kitapları ve incelemeleri (Zülfikar, 1995; Özkan, 2010) literatür taraması yapılarak derlenmiştir. Ortaya çıkan 51 kelimelik liste, kelimelerin kullanım sıklıkları kontrol edilerek ve

anlamlarının materyal algısıyla ilişkilendirilebilir olmasına dikkat edilerek eleme sürecine alınarak 47 kelimeye indirgenmiştir.

Bu çalışmada kullanılan sıfatlar, yumuşak malzemelerin dokunsal algısını inceleyen önceki bir çalışmadan (Dövencioğlu ve ark., 2018; 2019; 2022) derlenmiştir. Liste, bir malzemenin yumuşaklığı/sertliği ile ilgili 31 Türkçe sıfat içermektedir ve özellikle yumuşaklık algısını incelemek için uyarlanmıştır. Listedeki sıfatlardan ikisi, ana uyaran olarak çalışmaya dahil edilen yansıma kelimeler ile aynı olması nedeniyle değiştirilmiştir. Değiştirilen ilk sıfat aslen 'tiril tiril' idi ve 'havadar' olarak değiştirildi. İkinci sıfat 'vıcık vıcık' idi ve 'cıvık' olarak değiştirildi. Uyaranlar katılımcılara karışık bir şekilde sunuldu. Tüm deney oturumu yaklaşık 60 dakika sürdü.

2.2.2. Sonuçlar

Deney verileri, JAMOVI yazılımı (R Core Team 2018; The jamovi projesi, 2019) ve JASP (JASP Team, 2022) kullanılarak analiz edildi. Verileri analiz etmek için Temel Bileşen Analizi (TBA) seçildi. KMO örnekleme yeterliliği ölçüsü .658 puan verdi. Bartlett'in küresellik testi anlamlı bir sonuç verdi, x^2 (465) = 2070,27, p = .000, bu da gözlemlenen korelasyonların anlamlı olduğunu gösteriyor. Ana bileşenler, Kaiser normalizasyonu ve varimax döndürme kullanılarak çıkarıldı. Analizden, verilerdeki toplam varyansın %88,06'sını açıklayan yedi temel bileşen çıkarıldı: Akışkanlık, Pürüzlülük, Yüzey Yumuşaklığı, Taneciklilik, Dokusallık, Parlaklık, Kabarıklık. Çok Boyutlu Ölçekleme (MDS) Analizinin sonuçları yansıma kelimeler arasında belirli bir kümesel oluşumu göstermedi. Bu deneyi analiz etmek için ayrıca fonetik parametrelerin sıklığının TBA puanlarıyla korelasyonunu karşılaştıran bir fonetik analiz uygulanmıştır. Bileşen 1'deki yansıma kelime yüklemeleri ile sızıcı fonetik parametrenin sıklığı arasında anlamlı bir negatif korelasyon vardı (r(39) = -.57, p = .003). Yansıma sözcüklerin bileşen 1 yüklemeleri ile patlayıcı (r(39) = .45, p = .023) ve art damak (r(39) = .58, p = .002) fonetik parametreleri arasında pozitif bir korelasyon vardı. Bileşen 3 için yansıma sözcüklerin yüklemeleri ile sızıcı fonetik parametresi arasındaki korelasyon anlamlıydı, r(39) = - .68, p = .041. Son olarak, bileşen 7 için yansıma sözcüklerin yüklemeleri ile ünlü /o/ (r(39)= 0.82, p = .04) ve

ön damak ($r(39) = .82$, $p = .04$) fonetik parametreleri arasında iki anlamlı korelasyon gözlemlendi.

2.3. İkinci Çalışma

İkinci çalışmada 40 materyal videosu ve materyal niteliklerine ilişkin 29 sıfat kullanılarak yumuşaklık boyutları çıkarılmıştır.

2.3.1. Uyaranlar ve Prosedür

Bu çalışmada kullanılan 40 materyalden 32'si ana uyaran olarak yumuşak materyallerden ve 8'i ise sert materyallerden seçilmiştir. Önceki araştırmalara uygun bir şekilde, materyaller katılımcılara video olarak sunulmuştur (Cavdan ve diğerleri, 2021). Videolar laboratuvar ortamında siyah arka fon ile çekilmiştir. Videolarda sadece materyal, materyalin konulduğu kap ve keşif hareketlerini gösteren el görülüyordu. Videolar, malzemeden yaklaşık 50 cm uzakta bir tripod üzerine yerleştirilmiş Canon EOS M50 kullanılarak sessiz olarak kaydedilmiştir. Videolarda materyallerin özelliklerini en iyi gösterecek şekilde keşifsel hareketler kullanılmıştır: sünger için basınç uygulamak (deforme olabilir), tenis topları için döndürmek (sert), kadife için ovalamak (tekstil), el kremi için karıştırmak (akışkan), yeşil mercimek için parmakların arasından geçirmek (taneli) gibi. Çalışmada 29 sıfat kullanılmıştır.

Çalışma, Qualtrics platformu kullanılarak çevrimiçi olarak gerçekleştirildi. Bu çalışma ve sonraki deneyler için yapılan bir fark, daha önce birinci çalışma için kullanılan ölçeğin değiştirilmesiydi. Birinci çalışmadaki ölçek 0 ile 100 arasındaydı, 1-7 arasında Likert ölçeği ile değiştirildi.

2.3.2. Sonuçlar

TBA, JAMOVI yazılımı (R Core Team 2018; The jamovi project, 2019) ve JASP (JASP Team, 2022) kullanılarak yapılmıştır. TBA sonucunda verideki varyansın %87,58'ini

açıklayan 7 faktör bulunmuştur: Akışkanlık, Şekil Değiştirebilirlik, Taneciklilik, Yüzey Yumuşaklığı, Kabarıklık, Pürüzlülük, Kabukluluk.

2.4. Deney 1

Bu deneyde, yazılı yansıma sözcüklerin materyal videoların algılanan yumuşaklığı üzerindeki etkisi, uyumlu veya uyumsuz kelime-video eşlemeleri oluşturularak araştırıldı. Deney 1 için, yansıma kelimelerin materyal yumuşaklığı algısı üzerinde bir etkisinin olacağı varsayılmıştır.

2.4.1. Uyaranlar ve Prosedür

Bu deneyde yansıma kelimer ve materyal videoları kullanıldı ve eşleştirmeler birinci ve ikinci çalışmanın sonuçlarına göre yapıldı. Sadece her iki deneyde de ortak olan bileşenler kullanıldı ve sonuç olarak dört bileşen elde edildi: Akışkanlık, Yüzey Yumuşaklığı, Taneciklilik ve Pürüzlülük (kontrol). Her yansıma kelime yalnızca bir kez kullanıldı, ancak bazı materyaller ilgili Ana Sıfat üzerindeki derecelendirmelerde birden fazla kullanılmıştır.

Derecelendirme görevinde toplam 13 sıfat kullanılmıştır: jölemsi, sümüksü, yapışkan, cıvık, kaygan, pürüzlü, kum gibi, tanecikli, toz gibi, pul pul, ipeksi, kadifemsi ve tüylü. Derecelendirme yapılacak sıfatlar, Ana Sıfatlarla aynıydı.

Katılımcıların bir sonraki uyarana geçmeden önce tüm sıfat derecelendirmelerini tamamlamaları gereken bir blok tasarımı kullanıldı. Katılımcılara önce yansıtma kelimeler (2 saniye), ardından boş ekran (1 saniye), ardından bir materyalin videosu (5 saniye) sunuldu. Katılımcılar bu diziyi bir kez izledikten sonra 13 sıfat için derecelendirmeyi tamamladı. Tüm deneyi tamamlamak yaklaşık 60 dakika sürdü.

2.4.2. Sonuçlar

Her bir Ana Sıfat için yansıma sözcük ve malzemenin uyaranları farklı olduğundan, ayrı ayrı incelenmeleri gerekmiştir. 13 adet iki yönlü tekrarlanan ölçümlü ANOVA gerçekleştirdik. Veriler, katılımcı başına toplam 1014 derecelendirmeyle JASP (JASP Team, 2022) kullanılarak analiz edilmiştir. Veri Bonferroni düzeltmesi 0,05/13α = .003 ile çoklu karşılaştırmalar için düzeltilmiştir. Yansıma Kelime ve Materyal arasında anlamlı bir etkileşim etkisi beklenmekteydi, bu etkileşim deneydeki manipülasyon olan uyumluluğa karşılık gelmektedir. Hipotezi desteklemeyen bir şekilde, 13 ANOVA'nın hiçbirinde Yansıma Kelime ve Materyal arasındaki etkileşim anlamlı değildi.

BÖLÜM ÜÇ

SESLİ YANSIMA KELİMELERİN YUMUŞAKLIK ALGISINA ETKİLERİ

Bu bölümde laboratuvar ortamında gerçekleştirilen bir çalışma ve iki deney anlatılmaktadır.

3.1. Katılımcılar

Katılımcılar Orta Doğu Teknik Üniversitesi öğrencileri olup, çalışmaya katılmaya yazılı rıza vermiş ve karşılığında ders kredisi almışlardır. Çalışmalar Beşerî Bilimler Binası deneysel psikoloji laboratuvarlarında gerçekleştirilmiştir.

Üçüncü çalışmaya 30 kişi katılmıştır (O yaş = 22,4, SD yaş = 2,4, 7 Erkek, 3 solak). Deney 2'de veriler 30 katılımcıdan alınmıştır (O yaş = 22.5, SD yaş = 2.52, 11 Erkek, 1 solak). Deney 3'te veriler 30 katılımcıdan toplanmıştır (O yaş = 23.51, SD yaş = 2.93, 15 Erkek, 3 solak).

3.2. Üçüncü Çalışma

3.2.1. Uyaranlar ve Prosedür

Bu çalışmada kullanılacak yansıma kelimeler listesi, birinci çalışmadaki yansıma kelimeler kullanılarak yapılan, katılımcılara her kelimeye ne kadar aşina olduklarının sorulduğu bir pilot çalışma ile seçildi. Bu çalışma sonucu 27 yansıma kelime elde edildi. Yansıma kelimeler sesli biçimde sunuldu. Her bir kelime araştırmacı tarafından CANON EOS M50 kamera ve RODE gürültü önleyici mikrofon eklentisi kullanılarak ses yalıtımlı ortamda kaydedildi. Tüm kayıtlar daha sonra Audacity yazılımında düzenlenerek 1 saniyelik sessizlik, ardından yansıma kelime (~2 saniye), ardından toplam ses süresini 5 saniyeye eşitlemek için gereken sessiz blok miktarı eklenerek düzenlendi. Tüm kayıtların aynı ses seviyesine sahip olmasını sağlamak için kayıtlar daha sonra -3 dB'ye normalleştirildi.

Sıfat listesi çalışma ikiyle aynı olacak şekilde 29 sıfattan oluşmaktaydı. Deney MATLAB R2020b ve Psychtoolbox-3 ile kodlanmıştır. Sesli uyaranlar Sennheiser SK-507364 HD 206 kulaklık kullanılarak sunuldu. Uyaranlar katılımcılara karışık bir şekilde sunuldu. Deneyin tamamı tek bir oturumdu ve tamamlanması yaklaşık 40 dakika sürdü.

3.2.2. Sonuçlar

Deney verileri JAMOVI yazılımı (R Core Team 2018; The jamovi project, 2019) kullanılarak analiz edildi. TBA sonuçları verideki varyansın %92,36'sını açıklayan dört bileşenin varlığını göstermiştir: Akışkanlık, Yüzey Yumuşaklığı, Taneciklilik, Pürüzlülük. Sesli yansıma kelimelerle olan bu deneye de Çok Boyutlu Ölçekleme Analizi (MDS) uygulanmıştır. Bu analizin sonuçları yansıma kelimeler arasında çok belirgin bir şekilde dört farklı kümelenmeyi göstermektedir. Bu kümelenmeler, TBA sonuçlarıyla da uyumludur.

3.3. Deney 2

3.3.1. Uyaranlar ve Prosedür

Deneyde kullanılacak uyaranların seçimi ve yansıma kelime ve materyal videolarının eşleştirilme süreci için Deney 1'dekiyle aynı yaklaşım gösterilmiş ve önceki deneylerden elde edilen derecelendirmeler kullanılmıştır. İki deneyde ortak olan sıfatlardan toplam 13 adet Ana Sıfat elde edilmiştir. Katılımcılar deneyi laboratuvar ortamında tamamlamışlardır. Deneyde materyal videoları görsel, yansıma kelimeler ise işitsel olarak katılımcılara eşzamanlı verilmiştir ve katılımcılardan sıfatlar için derecelendirme yapmaları istenmiştir.

3.3.2. Sonuçlar

Veriler, JASP yazılımı (JASP Team, 2022) kullanılarak analiz edildi. Toplamda, her katılımcıdan 676 puan toplandı (13x13x2x2). Uyumun sıfat derecelendirmeleri üzerindeki etkisini karşılaştırmak için on üç tekrarlı ölçüm ANOVA'sı yapıldı, her bir Ana Sıfat ayrı ayrı analiz edildi. Çoklu karşılaştırmaları düzeltmek için Bonferroni düzeltmesi kullanıldı ve sonuç olarak α = .05/13 = .003 elde edildi. Yansıma Kelime ve Materyal etkileşim etkisinin, tüm Ana Sıfatlar için anlamlı olacağı varsayılmıştır, bu da sıfat derecelendirmelerinde uyumluluğun bir etkisi olduğu anlamına gelir. Sıfat ana etkisi 13 ANOVA'nın tamamında, Yansıma Kelime ana etkisi 13 ANOVA'nın 8'inde ve Material ana etkisi 13 ANOVA'nın 8'inde gözlendi. Yansıma Kelime ve Materyal etkileşim etkisi 13 ANOVA'dan 10'u için istatistiksel olarak anlamlı bir şekilde gözlemlendi.

3.4. Deney 3

Bu bölüm, yazılı yansıma sözcüklerin malzemelerin yumuşaklık algısını etkileyip etkilemediğini ve yansıma sözcüklerin modalitesi arasında anlamlı bir fark olup olmayacağını görmek için yapılan bir deneyi (Deney 3) içermektedir. Deney 3, yansıma sözcüklerin yazılı ve sözlü biçimlerini özellikle karşılaştırmak için yapıldı. Deney 3, Deney 2'ninkine çok benzer bir tasarıma sahiptir ve uyaranlarla aynı eşleştirmeyi kullanır. Deney 2 ve 3 arasındaki fark, Deney 2'nin yansıma kelimeleri sesli olarak sunması, Deney 3'ün ise yansıma kelimeleri görsel olarak sunmasıdır.

Burada, yine, manipülasyon 'uyumluluk' idi ve yansıma kelimeler ve malzemeler birbiriyle uyumlu veya uyumsuz olacak şekilde eşleştirildi.

3.4.1. Uyaranlar ve Prosedür

Bu deneyde kullanılan uyaranlar ve eşleştirmeler Deney 2'dekilerin aynısıdır. Deney 2'den farklı olarak yansıma kelimeler yazılı olarak gösterilmiştir. Yansıma kelime ve materyal videosu eşzamanlı olarak ekranda yer almıştır ve katılımcılar verilen sıfatlar üzerinde derecelendirme yapmıştır. Yansıma kelimeler ve materyaller uyumlu veya uyumsuz olacak şekilde eşleştirilmiştir.

3.4.2. Sonuçlar

Veriler, JASP yazılımı (JASP Team, 2022) kullanılarak analiz edildi. Toplamda, her katılımcıdan 676 puan toplandı (13x13x2x2). Her bir Ana Sıfatı ayrı ayrı analiz ederek, sıfat derecelendirmeleri üzerindeki uygunluğun etkisini karşılaştırmak için on üç tekrarlı ölçüm ANOVA'sı gerçekleştirildi. Birden fazla karşılaştırmayı düzeltmek için Bonferroni düzeltmesi kullanıldı ve sonuçta $\alpha = .05/13 = .003$ elde edildi. Deney 1 ve 2'ye benzer şekilde, Yansıtma Sözcüğü * Materyali'nin etkileşim etkisinin tüm Ana Sıfatlar için anlamlı olduğu varsayılmıştır. Bu etkileşim, yansımalı kelime ve malzeme eşleşmelerinin uyumuna karşılık gelir. Bu nedenle, önemli bir etkileşim etkisi, sıfat derecelendirmeleri üzerinde uygunluğun bir etkisini önerecektir. Sıfat ana etkisi 13 ANOVA'nın tamamında, Onomatopoeic Word ana etkisi 13 ANOVA'nın 5'inde ve Material ana etkisi 13 ANOVA'nın 10'unda gözlemlendi.

Buna ek olarak, Deney 2 ve Deney 3'ün sonuçları karşılaştırılmış ve yansıma kelimelerde yazılı veya sesli koşullar arasında anlamlı bir fark olup olmadığı araştırılmıştır. Her ana sıfat ayrı ayrı analiz edildi ve bu da 13 ANOVA ile sonuçlandı. Bu analizin sonuçları, yalnızca Jölemsi Ana Sıfatı için anlamlı çıkmıştır, $F(1,58) = 5.85$, $p < .001$, $\eta^2_p = .09$.

BÖLÜM DÖRT

GENEL TARTIŞMA

Bu tezde gerçekleştirilen üç çalışma ve üç deneyde, yazılı (Çalışma 1) ve sözlü (Çalışma 3) Türkçe yansıma kelimeler listesinden yumuşaklıkla ilgili algısal boyutlar çıkarılmaya, malzemelerden algısal boyutlar çıkarılmaya (Çalışma 2) ve uyumluluk değişkenini kullanarak malzemelerin yumuşaklıkla ilgili derecelendirmelerini manipüle etmeye (Deney 1, 2 ve 3) çalışılmıştır. Sonuçlar, yansıma kelimelerde yumuşaklıkla ilgili en az dört boyutun varlığını ortaya koydu ve yansıma kelimeler ile yumuşaklık derecelendirmelerini başarılı bir şekilde manipüle etmeyi başarıldığını gösterdi.

İkinci çalışmanın sonucu, daha önce yapılan deneyleri (Dövencioğlu ve ark. (2018, 2019, 2022)) destekler niteliktedir. Burada bulunan beş bileşenin (Akışkanlık, Şekil Değiştirebilirlik, Yüzey Yumuşaklığı, Taneciklilik, Pürüzlülük) yanı sıra, literatürde daha önce rapor edilmeyen iki yeni bileşen de bulunmuştur: Kabarıklık ve Kabukluluk. Birinci ve üçüncü çalışmaların sonuçları, yansıma kelimeler için de benzer yumuşaklık boyutlarının varlığını göstermiştir. Yazılı ve sözlü koşullarda kullanılan yansıma kelimeler için dört ortak bileşen bulunmuştur: Akışkanlık, Yüzey Yumuşaklığı, Taneciklilik, Pürüzlülük. Yansıma kelimeler için Şekil Değiştirebilirlik bileşeni bulunamamıştır. Bunun olası sebebi olarak, materyallerin şekil değiştirirken çıkardıkları belirgin seslerin olmaması, dolayısıyla bu seslerden türeyen yansıma kelimelerin de bulunmaması olarak gösterilebilir. Ayrıca yapılan fonetik analizin sonucu, bazı fonetik parametrelerle yansıma kelimelerden elde edilen bileşenler arasında korelasyonlar olduğunu göstermiştir.

Yapılan deneylerin sonuçları, yansıma kelimeleri kullanarak materyallerin yumuşaklık algısı hakkında verilen derecelendirmelerin manipüle edilebilir olduğunu göstermiştir.

Bu, birkaç ana sıfat grubu haricinde, yansıma kelimelerin yazılı ve sesli verildiği koşulların ikisi için de geçerlidir. Yalnızca, yansıma kelimelerin yazılı verildiği ve çevrimiçi ortamda gerçekleştirilen deneyde anlamlı sonuçlar elde edilememiştir. Bunun sebebi olarak deneyin çevrimiçi ortamda uygulanmaya uygun olmadığı, katılımcıların materyal videolarına ve yansıma kelimelere yeteri kadar odaklanamamış olmadıkları öne sürülebilir. Laboratuvar ortamında yapılan deneylerin sonuçları tezin hipotezlerini destekler niteliktedir.

4.1. Sınırlamalar

Bu tezin zaman çizelgesi küresel COVID-19 salgını ile örtüşmektedir. Bu sebeple bölüm ikide anlatılan çalışmalar ve Deney 1 çevrimiçi ortamda gerçekleştirilmiştir. Bu sebeple, Deney 1'de beklenen sonuçlar elde edilememiştir. Ayrıca, Deney 2 ve Deney 3'ün sonuçları, yansıma kelime koşulunun etkisini analiz etmek için birbiriyle karşılaştırıldı. Bu yaklaşım, iki deney tamamen aynı uyaran listesine sahip olduğu ve metodoloji benzer olduğu için seçildi. Ancak, katılımcılardan veri toplamak için zaman çizelgeleri farklıydı, burada Deney 3, Deney 2'den yaklaşık sekiz ay sonra tamamlandı. Veri toplamadaki zaman farkı, bu analiz için olası bir sınırlamadır. Son olarak, Deney 3'te yansıma kelime, materyal videosu ve sıfatın aynı ekranda gösterilmiş olması, dikkat ölçülmediği için bir sınırlama olarak söylenebilir.

4.2. Gelecek Çalışmalar

Gelecek çalışmalar, materyal videoları için kullanılacak keşifsel el hareketlerinin etkililiği üzerine odaklanabilir ve en uygun olan hareketler ile videolar hazırlanabilir. Bunun her bileşen için ne şekilde değişiklik göstereceği sistemsel bir şekilde araştırılabilir. Ayrıca, deneylerde kullanılan materyaller ve yansıma kelimeler için aşinalık kriteri eklenerek, katılımcıların derecelendirmelerinde herhangi bir etkisi olup olmadığı kontrol edilebilir. Her malzeme için aşinalık derecesi, deneyin test aşaması sırasında veya sonrasında elde edilebilir ve bu daha sonra aşinalığın olası etkilerini araştırmak için analiz edilebilir.

4.3. Sonuç

Bu çalışma Türkçe yansıma kelimeleri kullanarak materyal algısını araştıran ilk çalışmadır. Yansıma kelimeler yazılı ve sesli koşullarda kullanılmıştır ve iki koşul için ortak dört bileşen elde edilmiştir: Akışkanlık, Yüzey Yumuşaklığı, Taneciklilik, Pürüzlülük. Bu çalışmalar ayrıca yansıma kelimelerin yazılı ve sesli koşulda yumuşaklık algısını manipüle edebileceğini göstermiştir. Bu sonuçlar literatürde yumuşaklık algısı ve ses sembolizmiyle ilgili bir açığı kapatmaktadır ve gelecek çalışmalar için yol gösterir niteliktedir.

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