Effect of Adaption-level and Range-frequency on Subjective Judgment

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Abstract

This study intends to provide a better understanding of the cognitive representation of reference points, and how consumers formulate their reference levels in a judgment task.

To approach this issue, the range theory, the range-frequency theory, and the adaptation-level theory are compared while manipulating the range and frequency of stimulus in a contextual set. This article comprises two studies that test the range effect and frequency effect. Study 1 examines the range effect on the attractiveness evaluated by subjects exposed to different ranges with the same number of stimuli in a context set. Study 2 examines the frequency effect on the attractiveness evaluated by subjects exposed to two context sets, each of which contains a different number of stimuli within identical ranges. In addition, we consider each prediction of subjective judgment using the range-frequency theory and the adaptation-level theory. The MANOVA results and the non-linear regression model fittings of the two studies reveal that the adaptation-level theory provides a sufficiently good cognitive representation of a reference point.
when subjects are simultaneously exposed to a series of stimuli. Furthermore, the adaptation-level outperformed the range effect as regards a consumer’s cognitive representation when the range is fixed, but the frequency varies within the context set.

**Keywords:** reference point; subjective judgment; cognitive representation; adaptation-level, range-frequency effect

### 1. Introduction

While purchasing a product, consumers often compare features among available alternatives. One of the major findings of existing research on consumer decision-making is that consumers are context-dependent (Bettman, Luce, & Payne 1998). Numerous studies have consistently shown that consumers’ evaluations of a target product depend on what, when, where, and how many alternatives they are exposed to (Alba et al. 1994; Gupta 1988; Mazumdar & Papatla 2000). One major approach to understanding how consumers arrive at these evaluations involves the concept of a reference point (Blattberg, Briesch, & Fox 1995; Bruno, Hai, & Dutta 2012; Kalyanaram & Winer 1995; Kan et al. 2014), which can be defined as the reference level against which consumers compare the offered attribute levels included in a product or service (Monroe 1990). This concept has been well established by Kahneman and Tversky (1979). However, the process of how and where the consumer’s reference level is anchored when he or she evaluates alternatives is less understood. Thus, in this manuscript, we explore competitive theories on reference-level comparisons and evaluate the ability of each theory to predict the attractiveness ratings in our experiments.

Helson’s (1947, 1964) adaptation-level theory is the most widely cited explanation of reference point and judgment. The adaptation-level theory
asserts that judgments are proportional to deviations from a comparison standard or adaptation level. This standard is context sensitive as it is conceived as the mean of the stimuli presented within a contextual set (Helson 1964; Wedell 1995). Based on this view, the reference level that the consumers use to evaluate the stimuli is a weighted average of the category levels, which enable consumers to form their reference level. The adaptation-level model is consistent with a prototype representation of categories in which a single prototypical value is abstracted from a category set (Medin, Altom, & Murphy 1984). According to this prototype model, subjective judgments rely on a comparison of the product to a single, internal prototypical standard (Kalyanaram & Winer 1995; Thaler 1985). This prototypical standard is hypothesized to be the norm that serves as a neutral point for comparison, so that attribute levels below the neutral point are evaluated as relatively less attractive, and attribute levels above the neutral point are evaluated as relatively more attractive.

An alternative model to a prototype representation of categories is the exemplar representation, which posits that consumers may not always form abstract generalizations from a category set, but classify the item based on the category membership of the retrieved exemplars (Hintzman & Ludlam 1980; Medin & Schaffer 1978). The exemplar model assumes that consumer judgment is based on retrieved specific category members rather than summary information (Medin, Altom, & Murphy 1984). Furthermore, the range theory (Volkmann 1951) and the range-frequency theory (Parducci 1965) are consistent with the exemplar model of category representation. According to the range theory, people use the range of remembered attribute experiences to set lower and upper bounds of expectation; the attractiveness of the target attribute being a function of its relative location within this range.

Previous studies have shown that the exemplar models have outperformed the prototype models in explaining subjective judgment. Janiszewski and
Lichtenstein (1999) compared Volkmann’s (1951) range theory to Helson’s (1947) adaptation-level theory. In a series of experiments, subjects were exposed to sets of prices that manipulated the range, while holding the mean of the sets constant. Based on these experiments, Janiszewski and Lichtenstein (1999) concluded that the range theory is more consistent with the data than adaptation-level theory. In addition, Niedrich, Sharma, and Wedell (2001) showed that Parducci’s (1965) range-frequency theory provides the best fit of the data for subjective judgment, explaining the interaction between distribution and price levels. However, unlike previous literature, this study suggests that the adaptation-level theory also provides sufficiently good explanation for the data.

This research differs from previous research in terms of its presentation method and the number of stimuli formed in the contextual set. We show the subjects each stimulus simultaneously, while previous studies did so sequentially. This different presentation condition could affect a respondent’s accessibility to information retrieval. When the subjects are exposed to the stimulus one by one, they are more likely to retrieve salient information such as the highest or lowest level. However, when the subjects are exposed simultaneously to stimuli sets, they are less likely to withdraw from their memory. In addition, the contextual set of this study contains each unique stimulus. Thus, it equally contributes to the construction of the reference point. However, previous studies have exposed participants to several stimuli repeatedly, making them more accustomed to the repeated stimuli.

This study can provide salespersons with managerial implications to understand how the context of stimuli affects a consumer’s subjective judgment. If the consumer’s subjective judgment is influenced by the context of stimuli set, it is necessary to find out the kind of stimuli information that plays an important role in reference point formation. In other words, it means that a salesperson can influence consumers to
construct their reference levels by altering a series of alternatives. In the next section, we look over how contextual set of stimuli influences a consumer’s subjective judgment with respect to the range theory, range-frequency theory, and adaptation-level theory.

2. Theoretical framework

2.1. THE REFERENCE POINT IN PROSPECT THEORY

The prospect theory (Kahneman & Tversky 1979) is a more psychologically accurate description of preferences compared to the expected utility theory. It describes how people choose each probabilistic alternative and evaluate potential losses and gains. The prospect theory defines gains and losses relative to a psychologically neutral reference point that represents an individual’s current status quo. When we respond to attributes such as brightness, loudness, or temperature, our past and present context of experience defines an adaptation level, or a reference point. Thus, stimuli are perceived in relation to this reference point. The attribute value is therefore perceived in relation to the reference point and accordingly, the current position, or magnitude of change from the reference point affects an individual’s attitude toward the attribute.

Kahneman and Tversky (1979) acknowledged that the reference point might shift along an absolute scale of outcome in a manner similar to the shift of adaptation levels in response to psychophysical stimuli. This statement implies that the context of past and present experiences can influence the location of the reference point against which a particular outcome is judged as a gain or a loss.

2.2 REFERENCE POINT MODEL

The following theories could guide us with respect to changes in the reference level in a set of stimuli. According to the range theory
(Volkmann 1951), based on a range principle of judgment, the judged value is measured based on the proportion of the contextual range lying below the stimulus value. This range principle asserts that equal segments of the psychological judgment scale are assigned to equal segments of the contextual range. In other words, the judgment of a target within a set of stimuli is linearly related to the endpoints that anchor the subjective range. Thus, the subjective judgment ($J_{ik}$) of stimulus $i$ in context $k$ is given by the proportion shown in Equation 1:

$$J_{ik} = \frac{S_{ik} - S_{\text{min},k}}{S_{\text{max},k} - S_{\text{min},k}}, \quad (1)$$

where $S_{ik}$ is the subjective value of stimulus $i$, $S_{\text{min},k}$ is the minimum subjective value, and $S_{\text{max},k}$ is the maximum subjective value in context $k$ (Wedell, Parducci, & Lane 1990). Therefore, according to the range theory, subjective judgment is determined by the distance of the subjective value of each stimulus from the minimum subjective value, relative to the range between the maximum and minimum subjective value.

The frequency theory (Parducci 1965) explains that equal segments of the psychological scale are assigned to the same number of cognitive representations in the contextual set. The judgment of a target within a set of stimuli is proportional to the number of representations falling below the target stimulus. Thus, the frequency value of stimulus $i$ in context $k$, $J_{ik}$, is given by the proportion shown in Equation 2:

$$J_{ik} = \frac{\text{Rank}_{ik} - 1}{N_k - 1}, \quad (2)$$

where $\text{Rank}_{ik}$ is the rank of stimulus $i$ in context $k$, and $N_k$ is the total number of contextual stimuli (Wedell et al. 1990).

The range-frequency theory (Parducci 1965) asserts that the judged
value of a stimulus is determined by its location within the distribution of contextual stimuli. The two contextual principles determine the judged value of the stimulus based on a single dimension. While according to the range principle, judgments reflect the location of the target stimulus relative to the extreme values defining the relevant context, the frequency principle establishes the location of the target stimulus, which is described by its rank within the contextual set of stimuli. Therefore, subjective judgment \((J_{ik})\) is determined by the weighted average of the range \((R_{ik})\) and frequency \((F_{ik})\) values as shown in Equation 3.

\[
J_{ik} = w \times R_{ik} + (1 - w) \times F_{ik} \quad (0 \leq w \leq 1)
\]  

\((3)\)

The range-frequency model depicted in Equation 3 comprises two variables namely \((R_{ik}, F_{ik})\), and one parameter \((w)\). \(R_{ik}\) and \(F_{ik}\) are the subjective judgment variables of stimulus \(i\) in context \(k\) determined by the range theory and the frequency theory, respectively. \(w\) is the weight parameter, which takes on values from 0 to 1. Thus, the range-frequency theory is a composite of the range theory and the frequency theory. Moreover, each theory is nested within the range-frequency theory.

The adaptation-level theory (Helson 1947, 1964) explains that stimulus values are judged within a frame of reference. Helson (1964) proposed one version of a linear model in which the adaption level is the arithmetic mean of all subjective values. Equation 4 shows this linear model, where \(S_{al,k}\) is the adaptation level, \(S_{ik}\) is the subjective value of stimulus \(i\), and \(a\) and \(b\) represent the slope and intercept, respectively. In summary, according to the adaptation-level theory, consumers compare the target attribute level against the mean of the contextual set of attributes.

\[
J_{ik} = b + a \times (S_{ik} - S_{al,k})
\]  

\((4)\)
The relationship between the subjective judgment \((J_{ik})\) and rating \((A_{ik})\) is referred to as the response function. The subjective judgment in each, the range theory, frequency theory, and range-frequency theory takes on values between 0 and 1. Assuming a linear relationship between subjective judgments and attractiveness ratings, Equation 5 may be used to convert subjective judgments into attractiveness ratings of stimulus \(i\) in context \(k\), \(A_{ik}\), where \(\beta\) is the intercept of scale value and \(\alpha\) is the slope (Wedell, Parducci, & Lane 1990).

\[
A_{ik} = \beta + \alpha * J_{ik}
\]

### 2.3 HYPOTHESES

In order to test the range effect on subjective judgment, we consider two cases. In Hypothesis 1, we look into how a consumer’s subjective judgment changes in a skewed distribution, due to a decrease in the lower endpoint, or an increase in the upper endpoint in a uniform distribution. In Hypothesis 2, we look into the change in a consumer’s subjective judgment when he or she is exposed to a uniform distribution deformed by the symmetrical extension of the endpoints from such distribution.

First, we consider a case where only one endpoint extends, for example, the most expensive product increases its price, or the cheapest product discounts it. As discussed in each theory above, the determinants of subjective judgment of a target stimulus are the distance from the endpoint relative to range of stimuli and, either its own rank in range-frequency theory, or the arithmetic mean in adaptation-level theory. Therefore, each theory expects different subjective judgments when a range extension takes place either by an increase in the upper endpoint, or by a decrease in the lower endpoint.

Range theory (Volkmann 1951) postulates a linear relationship between
stimulus range and subjective judgment. Range theory proposes that the range of the value of the stimuli to be judged determines the subjective judgment of any one stimulus in that range. Therefore, a shift in endpoint stimulus results in a change in the relative distance between the stimuli within the range, such that it could affect subjective judgment.

For example, photographic resolution is one of the most important attributes in the choice of digital camera. A digital camera’s resolution differs from 20 megapixels at the high end, to 8 megapixels at the low end. The range theory predicts that a resolution of 12 megapixels should be judged as moderate, when the range of stimuli being judged is from 8 megapixels to 16 megapixels. However, a resolution of 12 megapixels is regarded as low resolution when the range is distributed from 8 megapixels to 20 megapixels, and the same resolution of 12 megapixels is judged as high resolution when the range is from 4 megapixels to 16 megapixels. Therefore, variations in the range width have an opposite effect on subjective judgment.

The range-frequency theory (Parducci 1965) combines the range theory and the frequency theory. According to the frequency model part of range-frequency theory, subjective judgment depends on the ratio of stimulus’ rank to the total number of stimuli. Therefore, the frequency model predicts that the subjective judgment does not vary even if the upper endpoint increases, or the lower endpoint decreases.

According to the adaptation-level theory, the context of experience defines an adaption level or reference point, based on which the new stimuli are perceived and compared. Thus, an increase in the upper bound causes the adaptation level to increase, thereby rendering the overall subjective judgment less favorable.

We introduce three different distributions to compare the subjective judgment expected by these three reference models due to a variation in range. As shown in Table 1, an increase in the upper bound of the
uniform distribution results in a positively skewed distribution; conversely, a decrease in the lower bound of the uniform distribution results in a negatively skewed distribution. We term the skewed distribution resulting from an increase in the upper bound of a uniform distribution as a positive skewed medium range distribution (PSMR), and the skewed distribution resulting from a decrease in the lower bound of a uniform distribution is termed as the negative skewed medium range distribution (NSMR). Contrary to the PSMR and NSMR distribution is the uniform narrow range distribution (UNNR).

We take an example using the resolution attribute of digital single lens reflex (hereafter DSLR) cameras. Table 1 illustrates the changes in the relative distance between each pixel of a DSLR camera in the range and arithmetic mean of contextual set, with a corresponding increase or decrease in the endpoint stimulus. Based on the discussion on the dependence of subjective judgment on changes in endpoint levels, we test the conceptual hypotheses inferred from each of the theories.

| Distribution       | Range | 4 M | 5 M | 6 M | 7 M | 8 M | 9 M | 10 M | 11 M | 12 M | 13 M | 14 M | 15 M | 16 M | 17 M | 18 M | 19 M | 20 M | Mean |
|--------------------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Uniform Narrow     |       | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 12   |
| Positively Skewed  | Medium| 1   | 1   | 1   | 1   | 1   | 1   |     |     |     |     |     |     |     |     |     |     |     |
| Negatively Skewed  | Medium| 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |

Note: Bold letters indicate the attribute levels that are common in the uniform narrow distribution and the other distributions.

H1 (RT, RFT): According to the range theory and range-frequency theory, an increase (decrease) in the upper (lower) bound of a distribution of attribute levels would cause the other stimuli to appear less (more)
attractive as the relative distance from upper (lower) bound to each stimulus level become further apart.

**H1 (ALT):** According to the adaptation-level theory, an increase (decrease) in the upper (lower) bound of a distribution of attribute levels would cause the other stimuli to appear less attractive as the arithmetic mean of summary information increases (decreases).

However, if the lower bound of the distribution decreases by the same extent by which the upper bound increases, the change in subjective judgment of the stimuli depends on their relative location.

First, for the mid-point stimulus, every theory agrees that the subjective judgment of the mid-point stimulus would not vary because the arithmetic mean, rank, and relative distance remain unchanged within the distribution. For example, as seen in Table 2, a comparison of the uniform wide range distribution (UNWR) and the uniform narrow range distribution (UNNR) shows that the arithmetic mean, rank orders, and relative distance are all equal because the upper bound increases by the same extent by which the lower bound decreases. Therefore, every theory expects that the subjective judgment of the mid-point stimulus (e.g., the 12 megapixels in Table 2) shared in both these distributions would be equal.

Second, for stimuli other than the mid-point stimulus (e.g., 8 megapixels, 16 megapixels), the range theory, range-frequency theory, and adaptation-level theory expect different subjective judgments. For example, in Table 2, while their endpoint levels differ, both the UNNR and UNWR distributions share common levels at 8 megapixels and 16 megapixels. In the UNNR distribution, the stimulus of 8 megapixels and 16 megapixels define the lower bound and the upper bound, respectively. Thus, according to the range theory, the subjective judgments of 8 megapixels and 16 megapixels are assigned values of zero and one, respectively. However, the stimuli of the same attribute level values in the UNWR distribution are located within
the lower bound of 4 megapixels and the upper bound of 20 megapixels. Thus, the relative distance of the 8 megapixels and 16 megapixels stimuli from both end-point stimuli differ in the UNWR distribution, compared to the UNNR distribution. Therefore, the range theory expects the subjective judgment of every stimulus except the mid-point stimulus to change when the range extends. The expectations of the range-frequency theory are consistent with the range theory, as the range-frequency theory is a composite of the range theory and frequency theory.

### Table 2 Distribution of Experimental Stimuli for Hypothesis 2

| Distribution | Range | 4 M | 5 M | 6 M | 7 M | 8 M | 9 M | 10 M | 11 M | 12 M | 13 M | 14 M | 15 M | 16 M | 17 M | 18 M | 19 M | 20 M | Mean |
|--------------|-------|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|
| Uniform      | Narrow| 1   | 1   | 1   | 1   | 1   | 1   | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 12   |
| Uniform      | Wide  | 1   | 1   | 1   | 1   | 1   | 1   | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 12   |

Note: Bold letters indicate the attribute levels that are common in the uniform narrow range and uniform wide range distributions used in Hypothesis 2.

Unlike the range-frequency theories, the adaptation-level theory expects that the subjective judgments of both 8 megapixels and 16 megapixels do not differ between the UNNR and UNWR distribution as the arithmetic mean is the same for both distributions. Thus, the adaptation-level theory assumes a different cognitive representation of subjective judgment compared to the range-frequency theory. The competing conceptual Hypotheses 2 is as follows.

**H2 (RT, RFT, ALT):** Each theory disagrees that the subjective judgment of the mid-point stimulus would vary as long as the lower bound decreases by the same extent by which the upper bound increases.

**H2 (RT, RFT):** According to the range theory and range-frequency theory, decreasing the lower bound by the same extent as increasing the upper bound would affect the attractiveness of all stimuli except the mid-
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point stimulus.
H2 (ALT): According to the adaptation-level theory, decreasing the lower bound by the same extent as increasing the upper bound would not affect the attractiveness of stimuli insofar as the arithmetic mean remains unchanged.

In order to understand how a consumer’s subjective judgment changes by the frequency of a stimulus, we manipulate stimulus distributions to cover an identical range, but to contain different quantity of stimuli. The asymmetric insertion of new stimuli into a uniform distribution transforms the uniform distribution into a negatively or positively skewed distribution, thereby decreasing or increasing the distribution mean. For example, the second row of Table 3 illustrates a uniform distribution where five stimuli of pixels are distributed from 8 megapixels to 16 megapixels at equal intervals. We refer to this uniform distribution as the uniform small frequency distribution (UNSF) in this study. However, as shown in the third row of Table 3, the insertion of two stimuli of 13 and 15 megapixels transforms the uniform distribution into a negatively skewed distribution by increasing the arithmetic mean of the distribution. We refer to this skewed distribution as the negatively skewed medium frequency distribution (NSMF). Conversely, the insertion of two stimuli of 9 and 11 megapixels below the mean of 12 megapixels transforms the uniform small frequency distribution into a positively skewed medium frequency distribution (PSMF) as shown in the last row of Table 3. These three different distributions cover identical ranges and contain the common stimuli of 10, 12, and 14 megapixels located in different rank orders. The arithmetic mean is also different for each distribution. Therefore, the three competing theories expect different subjective judgments for these common stimuli in UNSF, PSMF, and the NSMF distributions.
### Table 3 Distribution of Experimental Stimuli for Hypothesis 3

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Frequency</th>
<th>4 M</th>
<th>5 M</th>
<th>6 M</th>
<th>7 M</th>
<th>8 M</th>
<th>9 M</th>
<th>10 M</th>
<th>11 M</th>
<th>12 M</th>
<th>13 M</th>
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<th>15 M</th>
<th>16 M</th>
<th>17 M</th>
<th>18 M</th>
<th>19 M</th>
<th>20 M</th>
<th>Mean</th>
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<td>1</td>
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<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Negative Skewed</td>
<td>Medium</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
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<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>11.4</td>
</tr>
</tbody>
</table>

Note - Bold letters indicate the attribute levels that are common in the uniform small frequency distribution and the other distributions.

The range theory does not predict the attractiveness of these three stimuli which differ across the UNSF, PSMF, and NSMF distributions because the range of distributions is identical, from 8 megapixels to 16 megapixels. However, the adaptation-level theory expects that the common stimuli of 10, 12, and 14 megapixels located in the NSMF (PSMF) distribution are less (more) attractive than the same stimuli in the UNSF distribution because the arithmetic mean of the NSMF (PSMF) distribution is higher (lower) than that of the UNSF distribution. Therefore, the adaptation-level theory expects the subjective judgment to have a converse relationship with the arithmetic mean of the distribution.

Otherwise, according to the frequency theory, the subjective judgment of each stimulus depends on its rank order relative to the number of every stimulus included in the distribution. When the rank of a target stimulus is higher than the rank of most stimuli, the target stimulus seems more attractive. Thus, the range-frequency theory comprises the range model, and the frequency model agrees that the same three stimuli of 10, 12, and 14 megapixels located in the NSMF (PSMF) distribution are less (more) attractive than the stimuli in the UNSF distribution.

Thus, the prediction of subjective judgment of the same stimuli located in the UNSF and NSMF (PSMF) differs across the range theory, adaptation-level theory, and the range-frequency theory.
H3 (RT): The range theory does not expect the insertion of new stimuli in the distribution to affect the attractiveness of stimuli.

H3 (RFT): The range-frequency theory expects that the insertion of stimuli transforming a uniform distribution into a negatively (positively) skewed distribution causes the stimuli below (above) the rank of embedded stimuli to appear less (more) attractive than the same stimuli in the uniform distribution.

H3 (ALT): The adaptation-level theory expects that the insertion of stimuli transforming a uniform distribution into a negatively (positively) skewed distribution causes every stimulus to appear less (more) attractive, as the embedded stimuli increase (decrease) the arithmetic mean of the distribution.

3. Empirical study

The experiment for empirical study was conducted in a computer lab. This experiment was intended to test two studies related to the contextual theories. The objective of the first study was to examine the range effect on the attractiveness evaluated by subjects exposed to different ranges with the same number of stimuli in a context set. In addition, we considered each prediction of subjective judgment using the range-frequency model to represent an exemplar model, and the adaptation-level model to represent a prototype model, respectively. The second study was aimed at examining the frequency effect on the attractiveness perceived by subjects exposed to a different number of stimuli within identical ranges. We also compared the subjective judgment predicted by the adaptation-level model and the range-frequency model respectively.

The empirical study was based on a digital camera with several attributes to show a linear relationship between its attribute levels and attractiveness. The attributes were determined by a pretest in which participants were
required to select three important attributes from among brand, resolution, battery life, memory capacity, the number of pictures per second, the number of auto-focus, CMOS size, sensitivity ISO, and weight. The selected important attributes were a resolution, brand, battery life, weight, value of auto-focus, sensitivity ISO, the number of pictures per second, CMOS size, and the memory capacity in order. However, because a brand is a categorical variable, it is not appropriate to test the effects of the range and adaptation levels. Therefore, we tested the effect of range, frequency, and adaptation level using three attributes namely the resolution, battery life, and weight of camera in the empirical study.

The experiment manipulation for this empirical study differs from the previous works of Janiszewski and Lichtenstein (1999) and Suk et al. (2010) regarding the stimuli distribution and presentation mode. In these previous works, subjects were repeatedly exposed (from one to nine times) to the same stimuli to establish a skewed distribution. However, repeated exposure is more likely to affect reference levels compared to lower exposure, due to recollection. Hence, this study exposes a series of stimuli composed of each unique attribute level, to a subject on a computer screen at the same time.

3.1 METHODS

3.1.1 DESIGN

The research design for Hypotheses 1 and 2 is a single between-subjects factor with two types of distributions with different ranges, but with five identical five stimuli. The control group is exposed to the UNNR distribution while the test group is exposed to either the PSMR or NSMR distribution to examine Hypothesis 1, and to the UNWR distribution to examine Hypothesis 2.

The experiment design for Hypothesis 3 is also a single between-subjects factor with two types of distributions with identical range, but
with a different number of stimuli. The control group is exposed to the UNSF distribution, which is identical to the UNNR distribution used for Hypothesis 1, while the test group is exposed to either the NSMF or the PSMF distributions.

Table 4 shows how we manipulated the ranges and frequency of stimuli in each distribution, and how the mean of each context set changes. In the manipulation of the distribution, we created a series of stimuli to be used for the control group, and then manipulated the range and the number of stimuli sets to be exposed to the test groups.

Table 4 Distribution of Experimental Stimuli for Study 1 and Study 2

<table>
<thead>
<tr>
<th>Manipulation for Hypothesis</th>
<th>Distribution</th>
<th>Range Frequency</th>
<th>4 M</th>
<th>5 M</th>
<th>6 M</th>
<th>7 M</th>
<th>8 M</th>
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<th>Mean</th>
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<td>1</td>
<td>1</td>
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<td>12</td>
</tr>
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<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
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<td>1</td>
<td>1</td>
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<td>1</td>
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<td>1</td>
<td>1</td>
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<tr>
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</table>

Table 4 shows how we manipulated the ranges and frequency of stimuli in each distribution, and how the mean of each context set changes. In the manipulation of the distribution, we created a series of stimuli to be used for the control group, and then manipulated the range and the number of stimuli sets to be exposed to the test groups.

We draw the mean of reference distribution from the top twenty popular models of DSLR cameras sold on online shopping sites, considering the popularity order of the product based on the sales volume, the number of
sellers, and so on. We designed a series of symmetrical context sets using about 15% intervals from the median, which is larger than the 6% just noticeable difference reported by Kalwani and Yim (1992). Then the other distributions to test the range effect, frequency effect, and adaptation level effect were derived from the reference set by changing either the endpoint, or the number of stimuli.

3.1.2 SUBJECTS

The empirical test was conducted on a computer after a participant logged in, entering his or her name, age, and gender. A total of 437 students participated in the experiment. Participants were randomly assigned into one among six context sets as shown in Table 4.

Of these, 183 students were assigned to the uniform distribution as a control group, 158 students to one of the PSMR, NSMR and UNWR distributions to examine range effect, and 96 students to either the NSMF or PSMF distributions to examine the frequency effect. Of these subjects, 51.8% were female. The average age was 24.1 years with a range between 19 and 45 years. Collected data from college students is appropriate insofar as the purpose of this research is to test competing theories of psychological processes (Mook 1983).

3.1.3 PROCEDURES AND PRELIMINARY CHECKS

Each context set was composed of three attributes namely resolution, battery life, and weight. Participants were required to rate the attractiveness of each attribute level to a resolution, battery life, and weight attribute displayed on the computer screen using a twenty interval scale. The stimulus distribution was manipulated differently between each context set, but manipulated identically between each attribute within one context set. In order to mitigate order effects, the contextual attribute levels were randomized from top to bottom on a computer screen, and simultaneously
exposed to each subject.

The reliability of responses was determined by the correlation coefficient between the attractiveness ratings and attribute levels. The correlation coefficient of resolution was .944, battery life .921, and weight .755. These positive coefficients mean that a higher attribute level is regarded as more attractive for subjects. The coefficient of weight was lower than that of other attributes, implying that some participants preferred a heavy camera, and while other participants preferred a light one.

Some subjects who did not participate in the experiment seriously exhibited negative correlations and were removed. With five subjects removed, the remaining 432 subjects had a mean correlation of .956 between resolution levels and attractiveness ratings. The attractiveness rating of resolution attributes was the most reliable response to verify the hypotheses, and estimate the parameters of each reference model.

For manipulation checks, after rating the attractiveness of each attribute level, subjects were provided with a list of attribute levels, and asked to identify the highest and lowest level values for each attribute in the experiment.

### 3.1.4 MANIPULATION CHECKS

Manipulation checks were conducted using a one-way ANOVA. We expected large between-subject differences in identifying both the highest and lowest resolution levels when participants were exposed to the UNNR, PSMR, NSMR, and UNWR distributions for the test of range effect. However, we did not expect much difference while identifying the highest and the lowest levels, when participants were exposed to the UNSF, NSMF, and PSMF distributions for the test of frequency effect. The manipulation checks for Hypotheses 1 and 2 revealed that the recognition of the highest resolution was significantly higher ($F (3, 333) = 691.523, p < .000$) in the PSMR distribution ($M = 1989.2, SD = 45.4$) and in the UNWR distribution
than in both the UNNR distribution \((M = 1577.8, SD = 63.0)\), and the NSMR distribution \((M = 1572.0, SD = 70.1)\). Moreover, the recognition of the lowest resolution was significantly lower \((F(3, 333) = 1415.696, p < .001)\) in the NSMR distribution \((M = 408.0, SD = 39.5)\) and the UNWR distribution, \((M = 411.7, SD = 47.5)\) than in both the UNNR distribution \((M = 786.6, SD = 50.1)\) and the PSMR distribution \((M = 785.7, SD = 51.9)\).

The manipulation checks for Hypothesis 3 showed that there were no significant differences in the recognition of the highest \((F(3, 271) = .119, p > .949)\) and lowest \((F(3, 271) = .116, p > .951)\) resolution level among distributions. The significant differences of range recognition for Hypotheses 1 and 2, and the insignificant difference for Hypothesis 3 suggest that the manipulation was successful.

3.1.5 ANALYSIS METHODOLOGY

The attractiveness ratings of resolution levels common between the control group and the test group were used in the MANOVA. For example, for testing Hypothesis 2 which compares the attractiveness of attribute level within the UNNR and UNWR distributions, the attractiveness ratings of common attribute levels of 8 megapixels, 12 megapixels, and 16 megapixels, were compared using MANOVA. Because the arithmetic means of both the UNNR and UNWR distributions is the same as that of 12 megapixels, the attractiveness of these common attributes would not be significantly different in the UNNR (control group), and UNWR (test group) distributions if the adaptation levels influence consumer subjective judgment. On the other hand, if the range such as both endpoints influences consumer subjective judgment, then the attractiveness of these common attributes will be different due to different distances from the endpoints. In addition, the average attractiveness ratings of each resolution level in the control group and the test group were used to estimate the parameters of the
model. The subjective judgment calculated using Equations 1, 2, 3, and 4 were used as independent variables, and the attractiveness ratings measured using the twenty interval scale, as a dependent variable in the non-linear regression model.

3.2 RESULT AND MODEL FITTING

3.2.1 STUDY 1 FOR HYPOTHESES 1 AND 2

3.2.1.1 RESULT

Study 1 intended to verify the range effect on the attractiveness ratings of stimuli in the UNNR and the PSMR (NSMR) distributions, as well as the comparison of subjective judgment predicted by the reference model. The number of stimuli remains the same between the distributions, while the range differs, and the arithmetic mean also changes. After the subjects are exposed to a set of distributions, each theory competes in its prediction of consumer subjective judgments. Study 1 employs a 2 (distribution) by 4 (resolution levels common to distribution) MANOVA with repeated measures on resolution levels. The mean attractiveness of each resolution level in the UNNR distribution and the PSMR distribution, denoted by points, are plotted in Figure 1. The critical tests are provided by the main effect of the distribution, which is significant ($F (1, 181) = 4.01, p = .046$), and the interaction between resolution level and distribution, which is statistically insignificant ($F (3, 543) = 1.99, p = .114$). As predicted by the range, the range-frequency, and the adaptation-level theories, the increase in upper bound from 16 megapixels to 20 megapixels causes the other resolution levels to appear less favorable, such that the overall attractiveness ratings of common resolution levels in the PSMR distribution ($M = 8.133, SD = 2.766$) are lower than in the UNNR distribution ($M = 9.073, SD = 2.665$). The statistical results to compare the attractiveness rating at each level show significant difference at 16 megapixels ($F (1,181) = 16.490, p$
< .000), but insignificant difference at 8 megapixels \((F (1,181) =1.474, p < .226)\), 10 megapixels \((F (1,181) =1.278, p < .260)\), and 12 megapixels \((F (1,181) =2.327, p < .129)\).

On the other hand, the decrease in low end-point from 8 megapixels to 4 megapixels causes the other resolution levels to appear more favorable, such that the overall attractiveness ratings of common resolution levels in the NSMR distribution \((M = 10.916, SD = 2.366)\) are higher than in the UNNR distribution \((M = 9.998, SD = 2.362)\). The main effect of distribution \((F (1, 183) = 5.14, p = .024)\), and the interaction between distribution and resolution levels \((F (3, 549) = 3.30, p = .020)\) is also significant. These results for Hypothesis 1 indicate that the range and adaption-levels are used as consumer reference information.

According to Hypothesis 2, the range-frequency theory, and not the adaptation level theory, predicts that the attractiveness rating of other stimuli, except the mid-point changes when the upper end-point increases by the same extent by which the lower end-point decreases. To test Hypothesis 2, we compared the attractiveness ratings of stimuli common to the UNNR and UNWR distributions. We compared the means of attractiveness rating at the 12 megapixels, 8 megapixels and 16 megapixels.

A critical test was unable to prove that the main effect of distribution is significant on the attractiveness rating of the 12 megapixels resolution at the mid-point level \((F (1, 183) =.01, p = .943)\). The attractiveness rating of 12 megapixels at the mid-point level in the UNWR distribution \((M = 9.688, SD = 2.537)\) is as attractive as in the UNNR distribution \((M = 9.721, SD = 2.717)\). In addition, the main effect of the distribution on the attractiveness ratings of 8 megapixels \((F (1, 183) =2.07, p = .151)\) and 16 megapixels \((F (1, 183) =3.20, p = .075)\) is insignificant. Although the main effect is statistically insignificant, the p-values approach a significant level. This insignificance may be turned over by various manipulation settings. Therefore, more elaborate and additional experiments are required to draw more convincing
results.

3.2.1.2 MODEL FITTING

The parameters of the alternative models are estimated by iterative nonlinear regression using the least-squares method used in Suk et al. (2010). We computed each mean value of attractiveness ratings on the five focal resolution levels in the four distributions. Thus, twenty mean values of attractiveness ratings for five resolution levels were used to fit the models in Study 1. Figure 1 provides the average attractiveness ratings ($A_{ik}$) at each level within the UNNR distribution, and the PSMR distribution concerning Hypothesis 1; Figure 3 provides the corresponding ratings within the UNNR and UNWR distributions in relation to Hypothesis 2.

Additionally, a line in Figure 1 and Figure 3 marks the prediction of the range-frequency model and adaptation-level model for the PSMR and UNWR distributions, respectively. The results of the model fitting for Study 1 are provided in Table 5. All parameter estimates are significant at $p < .05$. As indicated by the $R^2$ values in Table 5, each theory fits the data very well. As seen by the relatively high $R^2$ values, and the model predictions shown from Figure 1 to Figure 3, the adaptation-level theory provides the best account of the data. In addition, the range-frequency theory provides better fit to data than the range model as it explains the interaction between resolution and distribution.
The formation of consumer's reference

**Figure 1** Prediction of PSMR

![Graph](image)

**Figure 2** Prediction of NSMR

![Graph](image)
Effect of Adaption-level and Range-frequency on Subjective Judgment

The formation of consumer’s reference

Table 5 Model Fitting and Estimated Parameters for Study 1

<table>
<thead>
<tr>
<th>Model</th>
<th>Parameter</th>
<th>Estimate</th>
<th>S.E.</th>
<th>t-value</th>
<th>sig.</th>
<th>$R^2$</th>
<th>Adj $R^2$</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
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<td>0.443</td>
<td>10.338</td>
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<td>0.928</td>
<td>0.924</td>
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<tr>
<td></td>
<td>$\beta$</td>
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<td>12.976</td>
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<td></td>
</tr>
<tr>
<td>RFT</td>
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<td>0.000</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>$w$</td>
<td>0.437</td>
<td>0.344</td>
<td>1.271</td>
<td>0.219</td>
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<td></td>
</tr>
<tr>
<td>ALT</td>
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<td>9.257</td>
<td>0.177</td>
<td>52.178</td>
<td>0.000</td>
<td>0.966</td>
<td>0.964</td>
<td>0.674</td>
</tr>
<tr>
<td></td>
<td>$\beta$</td>
<td>0.008</td>
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<td>19.314</td>
<td>0.000</td>
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</tbody>
</table>

Note: The letter $\alpha$ is the intercept and $\beta$ is the slope used to convert the subjective judgments to attractiveness ratings in Equation 5. $w$ is the weight parameter which takes on value from 0 to 1 in the range-frequency model.
3.2.1.3 DISCUSSION

Study 1 compared contextual theories in terms of the range effect on subjective judgment. As shown in Table 5, the adaptation-level theory provides a better account of the data than the range and range-frequency theories. In the works of Janiszewski and Lichtenstein (1999), and Suk et al. (2010), twenty randomized prices were presented to subjects sequentially; thus subjects might be unable to summarize the price information. However, we present only five stimuli simultaneously, so that this relatively small number of stimuli and presentation mode results in a better account of the adaptation model, as established by Niedrich, Sharma, and Wedell (2001). Thus, if salient information such as the highest or lowest price is more accessible as the number of stimuli increases, we expect that the effectiveness of the account of the adaptation-level model will decline.

3.2.2 STUDY 2 FOR HYPOTHESIS 3
3.2.2.1 RESULT

Study 2 examined the frequency effect formulated in Hypothesis 3. While the range remained equal between distributions, we manipulated the quantity of stimuli. The UNSF, NSMF, and PSMF distributions were provided to compare the predictions of the three alternative theories. The test employed a 2 (distribution) by 5 (resolution levels) MANOVA with repeated measures on resolution levels.

Every mean of attractiveness rating in the UNSF and NSMF distributions, denoted by points, is plotted in Figure 4, while the means in the UNSF and PSMF distributions are plotted in Figure 5. In addition, the lines denote the predictions of the range-frequency model and the adaptation-level model, to stimuli in the NSMF and PSMF distributions. Critical tests were conducted to assess the main effect of distribution and the interaction effect between resolution levels and distribution.

The overall attractiveness of stimuli is less in the NSMF distribution ($M =$
8.572, $SD = 2.542$), than in the UNSF distribution ($M = 9.555, SD = 2.512$) as shown in figure 4. While the main effect of distribution is marginally significant ($F(1, 171) = 3.85, p = .051$), the interaction between resolution levels and distribution ($F(4, 684) = 1.93, p = .156$) is insignificant. Moreover, the resolutions in the PSMF distribution ($M = 10.409, SD = 2.717$) are more attractive than those in the UNSF distribution ($M = 9.555, SD = 2.512$) as shown in Figure 5. Similarly, the main effect of distribution is marginally significant ($F(1, 181) = 3.65, p = .057$) at the 0.1 significance level, but the interaction between distribution and resolution level ($F(4, 724) = 2.43, p = .104$) is insignificant.

These results of the frequency effect provide support to the prediction of the adaptation-level theory, which expects that each stimulus in the NSMF (PSMF) distribution appears less (more) attractive than in the UNSF distribution due to a higher (lower) reference level. However, the range theory is not supported by Hypothesis 3.
3.2.2.2 MODEL FITTING

The results of the model fitting for Study 2 are provided in Table 6. All parameter estimates are significant at \( p < .05 \) except the weighting parameter, \( w \). As indicated by the \( R^2 \) values, both the range-frequency theory and adaptation-level theory fit the data well. However, as shown by the relatively low \( R^2 \) values, the range theory systematically does not fit the data as well as the range-frequency and adaptation-level theories do. In addition, because the weighting parameter, \( w \), is 0.012 with a standard error of 0.195, the range-frequency model is almost same as the frequency model.
Table 6 Model Fitting and Estimated Parameters for the Study 2

<table>
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<tr>
<th>Model</th>
<th>Parameter</th>
<th>Estimate</th>
<th>S.E.</th>
<th>t-value</th>
<th>sig.</th>
<th>$R^2$</th>
<th>Adj $R^2$</th>
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<td>$\beta$</td>
<td>7.494</td>
<td>0.506</td>
<td>14.807</td>
<td>0.000</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>RFT</td>
<td>$\alpha$</td>
<td>5.476</td>
<td>0.177</td>
<td>30.967</td>
<td>0.000</td>
<td>0.966</td>
<td>0.962</td>
<td>0.509</td>
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<tr>
<td></td>
<td>$\beta$</td>
<td>7.743</td>
<td>0.294</td>
<td>26.323</td>
<td>0.000</td>
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</tr>
<tr>
<td></td>
<td>$w$</td>
<td>0.012</td>
<td>0.195</td>
<td>0.062</td>
<td>0.951</td>
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</tr>
<tr>
<td>ALT</td>
<td>$\alpha$</td>
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<td>0.108</td>
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<td>0.000</td>
<td>0.964</td>
<td>0.961</td>
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<tr>
<td></td>
<td>$\beta$</td>
<td>0.0007</td>
<td>0.0004</td>
<td>23.734</td>
<td>0.000</td>
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</table>

Note: The letter $\alpha$ is the intercept and $\beta$ is the slope used to convert the subjective judgments to attractiveness ratings in Equation 5. $w$ is the weight parameter which takes on value from 0 to 1 in the range-frequency model.

3.2.2.3 DISCUSSION

Study 2 compared contextual theories by manipulating the number of stimuli between distributions with the contextual range held constant. As expected, not only the range-frequency theory but also the adaptation-level theory provides better accounts of the data compared to the range theory, as the distribution’s main effect cannot be explained by the range of a distribution. The prediction of the adaptation-level model is good enough in comparison to the range-frequency model in the NSMF and PSMF distributions. As stated in Section 3.2.1.3 Discussion, the $R^2$ of the adaptation-level model in Study 2 is not as good as in the case of Study 1, due to the larger number of stimuli.

4. General discussion

4.1 SUMMARY

This research intended to provide a better understanding of the cognitive representation of reference points, and how consumers formulate reference
levels in a judgment task. To approach this issue, Volkmann’s (1951) range theory, Parducci’s (1965) range-frequency theory, and Helson’s (1947, 1964) adaptation-level theory were compared, manipulating the range and frequency of stimuli sets.

As previously discussed, each reference model conceptualizes subjective judgment differently based on its different reference information, such as the arithmetic mean value as prototypical information, or the highest and lowest value of stimuli as specific exemplar information. The adaptation-level model provided the best fit to data in Study 1, which tested the range effect of the stimulus on subjective judgments. This result suggests that prototypical information, and not exemplar information plays a more important role in a consumer’s judgment. Moreover, the range-frequency model as well as the adaptation-level model showed a good fit to data in Study 2, which tested the frequency effect of stimulus on subjective judgments. The range-frequency model provided a slightly better account of the data than the adaption-level model in the frequency effect test of Study 2. Through these two studies, it is inferred that the cognitive representation of reference level appears to depend on the prototypical information. However, as the number of stimuli increases, the subjective judgment appears to depend on the exemplar information such as high value, or low value of the range. A few works support the notion that this exemplar information is salient, and thus more easily retrieved from memory when subjects are exposed to plenty of information (Fiske & Taylor 1991; Tversky & Kahneman 1973).

This study provides several implications. According to the results of Study 1, consumers seem to have a sense of the prototypical reference abstracted from every stimulus. Each stimulus exposed to a consumer can affect their underlying prototypical representation of the stimulus. In other words, a salesperson can also affect a consumer’s underlying reference level, by manipulating stimuli exposure to the consumer. However,
accounting for how many stimuli levels consumers can integrate into their reference levels is a worthwhile avenue for further research. Information overload often prevents consumers from processing data, thus causing them to employ more easily accessible information in decision making. If a salesperson wants a consumer to make use of prototypical information, then he or she needs to provide sufficient information for a consumer to process. By showing several alternatives for the consumer to process, a salesperson helps the consumer use the adaptation level as the reference point. In addition, in terms of experiment manipulation, each stimulus within a distribution has an even impact on a consumer’s reference level, because each different level stimulus is exposed to subjects only once. Consumers usually compare products based on their performance. While comparing the product attribute, our experiment manipulation gives a more realistic view.

In addition, compared to the Study 1, the fitness indices of the range-frequency model in the Study 2 increased marginally. Thus, we assumed that the consumer’s use of exemplar information as a reference level is activated more, as the number of stimuli increases. Furthermore, we assumed that the availability of prototypical information may be moderated by the number of stimuli due to information overload. The relatively lower increase in $R^2$ in the adaptation-level model compared to the range-frequency model supports this inference in Study 2. If a salesperson wants to anchor a consumer’s reference price to the cheapest or the most expensive price, he or she may expose a customer to numerous alternatives, as a sales strategy. However, salespersons must be careful of choice deferral due to information overload faced by customers (Dhar 1997; Dhar & Nowlis 1999; Shah & Wolford 2007).

4.2 LIMITATIONS AND FUTURE RESEARCH

This study has several limitations. As shown in Study 1 and Study 2, every contextual model provides a sufficiently good fit of data as indicated
by $R^2$ of a value more than 0.9. Therefore, we could not convincingly identify which specific information feature is used exclusively to evaluate stimuli in the context set. In a similar vein, Winer (1988) has also argued that at most, eight types of reference level prices may be used to make single price judgments. In general, multiple reference clues within a context set may be used for a single evaluation. Also, the main effect is not statistically significant in the test for Hypothesis 2, when the p-value approaches 0.05. This statistical insignificance can result from the specific experiment setting such as not enough sample size, the number of stimuli, and so on. Thus, a very elaborate set up, and a variety of experiment settings are required to understand when either the exemplar or prototypical representation model is activated in consumer judgment, and also to redeem unconvincing inferences regarding the Hypothesis 2.

In addition, the relationship between attribute levels and consumer preferences is not always in a straight line; it can be an inverted U-shape such as the preference of sweetness or temperature of a drink. Most previous researches tested the relationship between the price, and attractiveness of a product, assuming a linear relationship. We also assumed a linear relation between attribute level and attractiveness in these studies. However, we presume that the adaptation level model and the range-frequency model do not provide enough fitness of data, when employing stimuli to maximize utility at the ideal level. Thus, it is necessary to investigate the effects of range and frequency on the subjective judgment of an attribute with a nonlinear relationship between the attribute levels and preference.
REFERENCES


Effect of Adaption-level and Range-frequency on Subjective Judgment


