Ratios in Proportion:

What Should be the Shape of the Package?

Priya Raghubir*

Eric Greenleaf*

*Authorship reflects equal contribution. Correspondence should be addressed to Priya Raghubir, Associate Professor of Marketing, the Haas School of Business, University of California at Berkeley, Berkeley, CA 94720-1900; Phone: 510-643-1899; Fax: 510-643-1420; Email: raghubir@haas.berkeley.edu. Eric Greenleaf is Associate Professor of Marketing, Stern School of Business, New York University, 44 West 4th St., New York, NY 10012, Phone: 212-998-0512; Fax: 212-995-4006; Email: egreenle@stern.nyu.edu. The authors thank Nikki Lee for her assistance with stimuli preparation and data entry, Suchi Chandran for her research assistance, and Rishi Chand and Jane Gu for their assistance with survey data collection. We gratefully acknowledge the comments of Bob Krider on an earlier draft of this manuscript. An earlier version of this paper was also presented at the IC-1 conference on Visual Marketing at Ann Arbor, Michigan. Audience feedback is gratefully acknowledged.

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Consumers' preferences for rectangles have implications for package and product design, but studies of these preferences have proved inconclusive as to whether people prefer rectangles with a specific ratio of sides. Study 1 finds that consumers prefer a range of rectangles with ratios between √2 (1.414) and √3 (1.732), a range that includes Φ (1.618) but do so only in some contexts. Study 2 finds that in some contexts (but not in others) the ratio of a rectangular shape in which information is presented can influence product perceptions. Study 3 shows that the shape is related to consumer products' sales and market share.

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The focus on "pleasing" proportions in art and architecture extends back to the ancient Greeks 2500 years ago. One of the oldest controversies in aesthetics is whether people innately prefer certain visual proportions for the sides of rectangles. Scientific investigations of this question began in the 1870s with Fechner's work on the golden ratio whose myriad mathematical and aesthetic properties led it to be nick-named the "divine proportion" ($\Phi \approx 1.618$). The results of this research have been mixed, with no definite conclusions that people consistently prefer any particular rectangular ratios (Benjafield 1985; Green 1995), with the result that no clear recommendation can be given to marketers.

The average supermarket stocks over 17,000 items (Kesler 1986). To break out of the clutter, companies are focusing on packaging decisions, finding that seemingly small changes in package shapes can have a large influence on sales and profits (Prince 1994). Recent research in the trade press suggests that a package's shape is a critical way for a brand to differentiate itself, as package design has an overt (and possibly subliminal) impact on consumers' purchase decisions (Sherwood 1999). Practitioners credit the "New Age" beverages (*e.g.*, Snapple, Arizona Iced Tea, Perrier) with sparking the packaging renaissance (Miller 1994).

The package shape decision is not only important for brand managers it is also a theoretically rich domain to examine how consumers process visual information to make decisions as it has many facets (Bloch 1995). Academicians have recently begun to examine how package shape affects volume perceptions and consumption (*e.g.*, Raghubir and Krishna 1999; Wansink and van Ittersum 2003), but are yet to examine aesthetic considerations despite their importance (Hirschman 1983). This article applies the research on aesthetics to product design. We investigate whether the ratio of the proportions of the two sides of a rectangle can affect

perceptions of and preferences for a product and whether they do so in every situation or are context dependent. Our research questions are:

1) *Do consumer preferences for rectangular packages depend on the rectangles' ratio?*
2) *Do consumers prefer a single ratio, or a broader contiguous range of ratios?*
3) *Do the patterns of these preferences depend on context?*
4) *Do rectangular ratios affect consumer demand?*

Below, we review the literature on preferences for rectangles as a function of their dimensions, focusing on the discussion around the golden ratio: φ. Three hypotheses derived from this literature are tested in two laboratory experiments and a field study. The general discussion concludes with implications for package shape and the study of aesthetics.

Prior Literature

In this section we summarize literature that has shown the existence, use and impact of Φ in domains ranging from mathematics (Herz-Fischler 1987; Huntley 1970), and nature (summarized in Green 1995) to art (Alberti 1989; von Stimson 1974) and architecture (Ghyka 1977). Testifying to its age-old enigmatic appeal, the first recorded psychological experiment was conducted around this question over a century and a quarter ago (Fechner 1871), but has recently been critiqued on methodological grounds (Höge 1995, 1997).

The use of φ in Mathematics. The special mathematical properties of Φ have been studied since before Pythagoras. Mathematicians such as Euclid and Fibonacci were intrigued by its properties (Herz-Fischler 1987). The Φ rectangle's alleged mathematical and visual appeal stems from several properties (see Ghyka 1977; Huntley 1970; Livio 2002). It is the only ratio where the ratio of the greater part to the whole equals that of the two parts. Furthermore, if a square is

removed from a golden ratio rectangle, the remaining rectangle retains the golden ratio. The ratio of consecutive Fibonacci numbers converges to Φ. Drawing on the relationship between mathematics and aesthetics, other commentators have examined the use of φ in the fine arts (see Huntley 1970 for a review on the relationship between mathematical properties and beauty). Today, the use of φ continues in computer algorithms, and comes up in unexpected domains, such as marketing research. For example, Crowley (1991), showed that the ratio of positive and negative affective consumer judgments approaches φ.

Evidence from the Arts. Art over the centuries has often relied on geometric ratios and proportions (Alberti 1989; von Stimson 1974). One of the oldest controversies in perception and aesthetics is whether people innately prefer certain visual proportions with mathematical properties that may create appealing aesthetic properties. Most prominent is the "golden ratio," or Φ (Φ ≈ 1.618). Advocates of the golden ratio's aesthetic appeal, point to its alleged use in major works of art and architecture, such as the building blocks of the Great Pyramids, the Parthenon's façade and paintings by Georges Seurat (see Ghyka 1977).

The First Experiment. Scientific investigations of whether people actually prefer rectangles with prominent mathematical properties began with Fechner's pioneering work on the golden ratio (1871; 1876). Fechner's experimental evidence supports a strong preference for rectangles using the Φ ratio. In Fechner's (1876) study, he showed that given a range of 10 rectangles with length/ width ratios ranging from 1:00 to 0.40, 35% of all participants liked the golden ratio rectangle the best -- the closest to this were ratios of .67 (20.6%) and .57 (20%); no one judged it as the "worst" rectangle (for a recent translation see Fechner 1997). At the turn of the last century, other researchers successfully replicated his findings (Lalo 1908; Thorndike 1917; Witmar 1894; for a review, see Green, 1995).

Methodological Critiques of Fechner's findings. With advances in experimental methods in the last century, Fechner's findings have been critiqued on methodological grounds (see Green 1995; Plug 1980 for an extensive discussion). These include instructions given to study participants (Hekkert et. al 1994), the method used to measure preferences (McManus 1980; Ohta 1999), the range of ratios used in a study and the location of a particular ratio in the range (Benjafield and McFarlane 1997; Piehl 1976; Godkewitsch 1974), whether the rectangles have equal area (Benjafield 1976), whether the researchers examined average or individual preferences (Plug 1980), whether the rectangle is part of a more complex overall pattern (Boselie 1984) and the method of elicitation of preferences (Höge, 1995, 1997, Koneni 1997).

For example, Höge attempted to replicate the findings for the golden ratio under conditions where study participants were given different instructions: drawing rectangles, versus choosing and sorting rectangles (Höge 1995). While instructions and tasks affected preference ordering, he did not find evidence for the golden section using any method, and concluded that people's tastes may have changed over time. Koneni (1997) also used these two methods with vases that had to be "placed" on either an imaginary or a purpose-built laboratory mantelpiece. Placement choices appeared to be dictated by balance rather than an adherence to the golden section. There was also no preference for vases that followed the golden ratio. Benjafield and McFarlane (1997) found that the order of presentation of ranges influenced aesthetic preferences. The golden section proportion was only preferred when the range of rectangles stopped at 1:2.5 ("thick" rectangles only) rather than continued to more asymmetric ratios, or when it was the mid-point of the range presented.

Questioning the robustness of the preference for φ. Other researchers have examined whether the preference for the golden section is robust across different categories of shapes, and

for different people (for comprehensive critiques see Green 1995; Benjafield 1985). For example, Boselie (1997) tested for a preference for the golden ratio in shapes other than the rectangle, and did not find that it dominated the 1.8 ratio. Macrosson and Strachan (1997) found that participants experienced in "matters of aesthetic taste," were more likely to partition a line segment in the 1:1 or 1:2 ratio, rather than the 1:618 ratio. On the other hand, McManus and Weatherby (1997) found that there were individual differences in preference for the golden section. At the overall population level, they found that the ideal position in which participants placed an object in the frame of a picture was between the two golden sections horizontally and vertically. However, there were large population level differences, which suggest that the preference for the golden ratio may be contingent on individual and contextual factors. DeHeer and Nobbe (2000) studied the dimensions of print advertising, and found limited support for the existence of the golden ratio in ad space.

Examining Ratios other than φ: Aesthetic Preference for a Range rather than a point? As the field of experimental aesthetics remained mystified by when, for whom, and why, the golden ratio has appealing properties, evidence pointing to preferences for other ratios has surfaced (Borissavliévitch 1958; Ghyka 1977; Green 1995; Herz-Fischler 1987; Hambidge 1926; Huntley 1970; Lawlor 1982; Pennick 1980). Many of these, including 1.5, √2, and √3, are close to Φ. The current thinking is that there may be a range of ratios extending from approximately √2 (1.414) to √3 (1.732) and including Φ (1.618) that people prefer over others (Benjafield 1976; McManus 1980; Piehl 1978; Plug 1976; Svensson 1977).

Aesthetics of Package Shape. Bloch (1995) developed a conceptual model that details the antecedents, mediators, and moderators of the impact of aspects of package shape on consumer

preferences and choice. The two primary mediating constructs are: cognitive (including product beliefs and categorization), and affective (including positive aesthetic and negative responses). Bloch's model argues that the effects of product form on cognitive and affective responses are contingent on situational factors. Such a contingent approach has also been followed by Holbrook and Anand's empirical studies (1992) who found that that the tempo of music on aesthetic responses to music were contingent on the nature of the listening experience and the extent of situational arousal. The mixed evidence for ratios including and around φ suggest that preferences for any ratio over another may be domain specific, rather than universal.

Our approach. Given this prior literature, in our studies, we:

1. Control for methodological concerns that have been highlighted by others, such as the range of rectangles presented, the area of the rectangles, their orientation, and color). Further, given that the support for φ appears to be more robust in contexts where people are not consciously making a judgment about a ratio but this is implicit in their behavior (*e.g.*, art, architecture, nature), and less robust in contexts where they are explicitly asked to make a judgment, we use indirect as well as direct measures in our studies.
2. Manipulate context of product use within and across studies to examine whether patterns emerge suggesting which contexts favor the use of a range of ratios including the golden ratio, and which contexts do not. Such an approach has three distinct advantages:
    a. It has the potential of explaining contradictory findings in the prior literature, a lot of which asked participants to make choices of rectangles without a context;
    b. It establishes for which domains which range of ratios is preferred, which is an important managerial question; and

c. By identifying a moderating construct, it contributes back to the literature on aesthetics by shedding light as to *why* φ has an appeal.

We test the following hypotheses:

H1: People have preferences for certain proportions over others.

H2: Sales of a product are contingent on the shape of the package.

H3: Product use context moderates H1 and H2.

Study 1 tests H1 using a laboratory experiment shows that perceptions and purchase intentions are more favorable when identical information is presented in a golden ratio rectangle (versus one with a ratio of 1.38). Study 2 examines the robustness of H1, across four contexts using a range of 9 ratios from 1:1 to 1:2. It finds that preferences are contingent on context and follow a range of ratios rather than a single point. Study 3, a field study, examines whether the ratio of the rectangular dimensions of package sizes are related to sales to test H2 and H3.

Study 1 – Consumer Perceptions Based on Rectangular Ratios

Design and Procedure

The design was a one-way between-subjects design where ratio of sides was manipulated at two levels: 1.38:1 or 1.62:1 (the golden ratio). Participants were told that the study was a "Study of Music Tastes among University of California at Berkeley Students." They were asked to assume that they had been mailed two invitations to two concerts: Concert A and Concert B. The words in the “invitation” for Concert A titled “Music of Indonesia: Songs before Dawn” were printed in a square box 6” on each side (a 1:1 ratio), and described the music in Concert A. This concert was used as a control to create a reference point that individuals would compare against their judgments of a target concert, B, and to control for individual differences in scale

response. The target invitation for Concert B: "Dream Songs: Sounds of the Malaysian Rainforest," was printed in a rectangular box with ratio of sides either 1.38 or 1.62, with both boxes having the same area and containing the same description of Concert B (see Figure 1).

-- Insert Figure 1 around here. --

Measures

Perceptions: To examine underlying perceptions, we measured relative impressions of Concert B as compared to Concert A (1 = B Much less; 4 = B About the same; 7 = B Much more). Perceptions rated including: harmonious, stable, exciting, fast, and beautiful. These were averaged to make the Harmony Index ($\alpha = 0.75$), with higher values indicate perceptions of greater harmony for Concert B.

Overall Preference: Preference was measured by asking participants to choose which concert they would prefer to attend if they were both at the same time. Responses were elicited on a 6-point scale, with intervals labeled "Strongly," "Moderately," and "Slightly" prefer Concert A or B. Higher numbers reflect a preference for Concert B.

Purchase Intentions: Participants rated their likelihood of buying a CD of the music for each of the concerts using a 7 point scale ("Definitely Not" = 1 and "Definitely" = 7).

Covariates and Controls. All participants answered questions about their consumption of music (*e.g.*, concert attendance, spending on music, CD ownership) and gender to check that the two conditions were matched. Given that novelty can affect college age students music tastes, we also asked participants to rate the newness of the two concerts (using two 7 point scale ratings for contemporary and sophisticated), to use this as a covariate. To assess whether the manipulation affected depth of processing, subsequent to a filler task, we administered a surprise

recall task, followed by a 5-item multiple-response "quiz" on the content of the information provided for Concert B (the target concert).

Participants

Study participants were 102 undergraduate students enrolled in an introductory marketing course who completed the experiment for partial course credit (50 males and 52 females).

Study Results

There was no difference in the amount of recall of the concert information across conditions (*F*'s < 1), or in the number of questions that participants correctly answered in the surprise quiz task at the end of the procedure; suggesting no evidence for differential depth of processing in the two conditions. Gender and experience with the product category did not moderate the effect of the ratio condition on any of the three dependent variables (all F's < 1). Results for all three measures showed a preference for the golden ratio over the 1.38: 1 ratio and are displayed in Figure 2. Analyses use a one-way ANOVA, followed by ANCOVAs to test mediation paths. Tests reported are one-tailed.

-- Insert Figure 2 around here. --

Harmony Index: The target concert was rated as more harmonious when it was presented in the ratio of 1.62 (M = 4.69) as compared to 1.38 (M = 4.33; F (1, 100) = 3.27, $p < .05$).

Overall Preference: The target concert was preferred marginally more when it was presented in the ratio of 1.62 (M = 4.12) as compared to 1.38 (M = 3.70; F (1, 102) = 2.34, $p < .10$). The same analysis, incorporating harmony as a covariate, did not reveal a significant effect of the covariate. Including perceptions of the newness of the concert as a second covariate,

reduced the noise in the estimate, and improved the significance level of the ratio factor, suggesting that preferences are partially driven by novelty (F (1, 100) = 3.01, $p < .05$). However, the pattern is not statistically consistent with a model where beliefs in harmony mediate overall preferences (see Baron and Kenny 1986).

Purchase Intentions. An ANOVA showed that purchase intentions for the CD for the target concert were higher in the golden ratio condition as compared to the 1.38 ratio condition (Ms = 2.96 vs. 2.24; F (1, 102) = 4.66, $p < .05$). The same analysis, incorporating harmony as a covariate, did not reveal a significant effect of the covariate. However, the ANOVA on purchase intentions incorporating preferences as a covariate, showed a significant effect of the covariate ($F(1, 101) = 11.01$, $p < .001$), while the effect of the ratio condition reduced in significance ($F(1, 1010 = 3.12$, $p < .05$). This suggests that the willingness to buy a CD is partially mediated by overall preferences for the concert.

Discussion

To summarize, the results of this study show that a small difference in the ratio of the sides of a rectangular invitation can affect perceptions of a product, as well as relative preferences for it and purchase intentions for a related product (the CD). Note that despite an identical content of information about Concert B, purchase intentions were higher when information was presented in a rectangle with the golden ratio as compared to the ratio of 1.38. In the next study, we examine the robustness of this effect across different contexts.

This is important because the context used in this study was harmony – a domain that is closely related to the arguments claiming special properties for φ. Thus, our test was loaded in favor of finding support for φ. This limits the generalizability of our findings for marketing as consumers are not always in a frame of mind that highlights harmony. Many marketing contexts

are relatively frivolous and fun, and may be intended to reduce harmony. It is not only possible, but indeed plausible, that in these contexts rectangles with particular mathematical and aesthetic properties may not have any particular appeal. Therefore, Study 2 examines whether preferences for rectangular products and packages that use the golden ratio or other "special" ratios are stronger in contexts which evoke harmony versus the lack of harmony (frivolity).

Study 2: Contextual Preferences for Invitation Cards

Pretest

Four contexts were pre-tested to ensure that they differed in their degree of seriousness. Two of these were relatively less frivolous: a business presentation for prospective customers for accounting software, and a concert of classical piano music. The other two were relatively more frivolous: a three-year old child's birthday party and an outing with adult friends to a three-ring circus. The pretest (n = 40) showed that a circus ($\underline{M}$ = 1.68) and a three-year old's birthday party ($\underline{M}$ = 1.92) are rated as less serious occasions than a piano recital ($\underline{M}$ = 4.91) and an accounting seminar ($\underline{M}$ = 5.24: all rated on a scale of 1-7 anchored by "Not at all"/ "Very" serious; both serious contexts rated as significantly more serious than the less serious contexts at $p < .05$). These four occasions were chosen to represent 2 serious and 2 frivolous contexts in the study.

Design and Procedure

The experiment used a 2 (context: more versus less frivolous) x 2 (occasion: two replicates within each context) x 9 (rectangular ratios: 1: 1, 1.13, 1.26, 1.38, 1.5, 1.62, 1.74, 1.87, and 2.00) within-subjects design. Participants were told that the study was a "Study of Preferences for Custom-Printed Invitations." The instructions read: "Imagine that you are

selecting the invitations at the printer's shop. The printer tells you that you have to make three different decisions to design the invitations for each occasion." Context was manipulated by asking participants to make decisions for each of the four occasions, with four different order of occasions used.

Rectangular ratio was manipulated by asking participants to provide preferences for each occasion for each of nine different rectangular card blanks whose shapes varied in the ratio of their sides. These levels ranged from 1:1 to 2:1 in steps of approximately .13, and were chosen to include the ratio of 1:1.62 (the golden ratio). The range of ratios ended at 1:2 (rather than 1:2.5 as in the original Fechner study) so that the golden ratio would not be placed in the middle of the ratio distribution as such placement has been shown to favor it (Benjafield and McFarlane 1997).

The card blanks were labeled A to I in the bottom right hand corner using four different random orders. The orientation of the labeling letter was used to ensure that half the participants saw a horizontal orientation, and the other half a vertical orientation. The order in which participants saw the card blanks was randomized and each card set was shuffled and placed in an envelope. Thus, there were a total of 8 different types of envelopes used (4 order of letters x 2 orientations) x 4 (order of occasions).

Participants were asked to make two other design decisions to increase the realism of the cover story and avoid focusing exclusively on the choice of invitation shape. These decisions were the color of the envelope (white, blue, green and red) and the font to be used in the invitation (five fonts were provided).

Study Participants

Participants were 122 undergraduate students enrolled in a marketing course at U.C. Berkeley who completed the experiment for partial course credit.

Measures

Dependent Variables. Participants' preferences were obtained by asking participants to indicate the likelihood that they would choose each card option (A to I) from the available choice set using a six-point scale anchored at "Very likely" (= 6) to "Very unlikely" (=1). While preference ratings preserve inter-item distances, information on most and least preferred rectangles is less sensitive to aggregation problems (Green 1995). Further, the preference for ratios has been shown by Plug (1980) to be contingent on methodological variables that either examine the average population preference for a ratio (as would be seen in a rating task), or the individual distribution of preferences (which can be examined in a ranking task). Therefore, after indicating preference, participants were also asked to indicate which of the nine card blanks they were "most likely to choose" and "least likely to choose."

Manipulation Check. As the construct of serious/ frivolous has not been previously investigated in the literature, this limits our ability to use a tried and tested scale to measure this construct. We, accordingly, generated five items that should tap into this construct using brainstorming. At the end of the rating and ranking task, participants rated each of the four occasions using five, seven-point semantic differential scales anchored at: "Frivolous-Serious," "Orderly-Disorderly," "Unified-Fragmented," "Volatile-Stable," "Rational-Emotional." The first and fourth variables (frivolity and volatility) were reverse-coded, so that final item scores ranged from 1 (least frivolous) to 7 (most frivolous). These were used to verify whether participants perceived the four occasions differentially on their relative frivolousness.

A factor analysis for each the four occasions confirmed that the five variables loaded onto a single factor for each occasion (Eigen values = 2.28, 2.86, 2.23, and 2.34 for birthday, accounting software, circus and piano concert respectively). The five variables were averaged into a *frivolousness index* for each of the four occasions as they displayed a reasonable level of reliability for a new and untested scale (Cronbach's α = .69, .79, .68, and .66 for birthday, accounting software, circus and piano concert respectively).

Study Results

Manipulation Check. A repeated measures 2 x 2 (context x replicate) ANOVA on the *frivolousness index* showed that the two less frivolous occasions were rated as less frivolous (Accounting Presentation = 1.65; Piano Concert = 2.56) versus the other two occasions (Circus = 4.92; Birthday Party = 5.07; main effect of context $F(1, 121) = 895.25$, $p < .001$). The two occasions within each context domain differed from each other (main effect of replicate = $F(1, 121) = 28.80$, $p < .001$), and this difference was greater for the two occasions in the less frivolous domain (interaction $F(1, 121) = 70.04$, $p < .001$).

Likelihood of Choosing Card-Ratings. To test H1, we analyzed preferences using a 9 x 2 x 2 (ratio x context x replicate) within-subjects, repeated measure ANOVA. As predicted, preferences for cards differed by ratio (main effect: $F(8, 848) = 64.18$, $p < .001$). However, this effect was contingent on context (ratio x context interaction $F(8, 848) = 13.91$, $p < .001$). Mean likelihood ratings are presented graphically in Figure 3, and analyzed below. The overall analysis also produced additional significant effects of context ($F(1, 106) = 15.73$, $p < .001$), a replicate x context interaction ($F(1, 106) = 4.01$, $p < .05$), as well as a significant three-way interaction ($F(8, 848) = 8.02$, $p < .001$). The pattern of means suggests that the main effect is due

to higher preferences for ratios closer to symmetry for the more frivolous occasions, while the interaction effects involving the replicate factor reflect that the two less frivolous contexts differed in their degree of frivolousness, while the more frivolous contexts did not. The latter effect is not of concern to our predicted effects and is not analyzed further.

-- Insert Figure 3 around here --

To examine whether ratios in the $\sqrt{2}$ to $\sqrt{3}$ region were preferred over others the preference rating for each card was regressed on ratio and ratio squared as independent variables using OLS regression. If preferences follow an inverse-U shaped curve, the main effect should be positive and the square effect negative. This was the pattern observed (β for ratio = 2.15, and for ratio^2 = -2.41, both *p*s < .001).

To assess whether this inverse U-shaped pattern was contingent on context, we re-ran separate regressions for the less frivolous (accounting software presentation and piano concert) and the more frivolous contexts (birthday party, visit to the circus). The relative size of the standardized beta coefficients for the ratio and ratio-squared terms shows that the pattern is stronger for the less frivolous contexts (βs = 3.59 and –3.74) as compared to the more frivolous contexts (βs = 0.59 and –0.97).

Rankings: Rankings reveal a similar pattern of results (see Table 1). For each category, first choice was contingent on the ratio of the cards (χ^2 (8) = 73.56, 48.45, 30.15 and 68.63 for accounting, piano, circus and birthday respectively, all *p*'s < .01). However, the specific pattern of top-ranked preference for the nine ratios was contingent on the four occasions (overall χ^2 (24) = 71.83, *p* < .001).

-- Insert Table 1 around here –

For the less frivolous contexts, a majority of the first preferences were in a range of ratios of approximately √2 to √3. However, for the more frivolous contexts there was a stronger preference for rotational symmetry: almost 25% chose the square as their favorite shape, and less than 5% chose the golden ratio rectangle as their favorite. The only commonality in the two contexts was in their choice of the 1.26 ratio and lack of choosing ratios > 1.62.

A similar pattern emerges for the lowest ranked card. For each category, the least favorite card was contingent on their shape (χ^2 (8) = 164.29, 118.13, 105.07 and 180.44 for accounting, piano, circus and birthday respectively, all *p*'s < .01), but these choices were contingent on the occasion (overall χ^2 (24) = 47.60, $p < .001$). These differences are primarily driven by the lack of preference for the square and the 1.26 ratios in the less frivolous contexts (see Table 1, contrast in right-most column). Across all four categories, the ratio of 1:2 was the least popular ratio and the ratio's spanning √2 to √3 are not disliked in absolute or relative terms in either context.

Discussion. To summarize, the results of this experiment show people's preferences for specific ratios is contingent on context. The preference is in the region of ratios between √2 and √3 for contexts invoking harmony, and is skewed towards rotationally symmetric square shapes for contexts invoking frivolousness. One managerial implication that follows from our results is in terms of the shape of product packages. It is worth investigating whether marketplace offerings follow our predictions. Given that results show a strong preference for ratios in the proposed range, and a dislike for the 2:1 ratio, managers can use this information while deciding product packaging. A simple survey of store brands showed that many private labels use a ratio that we show to be less liked.[1] Study 3 asks the question as to whether this "matters" for managers: that is, do the contingent preferences found in Study 2 translate into sales?

[1] Safeway, a leading grocery chain in the west coast of the U.S., offers rice crispies bars in a box with dimensions (in inches) of 24 x 12 x 6; unsalted top crackers in a package with dimensions of 25.25 x 11.25 x 11, and sugar cones in a box with dimensions

Study 3: Frequently Purchased Grocery Products

To test H2 and H3, we chose four supermarket product categories which related to the question studies, and were matched on potentially confounding domains. Specifically, where:

1. Consumers primarily see the package as a two-dimensional rectangle on the shelf;
2. Package material are similar across brands (*e.g.*, cardboard);
3. There is within-category variation in the ratio of the rectangles; and
4. There is an external criterion to measure sales.

Pretest

Following the method used in Study 2, we pre-tested four categories that met the above criteria to ensure that two of them were perceived to be relatively more serious and two were perceived to be relatively less serious. A pretest (n = 38) showed that soaps and detergents were rated as more serious (Ms = 4.15 and 4.41 on a 1-7 scale anchored by not at all/ very serious) than cereal and cookies (Ms = 3.26 and 2.93, $p < .05$)

Method

The top eight to ten brands in terms of market shares were identified in each category, using market share data from the Market Share Reporter (2002), pp. 273-301 and 696. (In the last two categories, nine and eight brands respectively created the majority of category sales.) The average market share in the two relatively more frivolous categories was 3.53%, while the average for the two relatively less frivolous categories was 9.08%. The dimension of the height,

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25 x 12 x 6. Compare this with box dimensions of leading national brands; e.g., Betty Crocker's Pancake Mix comes in a box with dimensions 23.5 x 16.5 x 6 (shelf face ratio of 1.42), and Orville Redenbacher's popcorn comes in a box with dimensions 16 x 11.5 x 5.5 (shelf face ratio = 1.39).

width, and length of the box were recorded for each of these brands, and the following three ratios were calculated for each brand:

a. Longest dimension/ median dimension (MAX/MID)
b. Longest dimension/ shortest dimension and (MAX/MIN)
c. Median dimension/ shortest dimension (MID/MIN).

Note that the ratio (c) is the inverse of (a)/ (b). Examples of some of the brands considered and the variation in their shelf facings are provided in Figure 4.

-- Insert Figure 4 around here. --

Results

A regression on the market share of the product, using the three ratios of the dimensions as independent variables, was conducted separately for the two set of product categories: cookies and cereals versus soaps and detergents. Since market shares are percentages, they were transformed to *log(share/(1-share))*. Results are presented in Table 2 for the two sets of categories separately.

-- Insert Table 2 around here --

The regression results were significant for both categories (F's = 5.12 and 8.19 for less and more serious categories respectively, $p < .05$ for both), and explained a high degree of variation (R^2 = .490 and .654 for less and more serious categories).

However, the direction of the coefficients differed across the two categories. In the more frivolous category the coefficients for max/mid and mid/min were negative (βs = -1.23 and –1.31, ts = -2.81 and –2.82, both ps < .01), suggesting that as these ratios increased and the package shape moved away from the rotationally symmetric square, market share decreased.

For the less frivolous categories, the pattern reversed: that is, as the ratio of the packages elongated (away from rotational symmetry), market shares increased. Specifically, the signs of the parameter estimates for two ratios were positive (βs = 63.55 and 54.05 for max/mid and mid/min respectively, *t*s = 4.00 and 3.80 respectively, both *p*s < .01). This direction suggests that as the ratios increased, the market share increased. Note that while the three parameter estimates for the ratios are all significant for both types of product categories, the signs for the less frivolous categories are always the opposite of those for the more frivolous categories.

Discussion

Overall these results suggest that the ratios of the dimensions of a product's box are related to its market share for frequently purchased supermarket products that are sold to consumers in boxes. The direction of causality is unclear due to the nature of the survey data; that is, the relationship may be because "better" products are more appropriately aesthetically designed, or it may be as we suggest, that appropriately aesthetic ratios increase preference, which translates into sales. Irrespective of the direction of causality, these results attest to the importance of examining product shape as suggested by Bloch a decade ago (Bloch 1995).

General Discussion

In this paper, we studied *(i)* whether the ratio of the dimensions of rectangular products and product boxes affect consumers' preferences in the product categories those rectangles represent; *(ii)* which proportions are preferred over others, *(iii)* whether the product context affects these preferences; and *(iv)* whether there is a relationship between a products' package shape and its sales.

Our primary theoretical contributions are to show that *(i)* that there are preferences for some ratios of rectangular products and packages over others, *(ii)* that these preferences exist over a range of proportions (√2 to √3), rather than for any single proportion, *(iii)* but that these preferences only exist for contexts that are relatively less frivolous, and not for those that are relatively more frivolous, and *(iv)* preferences are correlated with sales.

Fechner's original observation, over a century and a quarter ago appears to hold in a domain far removed from the art and architectural realms that motivated his studies. We found that consumers appear to prefer rectangles over a range of ratios, from approximately √2 to √3, a range that also includes 1.5 as well as the famous Φ, or "golden ratio" rectangle of 1.618. More importantly, these preferences depend on context. The particular aesthetic qualities of these rectangles, which are often based on arguments of logic, reason, harmony, and balance, are more appreciated in contexts, and for attributes, that tap into these domains. These findings could explain why prior literature on rectangular preferences has been inconclusive as it has usually studied preferences for abstract rectangles in a context-independent format.

These results using indirect measures of preference that improve both the internal and external validity of the effects, suggest that the golden ratio can have a subtle, yet strong effect on consumers' preferences, and intentions. Interestingly, a small proportion of market place offerings used the range of ratios between 1.5 and 1.7, even in the less frivolous categories. This suggests that the findings of this paper, far from being conventional wisdom in the industry, may be able to inform product designers and brand managers.

Our approach to studying the question of preferences utilizes indirect measures of preference that are either ecologically valid (*e.g.*, sales in Study 3), subtly elicited (*e.g.*, preferences and purchase intentions in Study 1), or disguised among other tasks (*e.g.*, size

preference is one of three different choices that people make in Study 2). All preferences were examined in the context of an actual product rather than the abstract, rectangular shapes, without a particular context as used in most studies of rectangular preferences in psychology and aesthetics. Such preferences are not only more externally valid for marketing purposes, but they are also less prone to laboratory demand effects (where participants may choose to respond in a manner to confirm or disconfirm what they believe the researcher is trying to show) that might be especially active if no context is supplied to participants. The indirect or disguised elicitation method that we employ is of key importance given the methodological critiques leveled against Fechner's original studies, and the lack of replicable results on the one hand (Green 1995; Höge 1995, 1997; Plug 1980), and the robustness of the preference for Φ in other aesthetic domains, on the other hand (summarized in Green 1995). We conjecture that the inability to show a preference for Φ in the lab using direct measures of preferences may be partially due to respondents' increased level of sophistication in the last century (*e.g.*, McManus 1980; Ohta 1999). Indirect methods of soliciting preferences allow for a subtler, internally valid, yet also a more ecologically valid set of conclusions. Future research could examine whether indirect versus direct methods of elicitation also relate to whether effects are subliminal versus conscious. It is plausible that subconscious appeals like aesthetic beauty are more likely to manifest in indirect tasks, while more conscious and cognitive processes like volume estimation may be better measured using direct tasks. Such research would be of interest given the growing interest among non-conscious processes in marketing (see Fitzsimons, et al. 2002 for a review).

In his theoretical review of the factors affecting "ideal product form," Bloch (1995) suggests that "Although there is some disagreement on this issue … neo-classical forms that rely on the Golden section have been some of the most enduringly popular architectural forms … it

could prove useful for managers involved with design decisions to be acquainted with Gestalt principles … firms may find it useful to include these considerations in their initial set of design constraints." (pp. 21-22).

The results of this research have implications for the aesthetic aspect of package and product design. Branded products particularly need to pay attention to the aesthetics of their package or the product itself. While recent work in consumer psychology has examined the effect of elongation on volume perceptions and consumption (Krider, Raghubir, and Krishna 2001; Raghubir and Krishna 1999; Wansink and van Ittersum 2003; Yang and Raghubir 2005), the domain of the aesthetic appeal of various shapes is new to marketing, albeit with a rich history in visual perception, art, architecture, and the study of aesthetic appeal. We hope that by demonstrating the applicability of work on rectangular preferences to the frequency of consumer product offerings, albeit in a contingent manner and involving a range of proportions rather than just the golden ratio, our findings will encourage researchers to explore the aesthetic appeal of packaging variables, including, but not limited to proportion, shape, color, font, relative salience, and other visual characteristics. A wide range of marketing scholars have made contributions to the study of aesthetics in the arts by exploring consumer behavior in marketing contexts ranging from music (Holbrook and Anand 1992, Holbrook and Huber 1983), to promotional material design (Zinkhan and Stoiadin 1984), with others making methodological contributions for the study of aesthetics (Holbrook, Greenleaf, and Schindler 1986). We hope this paper will spur future research in aesthetic appeal as an antecedent to brand image.

Another interesting managerial implication of our research is that companies can change the specific perceptions associated with their product by changing the shape of package, or by making the package shape salient within its context. Study 1 results, in a comparative domain,

showed that one offering was preferred over another as a function of its shape, although content was held constant. Further investigations of the changing impressions of a product subsequent to a product shape change are also offered as another area for future research.

We examined how perceptions relating to the construct of harmony are affected by the proximity of a ratio to the golden ratio of 1.62:1. Further research can examine whether sensory aspects of a product (*e.g.*, taste), or cognitive aspects such as prices that people are willing to pay, may also be similarly affected by package shape. Further, while we found support that the golden ratio rectangle increased certain product perceptions related to harmony, compared to the 1.38 rectangle, our domain was one that was conducive to harmony: a music concert. Future research needs to examine whether the results would replicate or reverse if the context was one of relative frivolousness (such as many Cajun restaurants that encourage an informal and fun atmosphere). The proposed model suggests that they would reverse, and the ratio of 1.62 would be less favorable than the ratio of 1.38 in such a context.

Our results examined how a single context, relatively more versus less frivolous, affects consumer preferences for rectangles. While this context is very relevant to the arguments proposed for why consumers prefer certain rectangles, other contexts, such as whether the product is used for utilitarian or hedonic purposes may also affect these preferences (see Chandon, Wansink and Laurent, 2000, for a discussion on how the efficacy of a particular type of sales promotion depends on the type of product for which it is offered). We believe that seriousness and frivolousness tap into the properties of harmony, proportion, balance, rationality, and mathematical beauty that have been suggested as the antecedents of aesthetic appeal. Thus, they translate into the shape of the rectangles prompting corresponding thoughts and states of mind in those who view them. This rationale suggests that a purpose or mental state that makes

these properties more important should tend to make viewers more sensitive to the special visual appeal of these rectangles. However, while we see evidence consistent with the idea that the distinction between the categories examined is serious/ frivolous; further research needs to explore the construct validity of this distinction.

Furthermore, we have not examined contexts that may affect how carefully or accurately consumers will process information regarding rectangular shapes. This processing could be affected by color, other shapes near the rectangles, or even the material the rectangle is made of.

Bloch's model also proposed that individual differences (due to culture, personality, experience) can moderate the effect of product shape on preferences. While we did not find that gender or product category experience moderated the effects in Study 2, given that there is prior support for individual differences in aesthetic responses (Holbrook 1987) this is offered as an area for future research. Differences in the age of consumers may also moderate preferences if people become less frivolous and more serious as they age, leading to their preferences getting more skewed towards the golden ratio across time.

Finally, in Study 1, we did not see a clear mediation path between perceptions of harmony and overall preferences, although preferences did percolate through to purchase intentions. Further research exploring the link between beliefs and preferences could examine whether this null effect is due to a more complex pattern of moderated mediation, or is simply due to low power.

Table 1

Study 1: Number of First and Last Choices for Rectangular Cards, by Ratio of Sides

	Less Frivolous Contexts			More Frivolous Contexts		
	Accounting	Piano	Total	Circus	Birthday	Total[1]
Number of First Choices						
1:1	10	7	**17**	23	34	**57***
1.13	8	8	**16**	17	18	**35***
1.26	26	18	44	19	25	44
1.38	30	32	**62**	22	14	**36***
1.5	29	24	**53**	13	15	**28***
1.62	10	13	**23**	7	4	**11***
1.74	3	9	**12**	2	2	**4***
1.87	4	5	9	8	3	11
2	4	8	12	12	8	20
Number of Last Choices						
1:1	31	28	**59**	13	7	**20***
1.13	8	17	25	13	5	18
1.26	4	2	**6**	9	8	**17***
1.38	0	3	3	3	3	6
1.5	3	4	7	6	5	11
1.62	7	3	10	6	7	13
1.74	4	8	**12**	12	11	**23***
1.87	16	15	31	13	18	31
2	51	44	95	48	59	107

1: * = Numbers in bold with asterisks indicate a proportion that is significantly different across the two frivolousness contexts at $p < .05$.

Table 2

Study 3: Regression Predicting Market Shares of Frequently Purchased Grocery Products Relatively More Frivolous (Cereal and Cookies) vs. Less Frivolous (Soaps and Detergents)

	Cereal and Cookies		Soaps and Detergents	
R^2	0.490		0.654	
Observations	20		17	
Overall *F*	5.12 (p = .013)		8.19 (p = .003)	
Parameter	β	*t* value, (prob(*t*))	β	*t* value, (prob(*t*))
Intercept	-2.19	-1.96 (.068)	-81.35	-4.04 (.0014)
Max/Mid	-1.23	-2.81 (.013)	63.55	4.00 (.0015)
Max/Min	0.998	3.76 (.0017)	-44.11	-3.86 (.0020)
Mid/Min	-1.31	-2.82 (.0122)	54.05	3.80 (.0022)

Figure 1a: Stimuli used in Study 1

Study of Music Tastes among Cal Students

Assume you have been mailed invitations to two concerts. The concerts will be held on a Saturday night during the term at 8:00 p.m.

These invitations appear on the next two pages. They are labeled "Concert A" and "Concert B."

While these concerts do not feature music you are familiar with, you have decided to listen to different types of music and want to attend concerts that are offered in your area.

Please read each of the invitation cards carefully, and then turn the page and answer the questions that follow.

Control Concert -- Ratio of 1: 1 (All participants were provided the same information for Concert A)

Concert A

Music of Indonesia: Songs Before Dawn

"Compelling...Fascinating musical smorgasbord from this cultural crossroads."

In the Banyuwangi region, located in the eastern end of Java, a vibrant and earthy musical genre called gandrung is performed. This tradition begins sometime around 9 p.m. and ends just before dawn. An unmarried female singer performs a beautiful suite of songs backed by a small ensemble of musicians who play violins and drums. The male guests at this dance pay money for the privilege of dancing with this mesmerizing songstress. Reticent yet dynamic, this call-and-response singing is accompanied by compelling rhythms played on percussion instruments that express and control the performance of the singers and dancers. This performance is by one of the music's finest living singers, Gadrung Temu. A recent review in the SF Chronicle called this "An enjoyable example of thoroughly contemporary and unusual exotica."

Target Concert -- Ratio of 1: 1.26 (Participants were provided this information in either this size or the size on the next panel)

Concert B

Dream Songs: Sounds of the Malaysian Rainforest

"Rhythms that lure you irresistibly away to the land of dreams."

The Temiar people of the central Malaysian rainforest are deeply spiritual. Inspired by their vibrant natural environment, they have developed a musical landscape that evolves from their dreams♔dreamsongs. Dreamsongs form the basis for community-wide singing and trance-dancing ceremonies, which celebrate marriages in Temiar society. Sophisticated and delicate, this music contains cherished and exquisite compositions performed with an enchanting mix of xylophones, gongs, cymbals, fiddles, guitars, and breathtaking vocals. Instrumental and vocal music of the Temiar draws listeners into a realm of ornate tonal variations and textured rhythms. The performance features Kam Maitrasangi, a master of the Temiar dreamsong technique. A recent review in the SF Chronicle called this "A good introduction to this highly passionate and expressive artform."

Target Concert -- Ratio of 1: 1.62 (The Golden Ratio; Participants were provided this information in either this size or the size on the previous panel)

Concert B

Dream Songs: Sounds of the Malaysian Rainforest

"Rhythms that lure you irresistibly away to the land of dreams."

The Temiar people of the central Malaysian rainforest are deeply spiritual. Inspired by their vibrant natural environment, they have developed a musical landscape that evolves from their dreams♔dreamsongs. Dreamsongs form the basis for community-wide singing and trance-dancing ceremonies, which celebrate marriages in Temiar society. Sophisticated and delicate, this music contains cherished and exquisite compositions performed with an enchanting mix of xylophones, gongs, cymbals, fiddles, guitars, and breathtaking vocals. Instrumental and vocal music of the Temiar draws listeners into a realm of ornate tonal variations and textured rhythms. The performance features Kam Maitrasangi, a master of the Temiar dreamsong technique. A recent review in the SF Chronicle called this "A good introduction to this highly passionate and expressive artform."

Figure 2: Results of Study 1

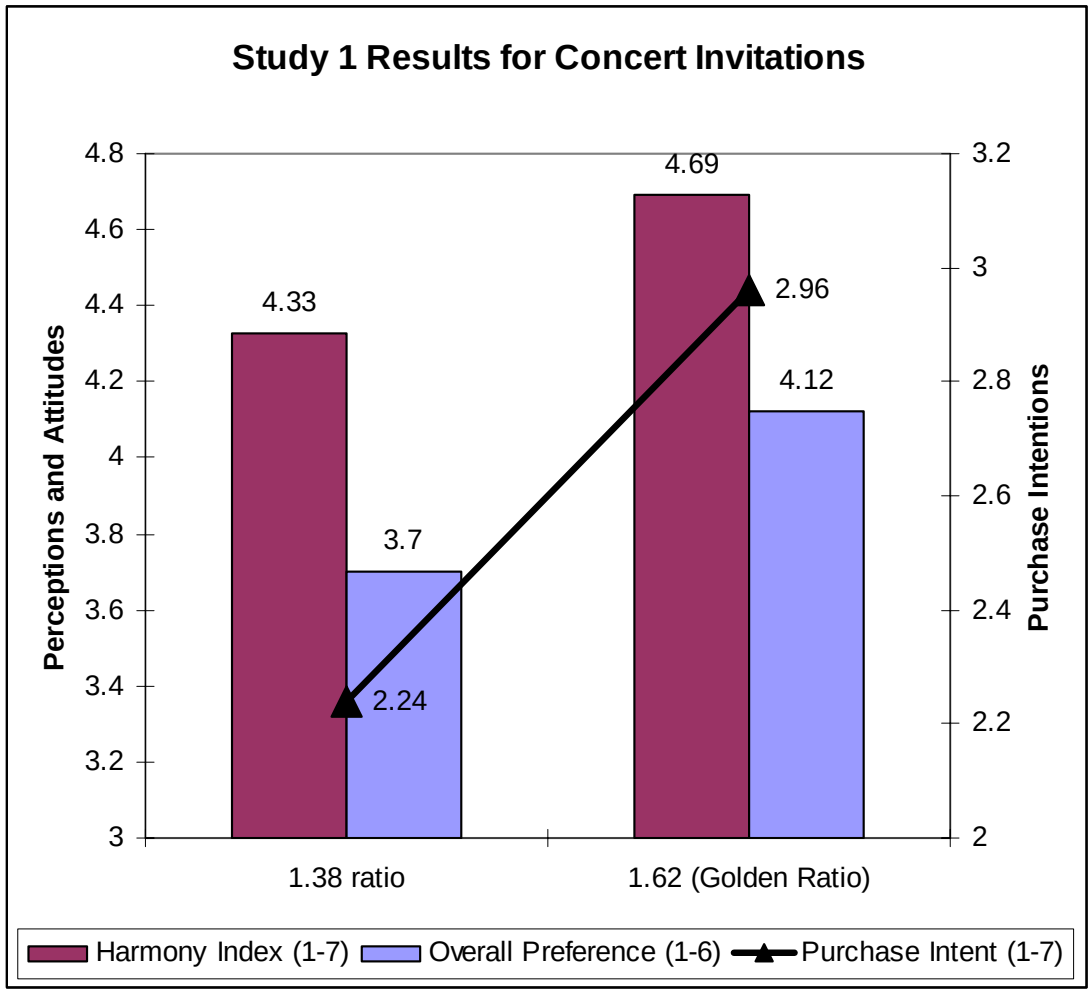

Figure 3: Study 1: Mean Preference Rating for Cards, by Shape and Context

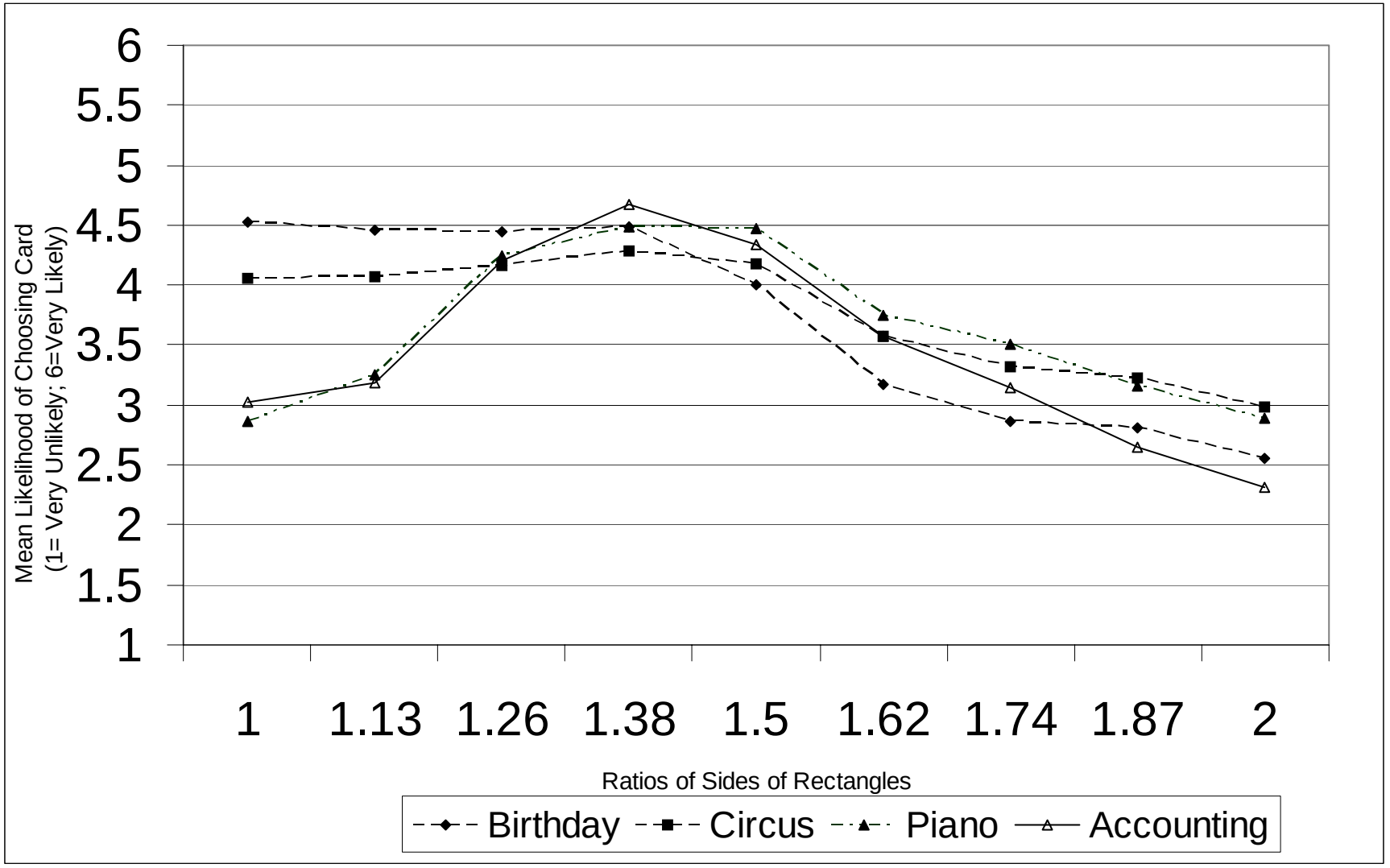

Figure 4: Examples of Products with different ratios tested in Study 3.

		SHARE (%)	HEIGHT (in.)	WIDTH (in.)	DEPTH (in.)	Max/Mid	Max/Min	Mid/Min	Area: HxWxD
ARM & HAMMER FABRICARE		3.96	10	11.19	6	1.119	1.865	**1.667**	671.40
WISK		2.32	7.75	8.81	5.19	1.137	**1.697**	1.493	354.36
ULTRA TIDE W/ BLEACH		5.49	8.63	10.88	6.31	1.261	1.724	1.368	592.47
ULTRA SURF		2.06	6.75	8.75	5.19	1.296	**1.686**	1.301	306.53
SURF		4.94	8.63	11.25	6.25	1.304	1.800	1.381	606.80
GAIN		12.94	8.13	11.25	6.31	1.384	1.783	1.288	577.13
CHEER		8.45	8	11.25	6.25	1.406	1.800	1.280	562.50
TIDE		36.01	6.06	8.69	5.06	1.434	1.717	1.198	266.47

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