

**THE GRANULARITY EFFECTS:
NUMERICAL JUDGMENT FROM A SOCIAL PERSPECTIVE**

by

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Abstract

In marketplace, information is communicated to consumers by marketers. Accordingly, judgments and decisions made in response to this information ought to be considered in their communicative context. Research in quantitative judgment typically fails to do so; it analyzes judgment and decision making in a social vacuum, essentially pretending that the quantitative information simply exists and comes from nowhere. In contrast, my research places quantitative judgment in its conversational context by investigating how people make inferences from the expression of a quantity. The theoretical basis of this research is built on Grice's (1975) logic of conversation, which suggests that information recipients interpret a piece of communication based on the assumption that the speaker provides as much information as is relevant while remaining truthful. A series of three essays addresses this issue.

In the first essay, I study how consumers draw inferences from a time estimate expressed at different levels of granularity. Consumers consider estimates expressed in finer granularity more precise and have more confidence in their accuracy. Hence, they perceive products as more likely to deliver on their promises when the promise is described in fine grained rather than coarse units. In the second essay, I find that precise numbers have a stronger influence on subsequent estimates than round numbers, in the way that people make small adjustment from the anchor when the anchor is a precise (vs. round) number. In the third essay, I argue that pragmatic inference is situated in the judgment task, so that the influence of numerical expression can go beyond quantitative judgment. In judgments of product value, precise statements of volume on a package give rise to the inference that the product is particularly valuable. Importantly, all these effects are eliminated when consumers doubt that the communicator complies with Gricean norms of cooperative conversational conduct. My dissertation concludes that there is more to “numeric cognition” than mere numbers – the numbers are communicated and we cannot fully understand their influence without taking communicative processes into account. It highlights the role of pragmatic inferences in consumer judgment and suggests important implications for the design of marketing communications.

Chapter 1: Introduction

Numbers are part of us. They are the basic element for measuring any magnitudes, and plays a crucial role in many aspects of consumers' everyday life, from price to product specifications, and from purchase planning to consumer budgeting.

How numbers are represented in our mind and how we use them are central to our curiosity about numbers. Scholarly pursuit of these questions has never stopped since the sixteenth century (Bernoulli 1738/1954). It has long been a tradition that these questions were approached from a cognitive and psychophysical perspective, as numerical input has been considered largely analogous to physical stimuli (Algom et al. 1996; Grewal and Marmorstein 1994; Dehaene, Dupoux, and Mehler 1990). Nevertheless, recent research suggests that the scope of how we think about numbers could be far broader: numerical perception is not only determined by the cognitive representations based on which the numbers are processed, but is also affected by the feelings elicited from processing them (Thomas and Morwitz 2009). Moreover, numbers in different presentations (e.g. round vs. sharp numbers) do not only differ in their perceived magnitudes, but could also trigger different levels of motivation (Pope and Simonsohn 2011).

In this dissertation, I introduce a new prospective to investigate how people think about numbers. Building on the theory of cooperative communication (Grice 1975), I study how numerical information presented in different forms conveys information about the communicator's knowledge and motives, which potentially affects the judgment of the target on which the numbers bear.

The first chapter of this dissertation is organized as follows. I will first briefly

review the literature on numerical perception from cognitive, psychophysical, affective, and motivational perspectives. Then, I will discuss the cognitive and the social basis that renders inferences from numerical presentations possible, and then briefly overview the chapters of this dissertation.

Different Perspectives on Numerical Perception

Numerical Perception from a Cognitive Perspective

Numbers are believed to be processed in dedicated cognitive subsystems (Ashcraft 1992; Dehaene 1992; McClosky and Macaruso 1995). In agreement with the notion of grounded cognition (Barsalou 2008), evidence has shown that these subsystems are grounded in different modal simulations, which give rise to different representations for numbers.

One of the representations places numbers on a mental number line, with small numbers resting on the left and large numbers on the right, referred to as the Spatial-Numerical Association of Response Codes (SNARC). Supporting this theory, research has shown that people respond faster to small numbers using their left hands, and to large numbers using their right hands, but slower the other way around. This effect holds no matter when the focal task requires judging the magnitude of the numbers or not (Dehaene et al. 1990; Dehaene, Bossini, and Giraux 1993). It has also been shown that SNARC is bi-directional, and has downstream effects in attention and judgment. For example, attention can be shifted to the left (vs. right) by small (vs. large) numbers (Fischer et al. 2003); numerical estimation can be biased by the spatial movement of either the perceiver (Eerland, Guadalupe, and Zwaan 2011) or the target (Cai, Shen, and Hui 2012). The spatial representation of numbers further predicts that the larger the difference between the magnitudes of the numbers, the larger the mental distance

between the numbers on the number line. Thus, people are faster distinguishing between numbers with greater difference than that between numbers with smaller difference (Duncan and McFarland 1980; Moyer and Landauer 1967).

Numbers have also been shown to be processed based on other representations. Numbers large in magnitude are associated with large physical sizes, as physical size and numerical magnitude overlap in the brain (Pinel et al. 2004). As a result, when printed in large fonts, number “9”, as opposed to number “1”, is faster to be identified than when printed in small fonts (Henik and Tzelgov 1982); numbers printed in large fonts are also judged to have a larger magnitude (Coulter and Coulter 2005). In addition to the number line and physical size, some other representations of numbers involve solving arithmetic problems of addition and subtraction (e.g. Roman numerals; Noel and Seron 1997), or visual-motor movements (e.g. beads arrangements on an abacus; Stigler 1984). Finally, for some people, the representation of numbers is also grounded in the sensory experience of colors, such that small numbers are associated with light colors and large numbers are associated with darker colors (Seron et al. 1992).

The cognitive perspective of numerical processing suggests that, when processing numerical inputs, individuals convert the input into one of these representations in an automatic and unconscious manner; which specific representation they take depends on the nature of the judgment task and the decision context.

Numerical Perception from a Psychophysical Perspective

Numerical input has been considered largely analogous to physical stimuli (Algom et al. 1996; Grewal and Marmorstein 1994; Dehaene et al. 1990). The comparison of numerical magnitudes typically displays a pattern that follows the Weber-Fechner Law. Specifically, the perceived difference between two numbers is proportional to the

magnitude of the numbers being compared. In line with this proposition, research has shown that, with the same absolute difference, the subjective difference between small numbers (e.g. 5 vs. 10) is perceived as greater than the subjective difference between large numbers (e.g. 155 vs. 160; Banks and Coleman 1981; Shepard, Kilpatrick, and Cunningham 1975). This evidence suggests that the perceived numerical distance is a joint function of both the absolute difference and the relative difference between the two numbers, or, more precisely, follows a log-Gaussian model (Dehaene 2007).

Numerical Perception from an Affective Perspective

The processing of numbers is not entirely based on the cognitive subsystems; people sometimes use heuristics and/or their feelings to form numerical perceptions as well. One of the consequences is that the perceived difference between two numbers does not necessarily reflect the actual difference between the numbers (or the log of numbers, per the psychophysical view). For instance, it has been widely observed in the pricing literature that prices ending with .99 are more attractive to consumers (Schindler and Kirby 1997). Thomas and Morwitz (2005) explain this effect by showing that consumers adopt a heuristic to form numerical judgment, namely, the magnitude of a number is largely determined by its left-most digit, so that the difference between 2.99 and 3 is perceived as larger than that between 2.98 and 2.99. In other research, the same authors identify that ease of computation also plays an important role in judging numerical differences (Thomas and Morwitz 2009). Specifically, the difference between two numbers is judged to be greater when it feels easier to compute (e.g. 5 - 4) than when it feels difficult to compute (e.g. 4.97 - 3.89). However, when experiment participants were forewarned that the following computation would be difficult, the difficulty in computation did not influence the subjective judgment of the numerical differences, presumably because the 4.97 - 3.89 did not feel as difficult as the participants had expected (Thomas and Morwitz 2009). This line of research suggests

that judgment of numerical information does not only rely on the cognitive representation of numbers, but is also influenced by the affective system.

Numerical Perception from a Motivational Perspective

Rosch (1975) suggests that round numbers serve as cognitive reference points for the sharp numbers close to it. For example, most people agree that “102 is essentially 100”, but not the other way around. Building on this notion, Pope and Simonsohn (2011) demonstrated that a round number is, by default, regarded as a goal; it motivates individuals whose current measure of performance is just below the round number to improve their performance, even though the round number is not explicitly set as a goal or attached to a direct consequence. For example, they find that professional batters are more likely to reach a batting average of .300 than .299, and high school students are more likely to retake SAT when their total score ends with “90” (e.g. 1190) than when their total score ends with “00” (e.g. 1200). This research suggests that round numbers differ from their close sharp numbers not only quantitatively (e.g. in their perceived magnitudes), but also qualitatively (e.g. in people’s motivation to achieve it).

The Cognitive and Social Basis of Inference from Quantities

Our brain pays more attention to the target when the target concerns small or round numbers, presumably because of our limited capacity of short-term memory (Dehaene 2011, p.100, 103). As a result, for the purpose of communication, encoding, or processing quantitative information, people prefer to present quantities in round numbers as long as the difference between the actual quantity (e.g. 96) and the rounded quantity (e.g. 100) is perceived small enough to be ignored in the given context. Similarly, people also prefer to present quantities in coarse units (which come with smaller numbers) when the difference between the actual quantity (e.g. 110 minutes)

and the converted quantity (e.g. 2 hours) is small enough to be ignored in the given context.

Given this idea, consider the following example in rounding. On the one hand, processing the round number 100 may require less cognitive resource than processing the sharp number 96. On the other hand, rounding 96 up to 100 will be at the price of precision. Therefore, using “100” to present an actual number of 96 will only occur in judgment contexts where the cost of ignoring the deviation of 4 is smaller or compatible to the benefit of rounding (e.g. saving cognitive resource). However, 96 will never be “rounded” to another sharp number, say 98, because although the perceived difference between 96 and 98 is even smaller than that between 96 and 100 (which means even smaller cost of “rounding”), there is no cognitive benefit to use “98” to present an actual quantity of 96. Or, using Rosch (1975)’s term, 98 is not a cognitive reference point for 96. Therefore, when a sharp number (e.g. “98”) is presented, the actual quantity could deviate from the presented quantity to a smaller extent than when a round number (e.g. “100”) is presented. In other words, *sharp numbers are more precise*.

A similar but slightly different logic applies to quantities expressed with units. The expression “1 kilogram” may present any quantities that are reasonably close to 1 kilogram, for example, 1.2 kilograms. And so does the expression “1,000 grams”. However, since processing a larger number (e.g. 1,000) needs more cognitive recourse than processing a smaller number (e.g. 1), presenting a weight as “1,000 grams” instead of “1 kilogram” only makes sense when the expression of “1,000 grams” is more informative than “1 kilogram”, which means less uncertainty, or smaller potential range of the quantities it may potentially represent. Therefore, when a quantity is expressed in a fine-grained unit, the actual quantity could deviate from the presented quantity to a smaller extent than when the same quantity is expressed in a coarse unit. In other words, *quantities expressed in a fine grained unit are more precise*.

However, there is an important presumption for the conclusions I made in the last two paragraphs, namely, a choice among different granularities of expressions is available. When a certain presentation in which a quantity is expressed is mandatory (e.g. in a system that 98 can never be rounded to 100), the presentation is no longer informative (e.g. “98” is no more precise than “100”). In other words, those conclusions could only be drawn in the context of numerical communication, where the communicator (usually) gets a choice of the numerical expression (i.e. rounding the number or not, converting to coarse units or not), and the recipients draw inference from the presentation they receive. For example, since less precise expressions may suggest a relatively large deviation from actual quantity, communicators often use them to describe the fact that they know that the actual quantity is, or may be, quite different from the presented quantity. Therefore, recipients who encounter such expressions will perceive uncertainty and less information from this communication.

In fact, the inference that information recipients could draw from the communicator’s intent behind their quantitative expression is consistent with the norms of cooperative communication (Grice 1975). The norms of cooperative communication require that communicators’ utterance should be truthful and, at the same time, relevant to the purpose of the communication. Thus, an expression low in the informational value (i.e. a less precise expression) could only suggest one of two things – either that the communicator does not know more and thus is not able to be more informative, or that any extra precision is irrelevant to the purpose of communication. Likewise, when an expression high in the informational value is used (i.e. a more precise expression), the recipients could infer that the communicator has sufficient knowledge and confidence about what s/he is talking about, *and* that the information communicated by the chosen precision is somehow relevant to the judgment task. Which of these two inferences will be made and how they will reflect on the judgment target depends on

the specific context of judgment, which will be further investigated in the rest of this dissertation.

Specifically, in chapters 2 and 3, I demonstrate that quantitative judgment can be affected by the expression in which the informational cues are presented. Specifically, in chapter 2, I show that information recipients believe that the communicator has more knowledge about and higher confidence in the estimate expressed in fine grained (vs. coarse) units, because the communicator should not have provided an expression with high informational value if s/he does not know that the potential deviation must be small or if s/he does not intent to convey extra information. This communicated certainty should result in higher confidence among recipients, reflected in narrower confidence intervals for about when an event will happen (e.g. repairing a car, developing a new product, life of a battery, etc.). In a similar vein, in chapter 3, I investigate how sharp vs. round numbers affect quantitative judgment when they serve as a numerical anchor. From the perspective of communication, I reinterpret findings that a sharp anchor leads to a stronger anchoring effect, which was initially demonstrated by Janiszewski and Uy (2008). While these authors suggest that sharp anchors create a fine grained mental representation of numbers, I show that people actually infer that presenting the anchor as a sharp number is necessary for the judgment task. Since sharp numbers suggest smaller deviation, people will conclude that the answer to the judgment task is close to the anchor, because otherwise a round anchor, which is easier to process, will do the job.

In chapter 4, I go beyond quantitative judgment and extend my investigation to cross-domain judgment. I show that consumers judge a product to have higher value if the product weight is expressed in a sharp (e.g. 9.7 oz.) rather than a round number (e.g. 10 oz.). Expressing the product weight in a sharp (vs. round) number conveys that the marketer guarantees that the actual weight of the product would not deviate much from

the expressed (sharp) weight. A reasonable interpretation behind marketer's intolerance against the potential variation of the weight is that the unit value of the product is high, such that small deviations in weight could lead to substantial differences in the total value of the product. Thus, when consumers make judgment about the product value, they infer high product value of from the sharp weight, and relatively low value from the round weight.

Across these three chapters, I also show that the effects are eliminated in cases where the conversational norms are violated, for example, when the communicator is non-human, when the communicator is considered not cooperative, or when there is no reason to assume that the potential inference from granularity would apply. The elimination of the effects provides strong evidence that the effect is caused by recipients' inference from the communication.

Chapter 2: Inferences from the Granularity of Quantitative Expressions

While talking with friends, you learn that your former boss has been sentenced for fraud. One of your friends thinks your boss received a jail term of “one year” and another friend reports that it is “366 days”. Who seems more knowledgeable about the details of the case? Similarly, suppose you want to order a custom made good. You ask the service representative how long your order would take if you placed it today. Would it make a difference if the representative answered, “one month”, “four weeks” or “30 days”? In both examples, the respective expressions refer to the same extension of time and are often used interchangeably. Nevertheless, recipients may perceive the speakers’ reports as differentially precise and reliable. The present research addresses this possibility and explores its consequences for marketing communications and consumer decision making.

We first place the issue in the context of Grice’s (1975) logic of conversation, which provides a conceptual framework for understanding how recipients arrive at different inferences from substantively equivalent speaker utterances. Next, we test three key predictions. First, we predict, and observe, that the granularity of the communicator’s quantitative utterance affects recipients’ confidence in the accuracy of the information. For example, study 1b asks consumers to place a time window around the completion date of a project by indicating the earliest and latest date at which they think the project may actually get done. This window, which resembles a confidence interval, shrinks with the granularity of the quantitative expression – thus, a completion time expressed as “one year” comes with a time window of 140 days, but this window shrinks to 84 days when the same time period is expressed as “52 weeks”. This effect presumably reflects that recipients draw pragmatic inferences from the form of a communicator’s utterance, consistent with the Gricean logic of conversation. If so, second, granularity

should only influence consumers' inferences under conditions in which they can assume that the communicator is cooperative, that is, follows Gricean norms of conversational conduct (Schwarz 1996). Empirically, this is the case. When the communicator's cooperativeness is called into question because the communicator either lacks relevant knowledge (study 2) or general trustworthiness (study 3), the otherwise observed effects are eliminated. This observation is incompatible with alternative interpretations of the influence of numeric expressions on consumer judgment, as discussed later. Consistent with their pragmatic inferences, consumers perceive products as more likely to deliver on their promises when the promise is described in fine grained rather than coarse terms, and choose accordingly (study 4). In combination, these studies contribute to our understanding of biases in quantitative judgment by drawing attention to the role of conversational inference processes. They highlight that substantively equivalent quantitative utterances can give rise to differential inferences depending on the communicator's choice of coarse or fine grained units and identify theoretical and applied implications.

Background

In everyday life, consumers encounter many quantitative expressions. Even when the values are precise and well-defined, consumers' understanding of quantitative expressions often deviates from their objective meaning. Previous research identified a number of cognitive heuristics that contribute to these biases (for a review, see Thomas and Morwitz 2009). As observed in other domains of judgment, however, biases are not solely a function of individuals' thoughts about the respective content domain or of the accessibility of applicable procedures. Instead, they often arise from tacit assumptions underlying the conduct of conversation, which license pragmatic inferences that go beyond the literal meaning of a speaker's utterance (for reviews, see Hilton 1995;

Schwarz 1994, 1996).

Logic of Conversation

These pragmatic inferences can be conceptualized in the context of Grice's (1975, 1978) logic of conversation. Grice, a philosopher of language, suggested conversations proceed according to a cooperativeness principle that is comprised of four maxims. First, a maxim of relation requires speakers to provide only information that is relevant to the aims of the ongoing conversation; hence, speakers' contributions come with a "guarantee of relevance" (Sperber and Wilson 1986), unless marked otherwise. Second, a maxim of manner encourages speakers to do their best to be understood by the recipient; this implies that utterances should not be more complex than needed for the task at hand. Third, a maxim of quantity asks speakers to provide as much information as the recipient needs, but not more and not less. Finally, a maxim of quality urges speakers to only say things they know to be true and accurate. All four maxims bear on how speakers should communicate quantitative information. Specifically, speakers should only provide truthful information (maxim of quality) that is relevant to the purpose of the conversation (maxim of relation) and they should do so in a manner that is easy to understand (maxim of manner) by providing the relevant level of detail, but neither more nor less detail than needed (maxim of quantity). Observance of these maxims is considered cooperative conversational conduct and most forms of uncooperative conduct involve violations of more than one maxim.

Violations of these maxims are common in everyday conversations, as Grice (1975) acknowledged. Nevertheless, a large body of linguistic and behavioral research (for reviews, see Clark 1985; Clark and Schober 1992; Levinson 1983; McCann and Higgins 1992; Schwarz 1996; Strack and Schwarz 1992) shows that recipients interpret speakers' utterances "on the assumption that they are trying to live up to these ideals" (Clark and Clark 1977, 122). Even when recipients doubt that the speaker is cooperative,

they first need to comprehend what the speaker intended them to infer before they can make meaningful corrections for the suspected intention to mislead (Gilbert 1991; Schwarz 1996), unless the statement pertains to highly accessible and specific knowledge of the recipient (Richter, Schroeder, and Britta 2009). Accordingly, Grice's tacit assumptions of cooperative communication govern the conduct of conversation in daily life and guide speaker's design of their own messages as well as listeners' inferences from these messages (Grice 1975; Levinson 1983).

The implications of Grice's (1975) logic of conversation extend beyond prototypical "conversations". Although Grice's initial analyses focused on personal conversations, later work showed that the maxims of cooperative conversational conduct guide pragmatic inferences in all communicative contexts (for a discussion, see Levinson 1983). In fact, their impact on recipients' interpretation of a speaker's utterance is particularly pronounced when no personal "speaker" is present. This is the case because presence of the speaker allows for queries and enables the collaborative negotiation of meaning when an utterance remains ambiguous (Clark and Schober 1982). Such opportunities are missing when the speaker is absent, which forces recipients to draw on general principles of conversational conduct and language use to infer what the communicator may have intended to convey. Accordingly, Gricean inference effects are particularly pronounced in settings that preclude the mutual negotiation of meaning as has been observed in standardized research settings, where experimenters and interviewers are often discouraged from providing explanations and where self-administered questionnaires are presented in the absence of any person who could be asked for clarifications (Schwarz 1995, 1996; Strack and Schwarz 1992). The same communicative constraint applies to most marketing communications, from product descriptions and reviews to company announcements and advertisements (Xu and Wyer 2010); throughout, they lack opportunities for consumer queries and hence encourage pragmatic inferences based on message and context characteristics. We acknowledge the impersonal nature of these "conversations" by referring to the participants as communicators and recipients, rather

than speakers and listeners.

Granularity Effects

The above reasoning implies that Gricean considerations will affect communicators' choice of the granularity in which they express quantitative information as well as recipients' inferences from this choice. In general, quantitative communications provide more information when the quantity is expressed in fine grained rather than coarse forms. This is most apparent when the information is communicated in form of an interval, for example, when a price estimate is expressed as "\$5,000 to \$6,000" or "\$1,000 to \$10,000". Here, the choice of interval width conveys the communicator's confidence in the accuracy of the estimate. Not surprisingly, recipients prefer narrow intervals, which provide more information. Moreover, they are willing to sacrifice formal accuracy for informational value. For example, when the true value is \$22.5 billion, 80% of participants prefer the estimate "\$18 to 20 billion" over the estimate "\$20 to 40 billion", even though the latter interval includes the correct value whereas the former does not (Yaniv and Foster 1995).

Whereas interval estimates convey the intended level of precision through the width of the interval, explicit precision information is missing when the communicator offers only one quantitative value, thus providing a point estimate. Nevertheless, recipients are aware that estimates come with a certain degree of uncertainty. Hence, you would not consider it misleading if a friend who is driving from another city said "I'll be there in two hours", even though she is aware that it may take her as little as one and a half hours or as much as two and a half hours to arrive. On the other hand, you might wonder what has happened to her if she told you in the same circumstance that she'll arrive "in 115 minutes", but has not yet shown up 30 minutes later. As this example illustrates, point estimates come with an implied interval and the size of this interval varies with the level of granularity in which the estimate is expressed.

Accordingly, cooperative communicators should satisfy the Gricean requests for simplicity, informativeness, and truthfulness by using a level of granularity that takes their own knowledge into account, conveying neither more nor less information than they can warrant.

We assume that recipients are sensitive to communicators' choice of granularity and take it into account when they interpret communicators' utterances. Hence, we predict (i) that recipients perceive the same quantitative estimate as more precise when it is expressed in fine grained rather than coarse units, resulting (ii) in narrower interval estimates (study 1). These effects should not be observed when recipients doubt that the speaker is a cooperative communicator. While many variables can undermine recipients' perceptions of a communicator's cooperativeness (Levinson 1983; Schwarz 1996), some are particularly relevant in the present context. The most germane variable is the perceived likelihood that the communicator's factual knowledge warrants the precision entailed in his or her utterance – does the communicator really know what he or she is talking about? A second relevant variable is the communicator's perceived general credibility – is there reason to believe that the communicator may be deliberately misleading? In either case, the assumptions of cooperative conversational conduct do not apply and recipients should hesitate to draw pragmatic inferences from the format of the utterance. This predicts, (iii) that the otherwise obtained granularity effects will not be observed when recipients suspect that the implied precision of the communicator's utterance exceeds the required knowledge (study 2) or that the communicator may not be trustworthy (study 3). Finally, consumers' pragmatic inferences are likely to have behavioral consequences. If the same estimate is perceived as more precise when conveyed in fine grained units, consumers should (iv) be more confident that a product delivers what it promises when the quantitative promise is expressed in fine rather than coarse units, affecting their product choice (study 4).

While we assume that these granularity predictions hold for all expressions of quantity, the present studies test them in the domain of time estimates. Consumers'

perceptions of time are an important element in many aspects of consumer behavior, from planning (Leclerc, Schmitt, and Dubé 1995; Ülkümen, Thomas, and Morwitz 2008) and waiting (Kumar, Kalwani, and Dada 1997) to service and product evaluation (Mogilner, Aaker, and Pennington 2008).

Related Work

Before we present our studies, it is worth highlighting how they differ from previous work that explored how the format of quantity expressions affects consumers' perceptions. Previous work showed that people judge the magnitude of a quantitative expression by focusing on foreground information (i.e., the number or the numerator) at the expense of background information (i.e., the unit or the denominator; Stone et al. 2003). For example, spending \$1 per day is perceived as a better deal than spending \$365 per year (Gourville 1998) and a gamble with a chance of 9 out of 100 is preferred to a gamble with a chance of 1 out of 10 (Pacini and Epstein 1999). Moreover, consumers judge prices in an unfamiliar foreign currency on the basis of their numeric face value and infer, for example, that a price of 1,100 Korean won is higher than a price of a 110 Japanese yen, despite their equivalence in U.S. dollars (Raghubir and Srivastava 2002). Similarly, people attend insufficiently to the format of a rating scale when judging the difference between two ratings and give a difference of 20 on a 100-point scale more weight than a difference of 2 on a 10-point scale (Burson, Larrick, and Lynch 2009). The latter effect is not limited to rating scales of differential length but also observed when two quantities are expressed in fine grained rather than coarse units (Pandelaere, Briers, and Lembregts 2011). For example, when choosing between two dish washers, a long warranty receives more weight when a fine grained unit results in a large numerical difference between the two warranties (e.g., 84 vs. 108 months) than when a coarse unit results in a smaller numerical difference (e.g., 7 vs. 9 years; Pandelaere et al. 2011). These and related studies share an interest in how numeric

values influence quantity estimates; they consistently find that higher values elicit perceptions of larger quantity with downstream consequences on judgment and choice. Different accounts have been offered for such numerosity effects, including anchoring (Tversky and Kahneman 1974), magnitude priming (Oppenheimer, LeBoef, and Brewer 2008), and the operation of a numerosity heuristic (Pelham, Sumarta, and Myaskovsky 1994; see Thomas and Morwitz 2009 and Pandelaere et al. 2011 for reviews).

In contrast, the present research emphasizes that the use of fine grained units does not merely result in higher numerical expressions, which can affect quantity estimation through several different pathways. Instead, the present research highlights that messages with fine grained units *also* convey a higher level of precision because cooperative communicators (Grice 1975) are not assumed to present information in a manner that is more precise than their knowledge warrants. Hence, consumers infer that the real value is closer to the communicated value when it is conveyed in fine grained rather than coarse units, unless they have reason to assume that the communicator may not be cooperative. This can result in circumstances where “higher numbers” (that is, more fine grained expressions) result in *lower* rather than higher estimates, as our studies will illustrate (studies 1-3). Such reversals are incompatible with number-focused accounts that predict numerosity effects in form of higher estimates in the context of higher numbers, as discussed above. Moreover, the reversals are only expected, and observed, under conditions where the communicator can be assumed to be cooperative (studies 2 and 3). In combination, these findings highlight that human judgment in a social context is a function of cognitive *and* communicative processes (Schwarz 1996; Sperber and Wilson 1986) and that thinking about quantities involves more than numbers. We return to these issues in the final discussion.

Study 1: Estimates of Precision

Study 1 tested the basic hypothesis: the same time expression is perceived as more precise when expressed in fine grained rather than coarse units. We measured the perceived precision of the estimate by asking participants to report their best and worst case estimates for the completion of a project, given the speaker's claim. In study 1a, participants provided these estimates in an open response format; in study 1b they marked the best and worst completion date on a calendar. On both measures, assumed low (high) precision results in a wide (narrow) time window around the speaker's claim, resembling a confidence interval.

Method

Study 1a. Two hundred and sixty-seven people were approached on the campus of the University of Michigan and asked to imagine that their car needed complicated repairs. Depending on conditions, the dealership estimated that obtaining the relevant parts and repairing the car would take “30 days”, “31 days”, or “1 month”. Participants were asked for their best and worst case estimates – that is the minimum and maximum number of days they might have to wait.

Study 1b. Ninety students taking an undergraduate marketing class read an announcement about a construction project. Depending on conditions, the expected duration of the construction project was described as “1 year”, “12 month”, or “52 weeks”. Next, participants were handed a calendar with the start date and the estimated end date of the project marked. They were asked to circle on the calendar the earliest and latest likely completion date, that is, their best case and worst case completion estimates, given the information they had.

Results and Discussion

In both studies, the unit in which the communicator expressed an otherwise identical estimate influenced participants' own time estimates: the more fine grained the unit, the narrower the recipient's time window (i.e., confidence interval) around the communicator's estimate.

Insert figure 1 about here

As shown in the top panel of figure 1, participants who were asked to provide best and worst case estimates of how long they would have to wait for their car (study 1a) indicated confidence intervals of 20.6 and 20.3 days around the speaker's estimate of 30 and 31 days, respectively. These two conditions did not differ from one another ($t < 1$), but were significantly smaller than the confidence interval of 24.8 days when the communicator's estimate was expressed as "1 month" ($t(266) = 2.42, p < .05$); this also holds for the underlying individual comparisons ($t(266) = 2.10$ for the contrast between 1 month and 30 days, and $t(266) = 2.27$ for the contrast between 1 month and 31 days, p 's $< .05$). Note also that each interval is composed of two component estimates (figure 1), one pertaining to how many days delivery may be ahead of schedule and one to how many days delivery may be behind schedule. Each of these component estimates was *smaller* when the communication provided high (30 or 31 days) rather than low (1 month) numbers, in contrast to the prediction of numerosity models.

Study 1b replicated this pattern with three levels of granularity (1 year, 12 months, 52 weeks) and a response format that did not require explicit numerical estimates of wait time. As shown in the bottom panel of figure 1, participants who were asked to check the earliest and latest plausible completion dates of a construction project on a calendar indicated confidence intervals of 140 days in the "one year", 105 days in the

“12 months”, and 84 days in the “52 weeks” condition; thus, the more fine-grained the unit, the smaller the confidence interval ($\beta = 27.8$, $t(88) = 3.24$, $p < .005$).

In both studies, recipients went beyond the literal meaning of the communicators’ utterances and attended to their choice of granularity in interpreting the meaning of time estimates. As predicted by Grice’s (1975) logic of conversation, they inferred higher precision of the estimate when the communicator expressed it in more fine grained units. Note also that recipients’ estimates reflected the common knowledge that projects of any type are more likely to be completed late rather than early (Kahneman and Lovallo 1993): independent of unit, their worst-case estimates deviated more from the communicators’ predictions than their best-case estimates. This observation implies that the use of coarse time units in marketing communications suggests more potential downside than potential upside to consumers: although coarse granularity in principle allows for earlier as well as later delivery dates, the likelihood of long delays will loom much larger.

Finally, it is worth noting that participants’ estimates involved “larger numbers” when the communicator’s message presented “small” (coarse granularity) rather than “large” (fine granularity) numbers, in contrast to what numerosity models would predict.

Studies 2 and 3: the role of Communicator Cooperativeness

The observed effects of granularity are consistent with Grice’s (1975) logic of conversation, which licenses inferences that go beyond the literal meaning of a communicator’s utterance. These inferences are based on the tacit assumption that the communicator is cooperative and presents information in a form that satisfies the maxims of conversational conduct. Once this assumption is called into question, recipients no longer rely on the form of the communicator’s utterances to interpret their meaning (Dodd and Bradshaw 1980; Schwarz, Strack, Hilton, and Naderer 1991; Smith

and Ellsworth 1987; for a review, see Schwarz 1996). Given that consumers are aware that companies have an incentive to influence them (Friestad and Wright 1994), one may wonder, however, whether they apply the cooperativeness assumption to marketing communications. The empirical answer is that they do, as the success of many misleading marketing communications illustrates (Boush, Friestad and Wright 2009). This is not surprising because acceptance of the cooperativeness assumptions is the default that underlies all communication in daily life – and even when we suspect misleading intentions we need to apply Gricean inferences to determine what the communicator wants us to conclude, before we can correct for it (Gilbert 1991; Schwarz 1996), unless the communicated message directly contradicts specific and highly accessible knowledge of the recipient (Richter et al. 2009). While many variables can undermine recipients' perceptions of a communicator's cooperativeness (Levinson 1983; Xu and Wyer 2010), two are particularly relevant in a marketing context, namely the communicator's likely topic-specific knowledge (study 2) and general trustworthiness (study 3).

Study 2: Communicator's Expertise

As seen in study 1, recipients assume that quantitative statements are more precise when they are expressed in fine grained rather than coarse units. The resulting estimation effects should be attenuated or eliminated when recipients suspect that the precision implied by the format of the communicator's message may exceed the communicator's actual knowledge. To test this prediction, study 2 attributed the message to a communicator who is vs. is not likely to have the relevant factual knowledge.

Method. One hundred and twenty-eight participants were recruited from an online subject pool and received a cash reward of 10 cents. The study followed a 2 (relevant

knowledge: given vs. questionable) X 2 (granularity: fine vs. coarse) between-subjects design. Participants read in an alleged news article that the world's largest car manufacturer is developing a new type of car based on cutting edge technology. The article reported that the new car would be released either in 2 years (coarse unit) or in 104 weeks (fine unit). To manipulate the communicator's perceived knowledge, half of the participants were told that the article was based on an announcement made by "the chief research officer of the company, who is well known in the industry for his strong project planning ability"; the other half was told that the news article was based on "a rumor spread by an auto fan website".

Subsequently, all participants were asked how likely it is that "the new car would be successfully launched to market as planned" (1= "extremely unlikely"; 7 = "extremely likely"). Next, they were asked, "If the launch of the new car took longer than planned, how many months do you think it would likely be delayed?"; they answered this question in an open response format in months.

Insert figure 2 about here

Results and Discussion. Our rationale predicts an interaction of granularity and source knowledgeability on the likelihood of on-time completion, which was obtained ($F(1,124) = 5.03, p < .05$). Diagnosis of this interaction shows that the granularity effects observed in studies 1a and 1b replicated when the news article was based on an announcement of the chief research officer. In this case, participants inferred that a timely launch was more likely when the article referred to "104 weeks" ($M = 4.0$) rather than "2 years" ($M = 3.3; t(126) = 1.74, p < .1$, for the simple effect). When the announcement was attributed to an auto fan website, the influence of granularity was eliminated ($M_s = 2.8$ vs. 3.4 for weeks and years, respectively; $t(126) = 1.42, p > .15$ for the simple effect).

Participants' open-ended estimates of how many months the launch might be delayed followed the same pattern. When the announcement was attributed to the chief research officer, participants predicted a longer delay in the 2-year ($M = 17.6$ months) than in the 104-week condition ($M = 9.6$ months, $t(126) = 2.82, p < .002$, for the simple effect after log transformation). When the announcement was attributed to an auto fan website, the influence of granularity was again eliminated ($M_s = 17.4$ vs. 13.8, for the 2-year and 104-week conditions, respectively; $t(126) < 1, p > .4$). This pattern is reflected in a marginally significant interaction of credibility and granularity ($F(1,124) = 3.03, p = .08$, after log transformation).

In sum, the previously observed granularity effect was only obtained when the communicator could be assumed to have the relevant knowledge. When the implied level of precision exceeded what the communicator was likely to know, participants' judgments were not influenced by the format of the utterance, consistent with the logic of a Gricean conversational analysis. This contingency is not predicted by other conjectures about possible underlying processes, such as differential semantic associations with the unit used (here, week vs. year) or some nonobvious effect of the numerical values (here, 2 vs. 104) themselves. Note also that participants again predicted a *shorter* delay when the use of fine categories resulted in a message with *larger* numbers, provided that they could assume that the communicator is cooperative; this runs counter to what an emphasis on the influence of numbers per se would predict. Study 3 provides an extended conceptual replication of these findings.

Study 3: Communicator's Trustworthiness

Study 3 manipulated the communicator's likely cooperativeness through general trustworthiness information. Depending on conditions, participants learned that a power company has been on Forbes' list of the "100 Most Trustworthy Companies" for the last 11 years or has repeatedly been found to "falsify financial records" over the last

11 years. In the context of a power outage, the company announced that power would be restored within “4 days” (coarse unit) or within “96 hours” (fine grained unit). Note that these announcements imply an unusually long power outage for U.S. customers (Apt, Lave, and Morgan 2006), whose usual experience is that power is restored faster. As seen in study 1, consumers bring such real-world knowledge to bear on time estimation tasks and more so when the message conveys low rather than high precision. They should therefore (i) perceive a higher likelihood that power will be restored ahead of time when a trustworthy company announces restoration “within 4 days” rather than “within 96 hours”; conversely, they should (ii) perceive a higher likelihood that power will be restored right on time when a trustworthy company announces restoration “within 96 hours” rather than “within 4 days.” In short, fine-grained units should result in a lower perceived likelihood of early project completion in study 3, just as they resulted in a lower perceived likelihood of late project completion in study 2. Finally, the predicted granularity effects should (iii) be attenuated or eliminated when the communicator is not trustworthy.

Method. Sixty-five participants (aged 18 to 68; female 62%) were paid \$10 for a one-hour study consisting of various unrelated tasks, in which the current study was embedded. The study adopted a 2 (source credibility: high vs. low) x 2 (granularity: high vs. low) x 2 (dependent variable: likelihood of completion ahead of time vs. likelihood of completion right on time) mixed design, with the first two factors manipulated between-subjects and the third factor within-subjects. Participants were told to imagine that a nearby power plant had an accident that resulted in a large power outage. The company promised to restore power within either “4 days” (coarse unit) or “96 hours” (fine grained unit). Half of the participants learned that the company “has been on Forbes’ list of ‘The 100 Most Trustworthy Companies’ for the last 11 years”, whereas the other half learned that the company “has repeatedly been found to falsify financial reports over the last 11 years”. After reading the scenario, participants were asked to estimate the likelihood that the power supply will be recovered within 3 days

[within 72 hours], that is, ahead of time, and the likelihood that it will be recovered on the 4th day [between 72 and 96 hours], that is, right on time. Both likelihood estimates were provided with slider bars on 60 mm scales placed in the middle of the screen. Note that there is no reason for the two likelihood estimates to add to 100 because it is quite conceivable that power will not be restored by the announced deadline.

Results and Discussion. Our rationale predicts that fine grained quantity expressions are perceived as more precise, which implies that power restoration should be more likely to occur *on time* rather than *ahead of time* when the communicator uses a fine grained rather than coarse unit. However, this inference should be more likely when the speaker is considered cooperative, paralleling the perceived likelihood of delayed completion in study 2. The results support these predictions (figure 3).

Insert figure 3 about here

Not surprisingly, consumers assumed that a trustworthy company is more likely to deliver on its promises than an untrustworthy one; hence they reported a higher likelihood that power is restored no later than the promised deadline (the 4th day or the 96th hour) for the trustworthy ($M = 68\%$) than the untrustworthy company ($M = 54\%$; $F(1,61) = 3.8, p = .055$, for the main effect of trustworthiness). More important, the predicted three-way interaction of granularity, trustworthiness, and judgment ($F(1,61) = 10.5, p < .005$) was obtained and was diagnosed with separate interaction contrasts under trustworthy and untrustworthy company conditions.

When a trustworthy company promised restoration “within 96 hours”, participants believed that there is only a 17% chance that the company would finish the job ahead of time (within 72 hours), but a 49% chance that it would finish the job very close to that time (in the 73 to 96 hours window) – presumably, the company used the precise

“96 hours” estimate for a reason. Participants’ estimates were more optimistic when the trustworthy company promised completion “within 4 days”, a less precise announcement that left more room for their real-world experience that power is usually restored faster. In this case, they believed that there is a 43% chance to have power restored early (within 3 days), which is significantly higher than in the fine-grained condition ($t(31) = 2.04, p < .05$); they further believed that there is a 26% chance to have it restored close to the communicated time (on the 4th day), which is significantly lower than that in fine-grained condition ($t(31) = 2.93, p < .01$). These differential effects are reflected in a significant interaction contrast of granularity and judgment ($t(61) = 4.1, p < .001$) when the communicator is trustworthy, replicating study 2. Further replicating study 2, the impact of granularity was eliminated when the company was untrustworthy ($t(61) < 1, p > .6$, for the interaction contrast; see figure 3 for means).

In combination, studies 2 and 3 highlight that the observed effects are not a function of “numbers” per se – they are a function of pragmatic inferences based on the choices made by a communicator. These inferences follow the Gricean logic of conversation and are only observed when recipients can assume that the communicator follows the maxims of cooperative conversational conduct. When this default assumption is drawn into question – for example, because the communicator lacks general trustworthiness (study 3) or lacks the relevant level of knowledge (study 2) – the otherwise observed granularity effects are eliminated. This contingency is not predicted by models of numerosity effects.

In addition, the obtained pattern of quantitative judgments does not follow the predictions of numerosity models, such as anchoring (Tversky and Kahneman 1974) or magnitude priming (Oppenheimer et al 2008) and their variants (see Thomas and Morwitz 2009; Pandelaer et al. 2011). All of these models predict that “higher numbers” result in higher estimates, which was not the case. Whether the higher numbers associated with more fine grained expressions of quantities result in higher or lower estimates depends on substantive nature of the message and the task. In studies 2 and

3, participants assumed that large deviations from the announced completion time were less likely when a trustworthy communicator expressed the intended time of project completion in fine grained rather than coarse units. In study 2, this resulted in estimates of longer completion times when the unit was coarse (and associated with small numbers) rather than fine grained (and associated with large numbers); in study 3, this resulted in estimates of longer completion times when the unit was fine grained (and associated with large numbers) rather than coarse (and associated with small numbers).

Finally, it is worth noting that fine-grained expressions of quantities can be more vivid and concrete than coarse expressions and can give rise to more concrete mental construals (Maglio and Trope 2011). From this perspective, granularity-elicited differences in the construal of the target may influence recipients' judgment. Studies 2 and 3 render this possibility unlikely. In these studies, granularity and possibly associated differences in vividness or concreteness were identical in the cooperative and uncooperative communicator conditions – yet granularity effects were only obtained when the communicator was cooperative.

Study 4: Impact on Choice

That fine grained expressions of quantity are perceived as more accurate has potentially important implications for product descriptions. Suppose you want to go on a hike that lasts about one and a half hour and you want to rely on a GPS device to find your way through the rough terrain. The local outfitter offers two devices that differ in their expected battery life and rental charge. Would the unit in which their battery life is expressed influence whether or not you rent the more expensive gadget to ensure a sufficient safety margin? Study 4 tests this possibility. We predict that consumers are more likely to infer that the product will deliver what it promises when the promise is expressed in fine grained rather than coarse units, and will choose accordingly.

Method

Study 4a: Estimate. Thirty-six participants from an online subject pool received descriptions of two GPS devices, whose battery life was described in hours or in minutes. One device had a battery life of “up to 2 hours” (“up to 120 minutes”) and the other a battery life of “up to 3 hours” (“up to 180 minutes”). Next, participants indicated their best guess of the devices’ actual battery life by moving slider bars along two 60 mm scales; the scales were labeled with “0” at the low end and with the respective “up-to” (i.e., 2 and 3 hours or 120 and 180 minutes, respectively) at the high end.

Study 2b: Choice. Eighty-four *different* participants, recruited from the same online subject pool, imagined renting a GPS device for a forthcoming hiking trip. The hike was described as a one-and-a-half hour (90-minute, respectively) trip in difficult terrain, “so having a GPS on during the entire trip is very important for completing the trip safely.” Participants were shown descriptions of two GPS devices offered for rent by a local outfitter. Depending on conditions, the duration of the hike and the battery life of both devices were expressed in minutes or in hours.

One device had a battery life of “up to 2 hours” (“up to 120 minutes”), weighted 300g, and was \$15 to rent; the other had a battery life of “up to 3 hours” (“up to 180 minutes”), weighted 400g, and was \$25 to rent. Participants’ choice of one of these two GPS devices served as the dependent variable.

Results and Discussion

Estimate. Not surprisingly, participants assumed that the actual battery life of GPS devices falls short of their producers’ “up-to” estimates (study 4a). More importantly, the extent of the expected shortfall depended on the granularity used in the product description. Participants estimated that a battery life claim of “up to 2 hours” would

translate into actual service of 1.49 hours (equal to 89 minutes), whereas a claim of “up to 120 minutes” would translate into actual service of 106 minutes. Similarly, they estimated that a GPS with a battery life of “up to 3 hours” would deliver 2.40 hours (equal to 144 minutes) of service, whereas a GPS with a battery life of “up to 180 minutes” would deliver 160 minutes. In sum, participants perceived the likely actual battery life as shorter in the “hours” than in the “minutes” condition ($F(1,34) = 5.68, p < .05$, repeated measures ANOVA).

This pattern replicates the results of studies 1-3; consumers again inferred that the likely actual value is closer to the communicated value when a (trustworthy) communicator uses a fine grained unit. Considered in isolation, the pattern of these ratings is also compatible with numerosity accounts that predict that higher numbers per se result in higher estimates; however, those accounts are not compatible with studies 1-3, where messages with larger numbers resulted in smaller estimates.

Choice. Based on the above estimates (provided by the participants in study 4a), a GPS device with a battery life of “up to 120 minutes” should seem a safer bet for a 90 minute hike than a device with a battery life of “up to 2 hours”, despite the numerical equivalence of the claims. Empirically, this is the case (study 4b). When battery life was described in minutes, 57% of the participants chose the 120-minute device over the more expensive 180-minute device. In contrast, when battery life was described in hours, only 26% of the participants chose the 2-hour device over the more expensive 3-hour device ($\chi^2(1) = 8.28, p < .005$).

Note that this large difference in choice was observed without drawing participants’ attention to the granularity of the speaker’s utterance. For all participants the duration of the hike and the battery life of the GPS devices were expressed either in minutes or in hours, thus avoiding any within-participant variation in units. Moreover, participants who made a choice (study 4b) were not asked to provide any estimates of the devices’ actual battery life – those data were provided by different participants in study 4a. Hence, our findings indicate that consumers who read product descriptions are sensitive

to the units in which a product's performance is described. Moreover, this sensitivity does not need external prompting beyond the desire to pick a product that serves one's needs.

Our desire to test consumers' spontaneous sensitivity to the granularity used by a communicator in a choice context required that the performance estimates and the choice data are not provided by the same participants. Accordingly, the above between-subjects data do not lend themselves to further within-subjects correlational analyses to determine mediation; instead, our argument rests on testing the logic of a causal chain in a series of cumulative experiments (for further methodological discussion see Spencer, Zanna, and Fong 2005; Zhao, Lynch, and Chen 2010).

General Discussion

In combination, the present studies identify a granularity effect in the communication of quantities and illuminate its implications for consumer judgment and decision making. We first summarize what has been learned and then turn to alternative accounts.

Pragmatic Inferences from Granularity

According to Grice's (1975) maxims of conversation, recipients assume that communicators provide information that is relevant, truthful and clear, which entails that their utterances are as informative as possible, but not more informative than their knowledge warrants. These tacit assumptions underlie the conduct of conversation in daily life (Grice 1975; Levinson 1983) and are at the heart of many biases and shortcomings in human judgment (Hilton 1995; Schwarz 1994, 1996). Drawing on these assumptions, consumers infer (i) that the same quantitative estimate is of higher

precision when it is conveyed in fine-grained (e.g., 104 weeks) rather than coarse (e.g., 2 years) units. This (ii) influences their confidence in the estimate as reflected in the width of the interval that they assume to contain the true value. When asked to estimate the earliest and latest likely completion date of a project, for example, consumers infer a narrower window of time when the speaker describes the intended completion date as “in 52 weeks” rather than as “in one year” (study 1).

If these effects are based on Gricean pragmatic inferences from the communicator’s message, they should be eliminated when the cooperativeness of the communicator is called into question (Grice 1975; Levinson 1983; Schwarz 1996). Consistent with this prediction, (iii) granularity only influenced consumers’ inferences when they could assume the speaker to have the knowledge required for a high level of precision (study 2) and to be generally trustworthy (study 3), but not otherwise. Finally, consumers’ pragmatic inferences from the granularity of a quantitative expression influence the decisions they make. Specifically, consumers are (iv) more likely to believe that a company or product will deliver on its promises when the promise is conveyed in fine-grained rather than coarse units (studies 1-4) and (v) choose accordingly (study 4b).

Not surprisingly, consumers bring additional real-world knowledge to the kinds of tasks presented in these studies. They know, for example, that projects are more likely to be delayed than to be completed early (Kahneman and Lovallo 1993; Kahneman, Lovallo, and Sibony 2011), and that companies have an incentive to present their products in a favorable light (Friestad and Wright 1994). The resulting interplay between real-world knowledge and pragmatic inference from granularity is apparent in figure 1. For example, when asked for the latest likely completion date of a project (study 1b), coarse granularity increases consumers’ estimates of likely delays from 52.3 days in the “52 weeks” condition to 96.8 days in the “one year” condition; however, it increases their estimates for possible early completion merely from 31.8 to 42.8 days. Clearly, consumers not only recognize coarse granularity as a way of hedging one’s claims, they also know in which direction a communicator is likely to hedge. This is

also apparent in study 4, where consumers' choices reflect the insight that battery manufacturers tend to exaggerate their product performance, especially when they report battery life in terms like "up to X hours". Hence, they inferred a shorter likely battery life in all conditions, but more so when a coarser granularity was used.

Alternative Accounts

Psychological research has identified numerous biases in quantitative judgment, which received particular attention in psychophysics (for a comprehensive review see Poulton 1989). Some of these biases found their way into the consumer literature, usually through work in behavioral decision making (for a review see Thomas and Morwitz 2009). Much of this work focused on the influence of numbers *per se*. It found that the presentation of higher numbers—either as part of the task or as part of a more or less incidental context—is likely to result in higher quantitative judgments, consistent with the anchoring heuristic (Tversky and Kahneman 1974) that inspired much of the research. Our results do not challenge the process assumptions that underlie models of numerical estimation *per se*; they merely highlight that forming a judgment on the basis of communicated numbers involves issues that go beyond numerical cognition.

From the perspective of numerical cognition, the important elements in the expressions "2 years" and "104 weeks" are the numbers "2" and "104". These numbers are assumed to affect estimates through anchoring or a related process, much as marking one's questionnaire with one's social security number results in higher estimates on unrelated tasks when the social security number has a high rather than low numerical value (Wilson et al. 1996). But this analogy misses crucial differences. Whereas the social security numbers in Wilson et al.'s (1996) classic study are incidental to participants' task and carry no unit of measurement, the expressions "2 years" and "104 weeks" (i) explicitly pertain to attributes of the target of judgment and are (ii) associated

with differentially fine-grained units of measurement. Hence, they differ not only in numerical value, but also in their conversational implicatures and the inferences these implicatures license. As long as the communicator can be assumed to be cooperative (Grice 1975), the more fine-grained expression conveys higher precision, which results in estimates of smaller likely deviation from the communicated value (studies 1-4). Whether a smaller likely deviation, in turn, leads to higher or lower absolute estimates depends on the nature of the specific task. These conversational influences do not arise when the numerical values are incidental and lack a unit of measurement, as in Wilson et al.'s (1996) anchoring study. Tasks with such characteristics presumably capture numerical estimation processes in a (relatively) pure form. Unfortunately, such tasks are rare in real-life consumer behavior, despite their popularity in consumer research. For other tasks, conversational inferences may enhance as well as impair the influence of numerical estimation processes. For example, the numerical component of the expression "104 weeks" may elicit a higher numerical estimate than the numerical component of the expression "2 years", but the influence of numerical estimation processes may be differentially constrained by the precision implied by the respective unit component. Future work may fruitfully develop paradigms that can identify the relative contributions of numerical and conversational processes. For now, the present studies highlight the importance of conversational inferences by documenting *reversals* that do not follow from models that focus solely on numbers: communications with *higher* numbers can result in *lower* estimates under conditions specified by Grice's (1975) logic of conversation.

Our conceptual analysis also suggests that some findings that have been confidently attributed to numerosity may have a conversational element. Recent results by Pandelaere and colleagues (2011) may serve as an example. Consistent with earlier work (e.g., Burson et al. 2009) they find, for example, that the difference between 704 and 903 on a 1000-point scale is perceived as larger than the difference between 7 and 9 on a 10-point scale, even though the opposite is the case (albeit by a miniscule one

per mille; $2/10 > 199/1000$). However, participants receive more information than the mere numbers – they are also told that these numbers represent ratings of the likelihood with which two different surgical procedures are successful. From a conversational perspective, this information is not irrelevant to the meaning of the numbers. The 10-point scale asks raters to differentiate at the level of deciles (where a 7 may represent a perceived success rate between 65% and 75%), whereas the 1000-point scale asks raters to differentiate at the level of 1/10 of 1 percent. As our findings show, recipients are sensitive to such differences in implied precision and assume that cooperative communicators would not use a granularity that is more precise than their knowledge allows. This underlies the influence of granularity on the width of confidence intervals (study 1). It also suggests that the confidence intervals around values of 7 or 9 are larger than the confidence intervals around values of 704 or 903, which would itself contribute to the perception that the former difference is less reliable than the latter and should therefore carry less weight. Hence, numerosity effects (higher numerical estimates when high values are presented), granularity effects based on conversational inference (narrower confidence intervals around the communicated value when fine-grained units are used) or both may contribute to the findings reported by Pandelaere and colleagues (2011). Moreover, their relative contribution may vary depending on the specifics of the task.

In other work, Monga and Bagchi (2011) noted that people usually use large units to communicate large quantities and small units to communicate small quantities, a convention that is consistent with Gricean (1975) conversational norms. Hence, units come with associated expectations that can run counter to the predictions of numerosity models. For example, Monga and Bagchi's (2011) participants inferred that it takes more resources to complete a building when its height was expressed in floors rather than feet, in contrast to what numerosity models would predict on the basis of the respective number of floors vs. number of feet. This influence of unit choice was only observed when the unit was more salient than the respective number, which itself can

be a function of task framing, construal level, and many other variables (Monga and Bagchi 2011).

As this discussion indicates, the exploration of how consumers think about quantities would benefit from a broader perspective that replaces the currently dominant focus on numbers per se with a consideration of the interplay of numbers and units in context. Explorations of this interplay require procedures that are sensitive to the situated and goal directed nature of human cognition (Smith and Semin 2004) and the conversational implicatures of research procedures (Bless, Strack, and Schwarz 1993; Schwarz 1994, 1996). A final example may illustrate this point: One account of numerosity effects holds that people focus on the numbers and ignore the units in which they are expressed (Stone et al. 2003). Testing this possibility, Pandelaere and colleagues (2011) drew some participants' attention to the fact that the same quantity can be expressed in different units; as predicted, this eliminated the influence of large vs. small numbers. This is consistent with the assumption that participants did otherwise not attend to the unit; but it is also compatible with a more general conversational analysis. As a default, people assume that the format of an utterance is tailored to the communicator's pragmatic intentions, which leads them to infer more precision from more fine-grained units (present studies) or larger quantities from larger units (as discussed by Monga and Bagchi 2011). Neither observation implies that people are unaware that expressions with different units can be numerically equivalent – they merely assume that a given unit is chosen for a reason. This assumption is undermined when they are asked to provide several magnitude ratings of the same quantity expressed in different units (Pandelaere et al. 2011), which conveys that units are exchangeable in the present context and the choice of one over another does not carry pragmatic information (for related findings and discussions see Igou, Bless, and Schwarz 2002; Schwarz 1996). Hence, the manipulation both highlights the equivalence of quantities *and* undermines the conversational implicatures of units, again rendering it difficult to determine the relative contributions of different processes.

In a similar vein, our own observation that conversational inferences *can* be undermined when the communicator is explicitly presented as unknowledgeable (study 2) or untrustworthy (study 3) is silent on how sensitive consumers are to such conversational variables in the wild, rendering it difficult to estimate the likely relative contribution of different processes under naturalistic conditions. In short, there is more to quantitative judgment than numbers or units alone and future research may fruitfully explore the interplay of numerical and conversational processes in context.

Implications for Marketing Communication

Our findings have important implications for marketing and public relations communication. Objectively equivalent quantities take on differential meaning when expressed at different levels of granularity. Accordingly, the choice of granularity needs attention. Consumers infer low precision from coarse granularity. Depending on circumstances, low precision may be perceived as a lack of knowledge or as deliberate hedging, with the latter suggesting that the firm may actually expect not to meet its promises. Neither is beneficial for the image of a firm, and objective uncertainty is probably better acknowledged explicitly. Note, however, that these considerations do not suggest that fine-grained quantity expressions are always preferable. When the level of granularity is finer than the communicator's likely knowledge warrants, it undermines the credibility of the claim and possibly the trustworthiness of the firm. Future research may address the proper tuning of granularity in the communication of quantities, shedding light on the interplay between numeric cognition, pragmatic inferences, and consumers' knowledge about the market place.

Chapter 3: The Power of Precise Numbers

Suppose two sports fans tell their friends about a marathon race. One reports the winner's completion time as 2h 48min, whereas the other reports it as 2h 48min 2.92sec. Whose friends are more likely to infer that the race was tight? Supporting your likely intuition, 82% of the participants in a pilot study (N = 45) believed that the second report is more likely to convey that the runner-up finished closely on the winner's heels. Different processes may contribute to this impression. First, listeners may assume that the speaker's level of precision conveys relevant information – why would a speaker report on split seconds if the race was won by minutes? This intuition is consistent with Grice's (1975) maxims of conversation, which entail that speakers should provide all the information that is relevant to a task, but not more (nor less). Second, theorizing in numerical cognition (Janiszewski & Uy, 2008) suggests that more precise expressions of quantities are represented along more fine-grained mental scales. Mapping a given subjective difference onto a more fine grained scale, say a scale of split seconds rather than minutes, gives rise to smaller estimates of objective difference, also resulting in the impression of a tighter race between the winner and runner-up. These accounts are not mutually exclusive. Mental representations of fine-grained numbers are indeed likely to differ from mental representations of coarse-grained numbers – yet no detailed representation needs to be formed when the precise number seems uninformative to begin with.

Numerical cognition and the logic of conversation

In everyday life, conversational conduct is guided by tacit norms of cooperative communication (Grice, 1975). A maxim of relation requires speakers to provide only information that is relevant to the aims of the ongoing conversation; a maxim of manner

encourages them to do their best to be understood by recipients, which implies that utterances should not be more complex than needed; and a maxim of quantity asks speakers to provide as much information as recipients need, but neither more, nor less. Finally, a maxim of quality urges speakers to only say things they know to be true and accurate. Although violations of these maxims are common in everyday conversations, linguistic and behavioral research (for reviews, see Hilton, 1995; Levinson, 1983; Schwarz, 1994) shows that recipients interpret speakers' utterances "on the assumption that they are trying to live up to these ideals" (Clark & Clark, 1977, p. 122).

Empirically, communicators and recipients observe these tacit norms. Compared to coarse expressions (e.g., one year), fine-grained expressions (e.g., 12 months) are more likely to be used when communicators have confidence in what they say (Goldsmith, Koriat, & Weinberg-Eliezer, 2002; Yaniv & Foster, 1995). Recipients, in turn, consider fine-grained expressions more precise and are more likely to rely on what they convey (Zhang & Schwarz, 2012). When the communicator's cooperation, expertise or trustworthiness are called into question, the granularity of the expression ceases to be informative and does not influence recipients' judgments (Zhang & Schwarz, 2012). The same logic should apply to precise (vs. rounded) numbers: their use is only consistent with cooperative conversational conduct when the implied level of precision is warranted and useful for the task at hand.

Implications for judgment

Janiszewski and Uy (2008) reported more pronounced anchoring effects when the anchor was presented with a high (e.g., 3.998 or 4.002) rather than low (e.g., 4) level of precision. Given the very small difference of 0.002 between these anchor values, their differential effect is difficult to derive from the two process models that account for the bulk of anchoring effects, namely the selective accessibility model (Strack & Mussweiler, 1997) and the anchor-and-adjust account (Epley & Gilovich, 2001).

Complementing a numerical anchor-and-adjust explanation, Janiszewski and Uy (2008) suggested that more precise anchor values are mapped onto more fine-grained subjective representational scales than less precise anchor values. This difference in the underlying representation can result in differential anchoring effects because “X units of adjustment along a fine-resolution scale (...) cover less objective distance than the same number of units along a coarse-resolution scale” (Janiszewski & Uy, 2008, p. 121). From a conversational perspective, the observed advantage of precise over rounded numbers should be limited to conditions where the speaker is assumed to be cooperative. We tested this prediction in two studies, using different strategies to vary the pragmatic implicatures of the numbers presented to participants.

Study 1

Participants in Study 1 (modeled after Janiszewski & Uy, 2008, study 1) were told how much a retailer charges customers for a DVD player; the price was given as \$29.75 or \$30, which served as the precise or rounded numeric values. To manipulate perceived communicative intent, the price was allegedly conveyed by the retailer or by a computer program that samples prices at several retailers and reports the average price. Previous research (Schwarz, Strack, Hilton, & Naderer, 1991) showed that messages from a human communicator are attributed more communicative intent than automated messages; hence, number precision should influence judgment under human communicator conditions more than under computer message conditions.

Method

In an online study, 112 U.S. participants recruited from Amazon Mechanical Turk read a scenario modeled after Janiszewski and Uy (2008, Study 1). They were asked to estimate what retailers pay for a DVD drive that is currently offered to

consumers at the price of \$29.75 (*precise number*) [or \$30 (*round number*), respectively]. For half of the participants, these numeric values were presented as the current price of the DVD drive “at a major retailer”. The other half was told that the computer would determine the average price at three retailers of the participants’ choice. Next, they selected three retailers from a list of five major online retailers and the computer program allegedly calculated the average price of the drive at the chosen retailers; during this time the screen displayed the message, “Fetching price data and calculating.” After a few seconds, the message changed to “Based on your selection, the average retail price of this DVD drive in these stores is \$29.75 [\$30].” Finally, all participants provided their best estimate of the retailer cost of the DVD drive.

Results and discussion

Analysis of variance revealed the predicted interaction of communicator and number precision, $F(1, 107) = 4.5, p < .04$. When the retailer provided the store’s retail price, participants estimated that the retailer’s cost is $M = \$8.2$ ($SD = 5.0$) below the round retail price of \$30, but only $M = \$4.7$ ($SD = 3.4$) below the precise retail price of \$29.75, $F(1, 107) = 6.5, p < .02$, for the simple effect; $d = .82$. This influence of number precision replicates Janiszewski and Uy (2008). It was not observed when the retail price was determined by a computer program, whose output is presumably void of communicative intent. In this case, participants estimated that the retailers’ cost is $M = \$7.6$ ($SD = 5.1$) below the round, and $M = \$8.1$ ($SD = 5.4$) below the precise retail price, $F < 1, d = .1$.

From a conversational perspective, the number participants received conveyed most information when it was precise (\$29.75) *and* provided by a cooperative human communicator. Consistent with this prediction, this condition differed reliably from all other conditions, $t(109) = 2.95, p < .005, d = 1.30$, which did not differ from one another, $F < 1$.

In sum, precise numbers elicited smaller adjustment than round numbers, but only when they were intentionally chosen by a human communicator rather than calculated by a computer program. This is consistent with earlier findings that indicate that human communicators are assumed to observe Gricean maxims of conversation in tailoring their message, whereas computational algorithms are not (Schwarz, 1994).

Study 2

Even in the case of human communicators, however, task characteristics can render the same level of detail differentially relevant. To return to our introductory example of a marathon race, pilot study participants inferred from numeric precision that the race was tight, indicating that people consider split seconds relevant to the distance between the winner and the runner-up, but not to the distance between the winner and the stragglers. If so, the precision with which the time of the winner is conveyed should affect performance estimates of close competitors but not of distant competitors. This does not imply, however, that information about the performance of the winner is without any informational value for the performance of much worse placed runners – learning, for example, that it took the winner more than 4 hours to complete the race might suggest that it was held under particularly difficult conditions. Hence, the absolute value of comparative information may influence estimation even when the precision of this information is deemed irrelevant.

To test these predictions we presented information about the shooting percentage of the 5th ranked player in the National Basketball Association (NBA) in a precise vs. rounded format and assessed its impact on estimates of the shooting percentage of the 8th ranked vs. the 108th ranked player (Study 2a). We predicted that the precision of the information about the 5th ranked player (round vs. precise numbers) would affect estimates of the 8th ranked player, but not of the 108th ranked one. This does not entail,

however, that drawing the pragmatic relevance of precise numbers into question is sufficient to eliminate the influence of comparison values in general; it merely entails that precise numbers do not exert more influence than round numbers under these conditions. Accordingly, Study 2b compared participants' estimates of the shooting percentage of the 108th ranked player after they received information about the shooting percentage of the 5th ranked player in either a precise or rounded format or received no information. We predicted that comparison information about the 5th ranked player would influence estimates pertaining to the 108th ranked player, but that this influence would be independent of numeric precision.

Method

Study 2a. Participants (N = 104; mostly undergraduate students) received \$10 for a 1h questionnaire session that included unrelated tasks from several investigators. For the present study, they were asked to guess the shooting percentage of an NBA player given the percentage of another player (adapted from Janiszewski & Uy, 2008, study 1). Following a 2 (precise vs. round number) x 2 (high vs. low relevance) between-participants design, they read: "NBA's 2011-2012 field goals leaders' board ranks 110 leading players' shooting percentage in the league. LeBron James from Miami Heat currently ranks No. 5 on the list. His shooting percentage is 50.2% (*precise*) [50% (*rounded*)]." Next, participants were asked to guess the shooting percentage of Steve Nash, who "currently ranks No. 8 on the same list" (*high relevance*) or of Carmelo Anthony, who "currently ranks No. 108 on the same list" (*low relevance*).

The estimates of 6 participants exceeded the shooting percentage of the 5th ranked player, indicating that they did not understand the task; the estimates of 3 participants deviated by more than three standard deviations. These 9 participants were removed, leaving 95 participants in the analysis.

Study 2b. Undergraduate students (N = 70) taking introductory marketing classes

participated for course credit. As in Study 2a, some were told that the shooting percentage of the 5th-ranked James was either 50.2% (*precise*) or 50% (*rounded*) before they estimated the shooting percentage of the 108th-ranked Anthony, whereas others received no information about James (*control*).

Results and discussion

Study 2a. In the high-relevance condition, the shooting percentage of the 8th-ranked Nash was estimated as 47.3% ($SD = .02$) when the performance of the 5th ranked James was described with a precise number, but as 41.0% ($SD = .07$) when it was described with a round number; $F(1, 91) = 4.9, p = .03, d = 1.27$, for the simple effect. Precision exerted no influence under low-relevance conditions. The shooting percentage of the 108th-ranked Anthony was estimated as 27.9% ($SD = .11$) under precise and 32.0% ($SD = .13$) under round number conditions, $F(1, 91) = 2.3, p > .1, d = .34$, for the simple effect. This pattern is reflected in the predicted interaction of number precision and relevance, $F(1, 91) = 6.9, p = .01$. In short, the influence of number precision was eliminated when the nature of the task rendered the pragmatic implications of precise numbers irrelevant. However, one might wonder whether this manipulation eliminated the influence of comparison information overall, rather than merely the influence of its precision. Study 2b addresses this issue.

Study 2b. Replicating Study 2a, the precision with which information about the 5th ranked James was conveyed did not influence participants' estimates of the 108th ranked Anthony's shooting percentage (M 's = 32.5% and 34.0%, $SD = .11$ and $.11$, under precise and round number conditions, respectively; $t < 1, d = .14$). However, both of these conditions differed significantly from the no-anchor control condition, where Anthony's shooting percentage was estimated to be 42% ($SD = .14$), $t(68) = 2.9, p = .005, d = .71$. Thus, information about the 5th ranked player influenced participants' estimates of the performance of the 108th ranked player, yet the precision of that

information was irrelevant under these conditions.

General Discussion

In sum, participants' estimates were more strongly influenced by quantitative information that was conveyed in precise rather than round numbers, consistent with previous research (Janiszewski & Uy, 2008). However, an increased impact of precise numbers was only observed when the message came from a human communicator (Study 1), whose choice of quantitative expression could be assumed to reflect communicative intent, and pertained to a task where fine-grained distinctions were relevant (Study 2). These findings extend the pragmatic analysis of the granularity of quantitative expressions (Zhang & Schwarz, 2012). Our previous work showed that the same objective quantity is perceived as more precise and reliable, and exerts more influence in judgment and choice, when it is expressed in fine-grained (e.g., 120 minutes) than in coarse (e.g., 2 hours) units. The present findings extend this observation to precise vs. round numbers as indicators of precision. More important from a social psychological perspective, the precision of a communicator's expression ceases to exert an influence when the communicator's cooperativeness (Grice, 1975) is called into question, either because the communicator is not human (Study 1) or the level of precision is inadequate for the task (Study 2). This extends previous observations that precision fails to exert an influence when the communicator is seen either as generally untrustworthy, self-interested, or incompetent in the domain of judgment (Zhang & Schwarz, 2012).

From a broader perspective, our findings are consistent with a familiar truism: information that is considered relevant and diagnostic for the task at hand is more influential than information that is not. Nevertheless, even information that is recognized as irrelevant can influence judgment, e.g., by changing the accessibility of related information (Higgins, 1996). This tension also applies to anchoring effects in

quantitative judgment. On the one hand, anchors are more influential when they seem relevant to the task at hand; on the other hand, this relevance is not always needed to obtain an anchoring effect. For example, incidental numbers are more influential anchors when researchers follow Tversky and Kahneman's (1974) original procedures by explicitly relating the anchor to the estimation task ("Is X larger or smaller than this number?"), which renders the anchor conversationally relevant (Wilson et al., 1996). On the other hand, anchoring effects of a smaller magnitude can be obtained without such conversational links (Wilson et al., 1996) and under conditions where the implausibility of the anchor is likely to undermine its conversational relevance (e.g., Mussweiler & Strack, 2001). In combination, such findings illustrate that quantitative judgment is subject to cognitive as well as conversational processes, highlighting the need to consider the interplay of both (Schwarz, 1996).

Chapter 4: Cross-dimensional Consumer Inference from Quantitative Expressions

In the marketplace, information about a product is rarely complete, even when the marketer does not intend to conceal. When making judgments and decisions, consumers usually need to draw on available information to make inferences about the product on missing attributes, such as quality and overall value (Deval et al. 2013; Gunasti and Ross 2009; Kardes, Posavac, and Cronley 2004; Zeithaml 1988). These inferences are made based on consumers' knowledge about the product, the marketplace, and the marketers, following the rules of physics, economics, and communication. For example, product with high price is often believed to have high quality as consumers assume an interplay between the supply and demand forces in the market place (Broniarczyk and Alba 1994; Rao and Monroe 1989); similarly, consumers favor unusual color or flavor names as they infer that messages communicated by marketers convey useful information (Miller and Kahn 2005).

In the current research, we propose and show that consumers infer product value through the numerical expression of product weight/volume. Product weight/volume expressed in a sharp (vs. round) number leads to an evaluation of higher (vs. lower) product value. For example, in study 1, participants estimate the price of a bottle of essential oil to be higher when its volume is 97ml or 103ml than when its volume is 100ml. Different from most previous research where the cognitive representation and processing of numbers are considered as the main drivers of numerical judgments (see Dehaene [2011] and Thomas [2009] for reviews), we argue from a social perspective that the observed effect is a result of consumer inferences from the marketer's choice of communicating the weight in a sharp (vs. round) number. Supporting this claim, the effect is only observed when the inference is considered relevant and applicable to the

target of judgment (study 2), and when the numerical expression reflects the communicator's choice (study 3 & 4).

Background

Classic economic perspective would predict that very close quantities have similar utility and would lead to similar judgments. Previous research in pricing and numerical cognition, however, has demonstrated all kinds of violations. It suggests that numerical perception is not solely a function of the conveyed magnitude, but also determined by the granularity in which the quantity is expressed. A large body of research has demonstrated that quantities with same or very similar magnitudes can differ in terms of their *perceived magnitudes* when expressed in different granularity (Burson, Larrick, and Lynch 2009; Gourville 1998; Monroe 1973; Schindler and Kirby 1997; Thomas and Morwitz 2005). For example, \$2.99 is perceived as significantly lower than \$3 (Thomas and Morwitz 2005), and the difference of 23 per thousand is perceived as greater than the difference of 2.3 per hundred (Burson et al. 2009).

Another line of research investigates how the judgment of a quantity is affected by the granularity of a *related* quantity on which the focal judgment is based (Janiszewski and Uy 2008; Mason et al. 2013; Zhang and Schwarz 2012, 2013). It has consistently demonstrated that a number would be judged to be closer to a given number when the given number is expressed on a fine grained (vs. coarse) scale. For example, the actual time needed for a project is believed to be close to the estimated time when the estimate is made in fine vs. coarse units (e.g. 52 weeks vs. 1 year; Zhang and Schwarz 2012). Similarly, anchors expressed in sharp numbers leads to smaller adjustments in anchoring and adjustment tasks (Janiszewski and Uy 2008; Zhang and Schwarz 2013), and initial offers made in sharp numbers lead to closer counteroffers (Mason et al. 2013).

All of these lines of research are focused on how numerical expressions influence judgment of numerical magnitude. An interesting question to ask is whether numerical expressions could also have an influence beyond numerical judgment and have a cross-dimensional impact. Previous research has demonstrated that some of the effects that numerical expressions may cause reflect the nature of communication: they are only observed in a social context where the providers of the numerical information are human and are considered trustworthy (Zhang and Schwarz 2012; 2013), and when the precision of the information is relevant to the judgment task (Zhang and Schwarz 2013). Extending this literature, in the current research, we study how numerical expressions could serve as a general cue of inference given the corresponding communicative context and consequently influence judgments in domains that go beyond the numbers.

Numerical Processing from a Social Perspective

Why are people able to draw inferences from numerical expressions? Our brain processes a target more fluently when the target concerns small or round numbers (Thomas and Morwitz 2009), presumably due to our limited capacity of short-term memory (Dehaene 2011, 103). Thus, using round numbers provides cognitive benefits for communicating, encoding, and processing numerical information. However, rounding also comes with cost, namely, imprecision – with rounding, the expressed (round) number deviates from the true value which it represents. Hence, people will express a quantity in a round number when its cognitive benefit outweighs the cost of discrepancy between the actual and the communicated number, but will present the actual (sharp) number when the cost is high. Consequently, the extent to which a round number (e.g. “100”) could possibly deviate from the actual quantity it represents is greater than the extent to which a close sharp number (e.g. “97”) could deviate, if at all.

On the other side of the communication, information recipients will take into

consideration that the communicator *chooses* to use sharp/round numbers, as suggested by the theory of conversational logic. Conversational logic is widely observed in interpersonal conversation (Grice 1975; Levinson 1983; Schwarz 1994; 1996) and marketing communication (Miller and Kahn 2005; Xu and Wyer 2010; Zhang and Schwarz 2012). It suggests that a cooperative communicator should provide as much information as needed for the communication (maxim of relevance), but no more than the communicator's knowledge could warrant (maxim of quality). It also suggests that recipients will interpret the communicator's utterance, assuming that the communicator follows this logic as if s/he is "trying to live up to these ideals" (Clark and Clark 1977, 122).

In the context of numerical communication, information recipients are aware that the numerical expression conveys the communicator's knowledge and intention, and will make judgments accordingly. Specifically, when the communicator chooses to present a sharp number, recipients will make two inferences: first, the communicator, if maybe unknown of the *actual* quantity which s/he communicates (e.g. when making estimates), is confident that the actual number would not be far away from the communicated (sharp) number, because otherwise the communicated number would be considered wrong, violating the maxim of quality; *and* second, the communicator, for a certain reason, considers the cost of rounding to be high – in other words, the difference between the actual number and the potential rounded number, even small, is relevant to the purpose of the communication and therefore cannot be ignored. Both inferences play important roles in judgment: when the communicator does not have complete information about the actual number (e.g., when making estimates), high granularity suggests that the communicator has more knowledge (Zhang and Schwarz 2012); when the communicator is believed to have (near) complete information about the communicated number, the relevance of precision then becomes the center of the judgment (Zhang and Schwarz 2013).

The current research is also focused on consumer inferences based on the relevance

of precision. However, different from the previous research (Mason et al. 2013; Zhang and Schwarz 2013), we show that recipients' postulation of the reason for the communicator to choose a sharp number instead of rounding it is largely situated in the communicative context, which influences the domains of judgment that go beyond what traditional numerical judgment would predict. Specifically, we study how expressing product weight in sharp/round numbers influences product valuation, and explore the boundary conditions predicted by its underlying mechanism.

Situated Inference in the Context of Product Valuation

According to the maxim of relevance, sharp (vs. round) numbers are chosen by the communicator for a reason that is relevant to the communication. The reason, postulated by the recipients, forms the basis of inference. This kind of inference is pragmatic in nature, and is situated in the communicative context (Gauker 2001). If the judgment pertains to the difference between two numbers, the reason of communicating a sharp number may be postulated as "the difference is small" (Mason et al. 2013; Zhang and Schwarz 2013); however, if the judgment pertains to a different domain, the postulation should be constructed within that particular domain.

In product valuation, the value of a particular SKU (e.g. a bottle of caviar) is highly correlated with its weight/volume: the same product containing more substance has higher value. Therefore, if the weight information is somewhat imprecise, the judgment of the value of this particular SKU would become uncertain. Such problem is undesirable to both marketers and consumers, and is particularly so when the unit value of the product is high. Therefore, when the product value is high, marketers will have greater motivation to describe the product weight precisely. Consequently, when the product weight is expressed in a sharp number instead of a round one, a reasonable postulation by consumers would be that the marketer could not tolerate the imprecision

in the product weight, which, in tasks of judging product value, would translate to the inference that (unit) value of the product is high.

Therefore, the granularity in which product weight is expressed may serve as a source of inference about product value. Note that such judgment is based entirely on the analysis of the communication between marketers and consumers, which is above and beyond the process of numerical perception. Formally, we hypothesize that:

H1 (The granularity effect): When the product weight is expressed in a sharp (vs. round) number, the product would be judged to have a high (vs. low) value.

We propose that this effect is based on the inference that consumers draw from the marketer *choosing* to use the sharp (vs. round) number, namely, the (unit) value of the product is high. Predicted by the conversational logic (Grice 1975), this mechanism requires that the necessity for the precise communication can be reasonably grounded, which suggests two necessary conditions for the granularity effect. First, the product could be valuable so that it is reasonable for the communicator to have the need to communicate the product weight in precision; and second, in the given communicative context, there should be no accessible reason that is more plausible than “high product value” to explain the communicator’s choice of the sharp number. Therefore, it is hypothesized that:

H2a: The granularity effect will be eliminated when the inference of high value is unlikely to apply to the target product; and

H2b: The granularity effect will be eliminated when the granularity can be explained by reasons other than the marketer’s intolerance of imprecise expressions, such as industry convention or government regulation.

Finally, there is a more fundamentally necessary condition for the communicative intent to be inferred: the information, which serves as the basis of inference and judgment, must be *communicated*. In other words, if it is impossible for the weight

information to convey any communicative intent beyond its literal meaning, no inference could be drawn in the first place. Thus, it is further hypothesized that:

H2c: The granularity effect will be eliminated when the weight information on which the value judgment is based is not directly communicated by the marketer, but is come up by the consumer themselves.

In the rest of the paper, we will test H1 in study 1, and will further confirm it through study 2 to 4. We will also test H2a-c as moderating effects in study 2-4, respectively, to further examine the proposed inference process.

Study 1

Method

Study 1 is a direct test of the granularity effect (H1). One hundred and fifty-three people recruited from an online survey panel in China participated in this study. Participants first read a print ad of a bottle of essential oil, together with several lines of product description printed in bullet points. Depending on conditions, the volume of this product, displayed as the last bullet point, was 97ml, 100ml, or 103ml, respectively. Participants were asked to estimate the market price of this product in RMB (1 RMB = US\$ 0.15) as the dependent variable.

Results and Discussion

The result was consistent with our hypothesis: the price estimate was influenced

by the numerical format in which the volume was expressed. While the price estimates for the 97ml bottle and the 103ml bottle did not differ from each other ($M = 96.0$ vs. 88.4 , $t(99) < 1$, $p > .3$), they were higher than the price estimate of the 100ml bottle ($M = 65.2$, $t(151) = 2.1$, $p < .04$ for sharp vs. round). That is, expressing the weight of a product in a sharp (vs. round) number leads to higher value judgment.

We propose that participants made judgment based on the inference drawing from the expression of 97ml/103ml: the oil was so valuable that the measure of the weight had to be very precise. However, one could argue that sharp numbers may be inherently associated with certain high-profile images because, for example, imported products, which are usually expensive, sometimes have sharp weight due to unit conversion; drawing on such association would not necessarily require an inference for the communicator's intention.

Naturally, a test of the inference process is desired. Understanding that not all thought processes can be correctly spelt out (Nisbett and Wilson 1977), we do not directly ask participants to justify their price estimates. Instead, we follow "moderation-of-process designs" (Spencer, Zenna, and Fong 2005) and demonstrate the proposed mechanism by showing the key moderation effects that are only predicted by inference process (H2a-H2c).

Study 2

Not all inferences apply unconditionally. The inference of high value, for example, may apply to a bottle of essential oil, or a piece of unique handmade chocolate, but may not be as applicable to a piece of unique chocolate that is available in every grocery store. If the granularity effect is due to consumer inference, the effect should be eliminated when the potential inference of high value is unlikely to apply. In study 2,

we test this rational by varying the extent to which the marketer has the need to express the weight precisely for the target product. Specifically, we ask participants to estimate the price for either a piece of unique chocolate or a regular one. A unique chocolate is more likely to have high value, so its weight is deemed more necessary to be presented precisely. In other words, the inference of high value from the sharp weight would be more applicable for a unique chocolate than for a regular one. Therefore, it is predicted that the chocolate with a sharp weight should have higher estimated price than the chocolate with a round weight, but only when the chocolate is unique.

Method

Four hundred and twelve U.S. participants were recruited from Amazon Mechanical Turk and were each paid 50 cents for participation. The study adopted a 2(product type: unique vs. regular) x 3(numerical expression: sharp-lower vs. round vs. sharp-higher) between-subjects design. Participants were shown a picture of a piece of chocolate. The information printed on the package included details about the type and the ingredients of the chocolate, as well as its weight (see appendix 1). The weight was 9.7 oz. or 10 oz. or 10.3 oz. (label edited by Photoshop). Half of the participants were told that the chocolate was “hand-made in a family-owned factory in northwest Connecticut” and was “only sold in the small town where the factory is located” (the unique condition). The other half were told that the chocolate was “made in USA” and would “soon be available at all major grocery stores across the country” (the regular condition). As for the dependent variable, participants were asked to estimate the price of the chocolate.

Results

Insert figure 4 about here

The results were consistent with our prediction (figure 1). For the unique chocolate, the estimated price did not differ between the two sharp weights ($M = \$9.4$ vs. $M = \$9.0$, $F < 1$, *ns.*). Combining the two sharp conditions by treating them as independent cells without difference (Rosenthal and Rosnow 2007), planned contrast shows that these two price estimates were higher than the 10 oz. chocolate ($M = \$7.0$, $F(1, 406) = 9.5$, $p < .005$). However, when the chocolate was regular, the price was estimated to be \$5.9, \$5.3, and \$5.2 for 9.7 oz., 10 oz., and 10.3 oz., respectively. First of all, these numbers were lower than the price estimates for the unique chocolates ($F(1, 406) = 39.0$, $p < .001$). More important, as predicted, the price estimate of the 10 oz. regular chocolate was not significantly different from the 9.7 oz. and the 10.3 oz. regular chocolate ($F(1, 406) < 1$, $p > .4$). This pattern resulted in a predicted two-way interaction ($F(1, 406) = 4.0$, $p < .05$).

The current study shows that sharp weights lead to high price estimate for the unique chocolate but not for the regular one. Note that this pattern could not be explained by mere association between numerical form and product value or any explanation based on numerical perception. Moreover, it has ruled out the possibility that sharp numbers are more salient and hence lead to more (positive) thoughts, as the evidence here suggests that the effect is simply not driven by numbers per se.

However, one could still argue that the reason for which the granularity effect did not occur for the regular chocolates was that participants might generally pay more attention to the information of a unique type of chocolate than a regular one, so the weight information in the unique conditions received more attention and was more

Carefully processed. This potential concern will be addressed in the next two studies, where exact same products are used across conditions.

Study 3

Inference drawn from a piece of information is context-dependent in nature. The specific inference that can be drawn is usually a function of the environmental cues that are most accessible on the individual's mind (Cho & Schwarz 2008; Deval et al. 2013). In the previous studies, the choice of using sharp numbers was attributed to the high product value, under which circumstance the marketer could not tolerate the possibility that the communicated weight deviates from its actual weight. However, if a different but more plausible reason is made accessible to consumers, the attribution should change accordingly.

To test this prediction, we show participants the weight information of a key ingredient of a product. The ingredient is either presented stand-alone, or within a *required* table of ingredients, with all the ingredients expressed in a uniform numerical format (sharp vs. round). We predict that using sharp numbers uniformly under the requirement of a third party (which has no interest in communicating product value) would be less likely to convey the marketer's communicative intent, and therefore eliminate the granularity effect.

Method

One hundred and fifty U.S. participants were recruited from Amazon Mechanical Turk and were each paid 30 cents for participation. The study adopted a 2 (listed

ingredients: single- vs. multiple) x 2(numerical expression: sharp vs. round) between-subjects design. Participants were shown a print ad of a bottle of pumpkin seed oil, with product description displayed in bullet points. For half of the participants (single-ingredient condition), the last bullet point indicated that the oil contained 0.95/1 gram(s) of cinnamoyl per serving. For the other half (multiple-ingredients condition), the product description did not include this particular bullet point; instead, a table of “Nutrition facts per serving” was shown below the product description. Participants were also advised that this table was a required presentation by FDA. The table contained four items and their weights per serving: total fat, saturated fat, sodium, and cinnamoyl (see appendix 2 for the stimuli). In the sharp condition, the weight of these four items were all presented in sharp numbers, including 0.95 grams of cinnamoyl. In the round condition, all the weights were presented in round numbers, including 1 gram of cinnamoyl. In all conditions, an asterisk was placed next to the word “cinnamoyl”, noting at the bottom that “Cinnamoyl is a nutritious ingredient that is beneficial to protect us against heart diseases.”

Because the different amount of total information presented in the single- vs. multiple-ingredients conditions could lead to different levels of attention paid to the focal information of cinnamoyl, all participants were first asked “To make sure you have read the product description above, how many grams of cinnamoyl per serving is contained in this product?”. The purpose of this question is to make sure that all participants have paid enough attention to notice our manipulation of the numerical expression. Next, all participants were asked to estimate the price of this bottle of pumpkin seed oil, which served as our DV.

Results and Discussion

Insert figure 5 about here

Replicating the granularity effect, the price of the pumpkin seed oil was estimated to be higher when it contained 0.95 grams of cinnamoyl per serving than when it contained 1 gram ($M_{sharp} = \$10.4$ vs. $M_{round} = \$7.2$, $F(1, 146) = 7.4$ for planned contrast after log transformation [and same below], $p < .01$). However, this was only the case in the single-ingredient conditions where the weight of cinnamoyl was the only weight presented (figure 2). When multiple ingredients and their weights were presented, the difference was gone ($M_{sharp} = 8.5$ vs. $M_{round} = 8.0$, $F(1, 146) < 1$, $p > .6$), resulting a predicted two-way interaction ($F(1, 146) = 4.3$, $p < .04$).

Same as in the previous studies, we propose that the difference of the price estimates in the single-ingredient conditions occurred because participants inferred that the cinnamoyl contained in the oil was more valuable when its weight was precise. This judgment of the value of cinnamoyl was reflected in the price estimate of the oil. In contrast, in the multiple-ingredients conditions, sharp numbers were used on the weights of all ingredients rather than on cinnamoyl only. Although cinnamoyl could still be valuable and its weight needed to be communicated in precision, the other ingredients were unlikely to have the same need, which rendered the inference of high product value unlikely. In the meantime, the “FDA requirement” provided a plausible explanation – it may be FDA who had a certain format requirement for the ingredient table. Participants might or might not adopt this particular explanation. But as long as the explanation they adopted was not related to product value, the different numerical expressions would not lead to a difference in price estimate. Consequently, the granularity effect disappeared as we have observed.

Study 4

Communication takes place between two parties. For communicative intent to be inferred, there first needs to exist a communicator, a person that could *have* a communicative intent. Previous research has shown that if the information on which judgments are based could not possibly convey communicative intent, for instance, based on computer generated messages, the communication will not be attributed to communicative intent (Schwarz et al. 1991; Zhang and Schwarz 2013). Following the same logic, if the numerical information on which the judgments are based does not directly come from the communicator, but instead are derived by the judgment makers themselves, no inference would be made. In this study, we test this idea by having participants to calculate the product weight by themselves. If the granularity effect is due to consumer inference from the information conveyed by the communicator, it should be eliminated when the product weight directly comes from recipients themselves instead a communicator. After all, it does not make sense for anyone to *infer* “communicative intent” from their self-generated information.

Method

Three hundred and thirty-five U.S. participants were recruited from Amazon Mechanical Turk and were each paid 30 cents for participation. The study adopted a 2 (calculation vs. not) x 2 (sharp vs. round) between-subjects design. Participants read about a highly effective new weight loss drink. In the no-calculation condition, participants were told that the product was “sold in individual shots, while a course of treatment takes 10 shots *with a dosage of 9.8[10]ml each shot.*” (*Italic added for the paper*). After reading the product description, they were asked to estimate the price of

each shot of this drink, which served as our DV. In the calculation condition, participants were told the same information, except that the last few words were changed to "... with a total dosage of 98[100]ml." In these conditions, participants were first asked: "Based on the description above, how much is the dosage each shot?", and then asked to estimate the price of each shot.

Results and Discussion

Insert figure 6 about here

Four participants made price estimates beyond three standard deviations (after log transformation), and were removed, leaving 351 participants in the analysis. As shown in figure 3, the results in the no-calculation conditions again replicated the granularity effect: the price was estimated to be $M = \$5.1$ per shot when the volume was 9.8ml/shot, but only $M = \$3.7$ per shot when the volume was 10ml/shot ($F(1, 327) = 12.8$ for the planned contrast, $p < .001$). However, in the calculation conditions where the volume of each shot was calculated by the participants themselves, the volume did not make a difference ($M = \$3.9$ vs. 3.9 , $F(1, 327) < 1$, $p > .9$), resulting in a predicted two-way interaction ($F(1, 327) = 3.9$, $p = .05$). More important, our theory suggests that the number that participants received conveys information only when it is precise *and* conveyed by a communicator. Therefore, participants who calculated the number by themselves should make judgments *as if* they were provided round numbers which did not convey information. Consistent with this prediction, the sharp & no-calculation condition was significantly different from the other three conditions ($M = \$5.1$ vs. $\$3.8$, $t(329) = 3.8$, $p < .001$), while the other three conditions did not differ from each other

$(F(2, 213) < 1, p > .7)$.

This study shows yet another boundary condition that is predicted by the inference process: when the base of judgment (i.e. weight of each shot) is come up with by the recipients rather than communicated from a communicator, its granularity does not convey extra information, and therefore does not affect judgment. The results further rule out the attention account which might be a confounding in study 2: the calculated weights were supposed to be more deeply processed than in the informed weights, yet still led to the elimination of the effect.

One may wonder why the calculation turned off the granularity effect without being influenced by the communicative intent that the precise 10-shot dosage (98ml) may convey. Our explanation was that it was the dosage of *one shot*, rather than the dosage of 10 shots, that was more likely to serve as the basis of the estimate for price *per shot*; hence, the judgment was unaffected by the 10-shot volume.

General Discussion

Theoretical Implications

In marketing communication, numbers are used everywhere, from price to warranty, from shipping time to product specifications. These numbers do not only provide specific measurements for their own dimensions, but may also affect consumers' perception on other dimensions of the product. The current research provides a first exploration of such cross-dimensional impact originated from numerical expressions. Building on Gricean logic of conversation (Grice 1975), we show that product valuation can be influenced by the numerical information of product weight. Specifically, product

weights expressed in sharp (vs. round) numbers lead to a judgment of higher product value. By examining three different types of moderators, we provide evidence that the granularity effect is driven by consumer inference. Namely, the weight is purposefully communicated in precision because the value of the product is high. Such effects, as far as we are aware of, cannot be predicted by any other mechanisms, from numerical perception (Janiszewski and Uy 2008) to marketplace metacognition (Wright 2002).

Our paper has made theoretical contributions by extending (i) the literature of consumer inference and (ii) the literature of numerical cognition in several ways. First, we demonstrate that product value can be inferred not only from price, availability, country of origin, and product name (Deval et al., 2013; Gunasti & Ross, 2009; Kardes, Posavac, & Cronley, 2004; Miller & Kahn, 2005; Zeithaml, 1988), but also from the numerical expression of product weight, which has never been identified by consumer literature before.

Second, consistent with the theory of situated inference (Gauker 2001), we demonstrate that the potential influence of numerical expressions goes beyond numbers, which is out of the reach of traditional numerical cognition and pricing research. Depending on the judgment task, people draw inferences about domains which the judgment task pertain to; depending on the specific communicative context, people draw inferences about the aspect of the target in which necessary information is absent. The inference and judgment based on a same piece of communication could virtually go to any domain, as long as the inference is relevant and logically reasonable. For example, one could expect that products with sharp weight can also be judged as having high quality or being more carefully processed in the proper communicative contexts.

Third, this research provides stronger and clearer evidence that numerical judgment is not only a cognitive process, but is also made with social considerations. On the one hand, the fact that such cross-dimensional impact by numerical expressions is impossible to be accounted for by any models of cognitive representation of numbers.

On the other hand, the boundary conditions for pragmatic inferences that we explore, namely, the target relevance (study 2), the accessibility of other (non-pragmatic) inferences (study 3), and the source of information (study 4), have provided direct support for the proposed process.

Practical Implications

Information that leads to consumer judgment and decision making does not exist in a social vacuum; rather, it is *communicated* to consumers from manufacturers, advertisers, customer reviewers, and so on. In marketing communication, the conversational logic does not only apply, but may play an even more prominent role than it does in daily conversation. Presumably, this is because consumers usually do not get a chance to query the communicator, and hence have to rely more on pragmatic inferences from the message in context (Zhang and Schwarz 2012).

In marketing practice, communicating sharp weights does not necessarily mean that the marketer intends to manipulate consumers' product perception on purpose. However, the current research suggests that it is a possible strategy that the marketer could tactically adopt. More broadly, it reminds marketers about their abilities to "lie" about certain product attributes (e.g. value) by telling the truth about some others (e.g. weight). On the other hand, the conversational nature of the granularity effect suggests that consumers may not be able to distinguish purposefully-designed messages of this kind from natural logical conversations, and thus they may not be able to immune themselves from the marketer's manipulation.

Limitations

Gricean conversational logic plays a critical role in many communication contexts between communicators and recipients, including the communication between experimenters and participants in research settings (Schwarz 1994). Therefore, the effect we found in the studies could reflect participants' inference from the communication delivered by the experimenter rather than by the marketer. This possibility of misrecognizing the communicator does not invalidate the theoretical investigation of this paper, as the inference processes from marketer and from experimenter are essentially subject to the same conversational logic. Nevertheless, this possibility could mitigate the external validity of the findings of this research. Future research could look into field data to demonstrate this effect in the real world.

Chapter 5: Conclusion

Traditionally, numerical perception and judgment has been studied from a cognitive, psychophysical, affective, or motivational perspective. However, in many situations, numbers that we encounter in everyday life are communicated to us by others. As consumers, for example, we receive numerical information from manufacturers, advertisers, customer reviewers. In this dissertation, I contribute to the numerical perception literature by studying how social considerations affect judgments made from numerical information.

Numerical communication, first of all, always tells us about the magnitude of the communicated target. However, as demonstrated in this dissertation, the information that a piece of numerical information conveys could go beyond what it literally presents; the information recipients draw pragmatic inferences from its precision. As discussed in chapter 1, in numerical communication, a less precise expression (i.e. a round number, or a quantity expressed in a coarse unit) could actually be used to communicate a quantity that is quite different from it, while a precise expression will not. This notion is what all the inferences discussed throughout this dissertation are based on. In chapter 2, the granularity of a quantitative estimate reflects how much knowledge and confidence the communicator has about the target; the finer the unit, the more confident she is that the actual outcome will not deviate far from her estimate. In chapter 3, the granularity of a numerical anchor implies the actual adjustment needed to arrive at the correct answer; a sharp anchor suggests that the adjustment should be small, and a round anchor suggests that the adjustment could be large. In chapter 4, I show that the granularity in which the weight of a product is expressed conveys how likely the actual weight could potentially be deviated; a sharp weight suggests that the marketer guarantees little deviation, which implies that the value of a product is high.

These granularity effects are all driven by the fact that people, including communicators and recipients, follow the norms of cooperative communication (Grice 1975). In the context of quantitative communication, these norms suggest that communicators will use precise expressions only when they (i) are relatively certain about what they say, and (ii) consider precision relevant to the recipients' judgment task. The former condition speaks to the quality of the communicative input made by the communicator, while the latter condition reflects the communicator's motive for influencing the recipients' judgment. Consistent with Grice's (1975) theory of cooperative communication, the effects demonstrated in this dissertation all suggest that recipients understand that a cooperative communicator will only use precise expressions when both conditions are met, and will make inferences accordingly. Specifically, in chapter 2, the communicator using a fine grained unit means that she has confidence in the estimated event, *and* that she intend the recipients to know this fact. In contrast, the communicators in chapter 3 and 4 are assumed to have complete knowledge about the quantities she provide. Thus, the only inference from the communication is that the granularity is relevant to the communicated target. In chapter 3, a sharp anchor suggests that a fine grained scale is relevant, and thus should be used, to arrive at the correct answer. In chapter 4, a sharp weight suggests that the marketer thinks that the tiny range of variation of the weight is required to describe the product, which leads to the downstream inference the product (unit) value is high.

Throughout this dissertation, the mechanism of inference is proven through the elimination of granularity effects when the norms of communication are violated. First of all, for the communication to reflect the communicator's intent, the communicator has to be a human. As shown in study 1 of chapter 3, when the numerical anchor is believed to be generated and communicated entirely by computer, the granularity effect disappears. Secondly, the granularity effects also disappear when the potential inference

from using the precise expression cannot be grounded. Specifically, when the communicator is unlikely to have precise knowledge about the target, using a fine grained unit would not lead to the inference that the communicator has knowledge and confidence (chapter 2, study 3). Similarly, when the difference between the target and the anchor cannot be small (chapter 3, study 2), or the product cannot be precious (chapter 4, study 2, 3), communicating sharp numbers would not lead to the inference that small deviation is necessary for making the right judgment. In these cases, the granularity effects disappear. Consistent with previous research (Dodd and Bradshaw 1980; Schwarz 1996; Schwarz, Strack, Hilton, and Naderer 1991; Smith and Ellsworth 1987), these moderation effects show that the application of conversational norms is not unconditional. The norms stop affecting recipients' inference not only when the cooperativeness of the communicator is called into question, but also when the potential inference is unlikely to be true given the judgment context or the nature of the target.

In everyday life, individuals make sense of the information they receive, including quantitative information. A precise quantity suggests that the (potential) deviation from it is small. This dissertation has demonstrated and analyzed examples of judgment contexts in which such inference would or would not occur. However, inferences are context dependent and the same numerical expression may have different or even opposite downstream inferences with different environmental cues, which is an avenue worthwhile to pursue.

Figures

Figure 1: Results of Study 1, Chapter 2

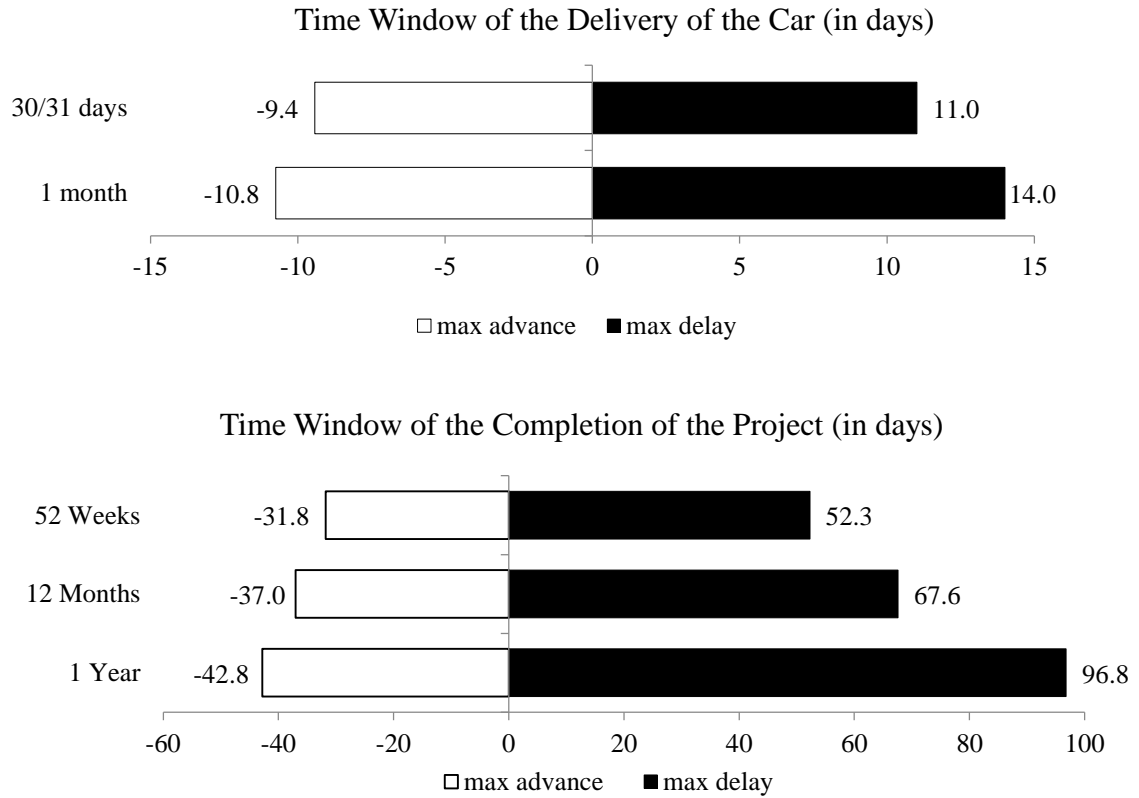


Figure 2: Results of Study 2, Chapter 2

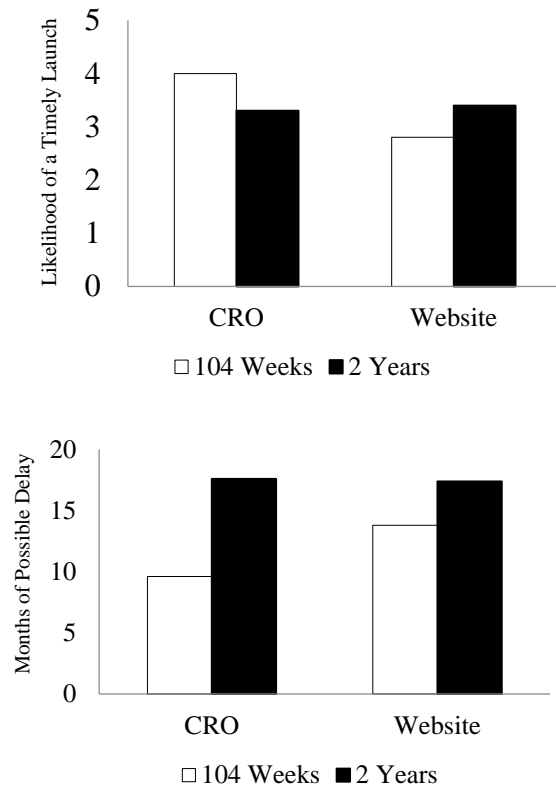


Figure 3: Results of Study 3, Chapter 2

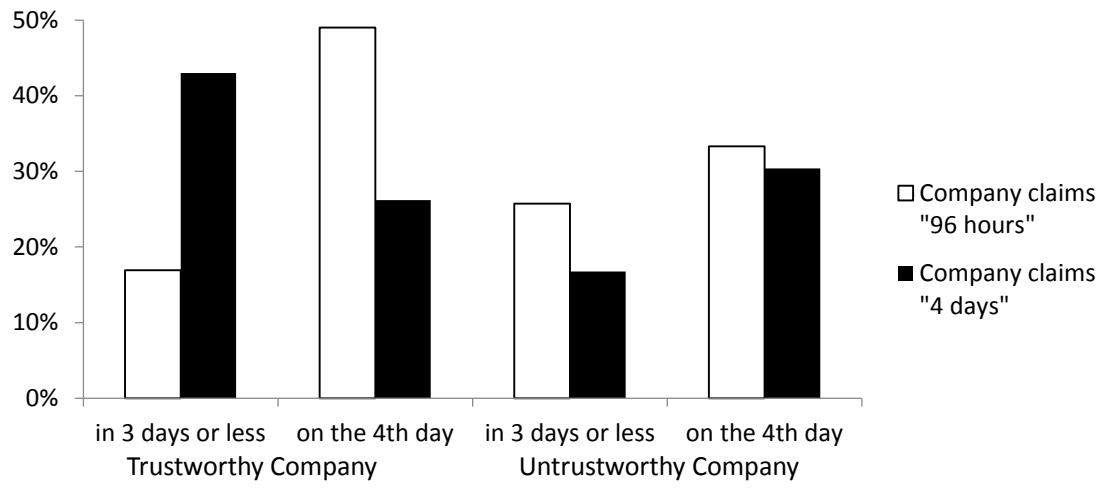


Figure 4: Results of Study 2, Chapter 4

CHOCOLATE PRICE ESTIMATE

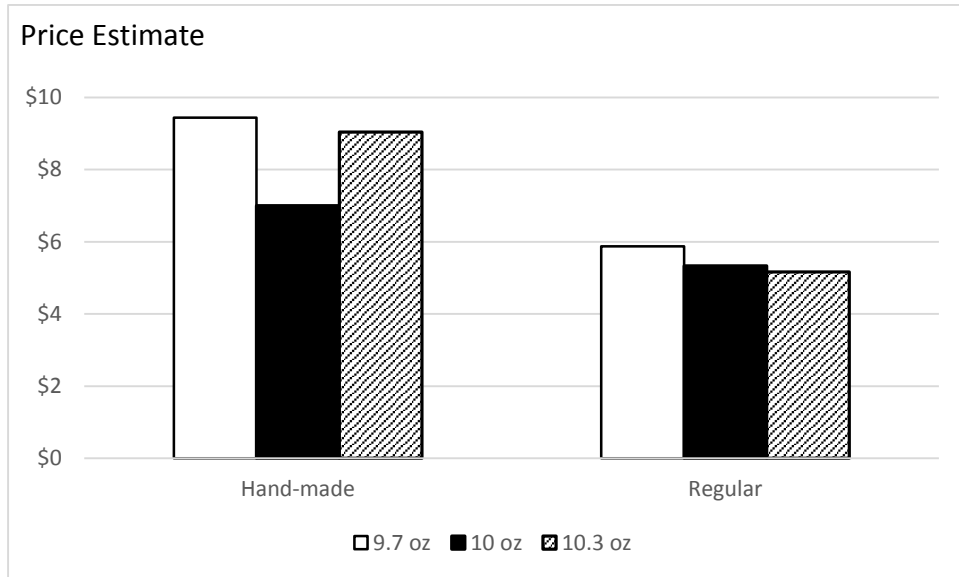


Figure 5: Results of Study 3, Chapter 4

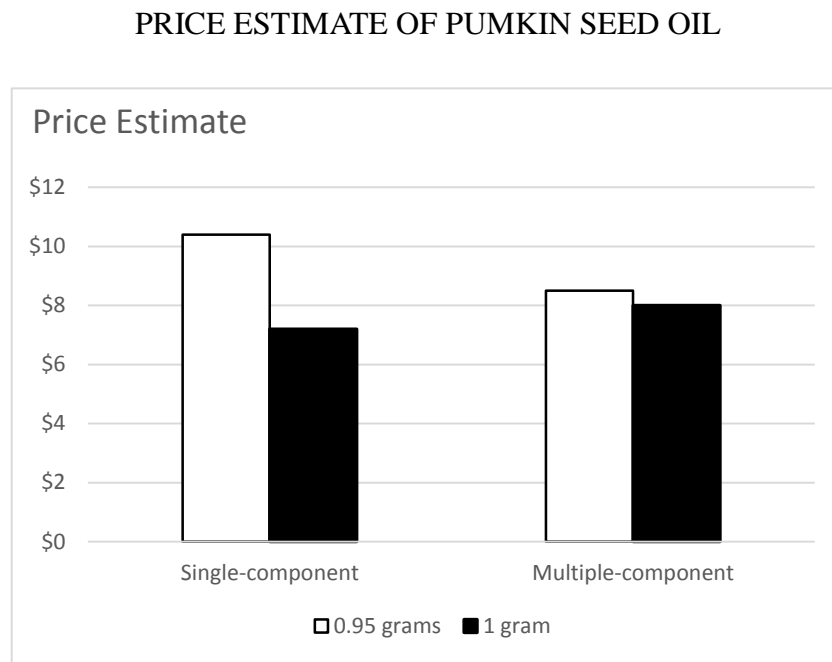
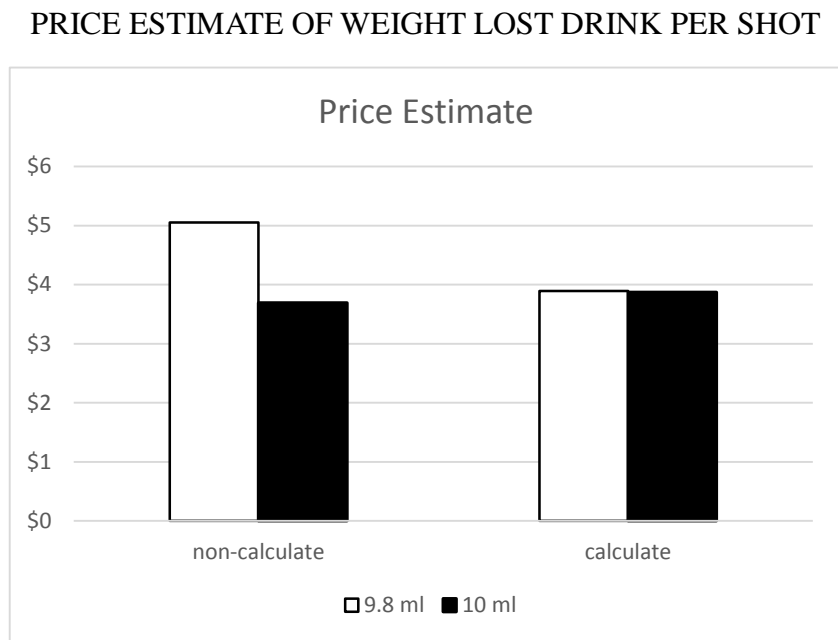


Figure 6: Results of Study 4, Chapter 4



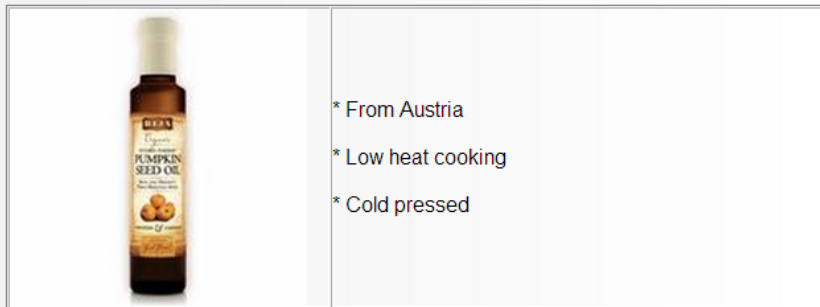
Appendices

Appendix 1: Sample image for the chocolate (9.7 oz.) in study 2, chapter 4.



Appendix 2:

Experiment materials for study 3, chapter 4(multiple-ingredient conditions).



Nutrition Facts per serving (Required presentation by FDA)

Total Fat	9.25 g
Saturated Fat	2.15 g
Sodium	0 g
Cinnamoyl *	0.95 g

*Cinnamoyl is a nutritious component that is beneficial to protect us against heart diseases.

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