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A methodological investigation of double filter by frequency theory as applied to lateralized decision making : risky choice, attribute, and goal framing

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A Methodological Investigation of Double Filter by Frequency Theory as Applied to Lateralized Decision Making: Risky Choice, Attribute, and Goal Framing.

by

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Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Master of Arts Degree in Experimental Psychology

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An Abstract of

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Lateralized cognition has become a hot topic in multiple sub-fields of psychology including memory, decision making, emotion, and perception research. Several theories of laterality have been posited and researched, with no single theory receiving universal support. Of these, Double Filter by Frequency theory aims to provide a cohesive framework to evaluate the effects of laterality across several domains. This theory posits that the left and right hemispheres are uniquely attuned to the relative frequencies of incoming information, with the left hemisphere taking primary processing responsibility for the relatively high frequencies of a message, while the right hemisphere takes primary processing responsibility for the relatively low frequencies of a message. Although Double Filter by Frequency theory has received some support, previous research has not systematically investigated the effects of Double Filter by Frequency theory across several frequency ranges or with multiple framing paradigms.

This study, therefore, sought to investigate Double Filter by Frequency theory across multiple frequencies within the context of risky choice framing, attribute framing, and goal framing. In accordance with the logarithmic nature of sound perception, a frequency range of four octaves (500 Hz – 8000 Hz) was established and manipulated

within each framing paradigm. The framed information was presented in a series of one, two, or three octave ranges, with a random string of words presented in a frequency range that was either relatively higher or lower than the framed message, which completed the four octave overall range. The framed information was also presented in a consistent frequency across all three paradigms.

Contrary to previous studies of the Double Filter by Frequency theory, the relative frequency of the message alone was not a significant predictor of participants' decision-making processes. However, significant differences did emerge between several specific frequency ranges for the risky-choice and attribute framing paradigms. This indicates that relative frequency alone may be inadequate to predict differential hemispheric activation and decision biases.

Exploratory analyses also indicated that the amount of frequency information that made up the primary voice might play an important role in the presence of a framing effect. When the framed information was presented in only a single octave, there was no difference between participants' responses in the positive and negative frames. When this information was presented in two or three octaves, however, the standard framing effect emerged.

The present results suggest that Double Filter by Frequency theory may not extend to differences in lateralized cognition for higher order cognitive functions, such as decision making, that are apparent for lower level perceptual identification tasks. Future research is warranted to understand the differences between the present findings and previous research investigating the link between Double Filter by Frequency Theory and decision making. In conclusion, any future research needs to investigate the effects of relative frequency (location), absolute frequency (range), and amount of frequency information (number of octaves) presented in the target information.

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List of Abbreviations

ANOVA ....Analysis of Variance

DNA...........................Deoxyribonucleic Acid

HERA.........................Hemispheric Encoding / Retrieval Asymmetry
Hz...............................Hertz

mRNA ....Messenger Ribonucleic Acid

PET ....Positron Emission Tomography

List of Symbols

d..........Calculated value of Cohen's d, an effect size measure used to indicate standardized differences between two mean values
F ....Calculated value of the *F*-statistic
M ....Calculated mean value
N.........Number of participants used in specific analyses
p..........Calculated *p* value, defined as the probability, under the assumption of a hypothesis, of obtaining a result equal to, or more extreme, than what was actually observed
SD.......Calculated standard deviation
t ....Calculated value of the *t*-statistic

η^2_p ....Calculated value of Partial Eta Squared, an effect size measure representing the amount of variance explained by a predictor after excluding variance explained by other predictors
χ^2.........Calculated value of the χ^2-statistic

Chapter One

Introduction

Evolutionary Basis of Laterality

Hemispheric asymmetries are long established byproducts of evolution that have been shown to influence individuals' perception, processing, and decision making. The exact evolutionary process that occurred is still under vigorous debate, with some researchers focusing on a homologous origin, while others focus on convergent evolution (Hopkins & Cantalupo, 2008). In humans, for example, the most striking asymmetry is in a specific area of the temporal lobe, known as the planum temporale. The planum temporale is on average larger in the left hemisphere as compared to the right hemisphere, sometimes as much as five times larger, and has been implicated in language processing (Bear, Connors, & Paradiso, 2007; Geschwind & Levitsky, 1968). This level of asymmetry is not unique to humans, however, as lower vertebrates and reptiles seem to show distinct physical and functional asymmetries as well (Bisazza, Rodgers, & Vallortigara, 1998). In many species of fish and some amphibians, the habenular nucleus, a section of the diencephalon implicated in several cognitive tasks, is markedly asymmetrical (Bianco & Wilson, 2009; Bisazza et al, 1998). In a large review, Bisazza, Rodgers, and Vallortigara (1998) noted that several of these asymmetries amongst species seemed to follow similar trends. Most species, for example, seem to share a left hemisphere advantage for vocalizations. In humans, recent studies have pointed to several possible evolutionary mechanisms such as changes to mRNA, protein expression, and amino acid sequences, through DNA (Hill & Walsh, 2005). Although these possible mechanisms provide a solid foundation for analysis, the adaptive advantage of these changes, and other functional asymmetries, is even more difficult to determine.

Several researchers have postulated that these asymmetries evolved to facilitate parallel processing. Rogers (2000), for example, compared the behavior of chicks lateralized for feeding behavior (left hemisphere) and attack behavior (right hemisphere) against non-lateralized chicks in a predator recognition task coupled with a pecking/feeding task. Lateralized chicks and non-lateralized chicks can be experimentally manipulated by varying the amount of light and exposure time of light during the incubation period of the eggs (Rogers, 2000; for a more in depth explanation see Rogers, 1982 and Rogers, 1997). Rogers (2000) found that, while feeding, lateralized chicks discovered the presence of the simulated predator much quicker when the simulated predator was identified in the chicks' left visual field (right hemisphere) than in the chicks' right visual field (left hemisphere). Non-lateralized chicks, however, showed no difference in latency times between the visual fields. There were no significant differences between the overall latencies of the two groups, but the non-lateralized chicks' latencies tended to fall between the latency times of the left and right visual field identifications of the lateralized chicks. The latencies of the non-lateralized chicks were also significantly more variable than the latencies of lateralized chicks. Rogers' (2000) experiments with chicks demonstrated a solid positive adaptation (quicker response to a predator when presented to the right hemisphere, dual focus of feeding and predator awareness), but it was not without costs (less ability to recognize predators when presented to the left hemisphere). This evolutionary costs vs. benefits analysis also provides evidence as to why some traits continue to propagate even despite selection pressure. As both symmetry and asymmetry provide some benefits, it benefits the species as a whole to maintain both functions within a given population (Hopkins & Cantalupo, 2008).

Lateralized Functional Differences and Explanatory Theories

Similar functional differences between the hemispheres can be seen in humans as well. For example, episodic memory seems to be served by the cerebral hemispheres in differing but complimentary ways. According to the HERA (hemispheric encoding/retrieval asymmetry) model, the left hemisphere plays a specific role in the encoding of episodic memories whereas the right hemisphere is instrumental in retrieving episodic memories (Habib, Nyberg, & Tulving, 2003). Thus, to excel at episodic memory, an individual requires the right and left hemispheres to work together.

There are also several theories that point to perceptual processing differences amongst the hemispheres. First, is has been shown that the left hemisphere is more apt at processing verbal information, while the right hemisphere is more apt at processing visuospatial information(Dien, 2008). This notion was originally developed from work with aphasiac and spatial neglect patients that showed left hemisphere lesions often resulted in language difficulties, while lesions to the right hemisphere resulted in spatial problems. More recent research has provided evidence that the verbal/visuospatial distinction is too general to adequately explain the complexities of left hemisphere / right hemisphere asymmetry (Dien, 2008). Hough (1990), for instance, showed that patients who suffered from right hemisphere lesions experienced greater difficulty in following certain aspects of narrative story telling as compared to patients with left hemisphere lesions and a control group with no brain damage. Similarly Brownell, Michel, Powelson, and Gardner (1983) showed that the right hemisphere was involved with maintaining coherence in the punch line of jokes. In nonclinical populations, the right hemisphere has also been shown to access dominant and subordinate word meanings equally, while the left hemisphere has an advantage with dominant meanings (Birgess & Simpson, 1988; Sontam & Christman, 2012).

Just as the right hemisphere has been implicated in some language comprehension and production processes, the left hemisphere has also been implicated in some spatial processes. Langdon and Warrington (2000) found that patients who suffered left hemisphere lesions showed impairment on both verbal and spatial reasoning tasks.

A second theory of laterality posits that the left hemisphere is better suited at processing information categorically, while the right hemisphere is better suited at processing information coordinately (Dien, 2008). Kossyln et al. (1989) showed a left hemisphere advantage in response time to categorical spatial judgments, while the right hemisphere maintained an advantage at distance judgments. Expanding on their previous research, Kossyln and colleagues also used PET (positron emission tomography) scan data to show that the left hemisphere was relatively more active during a categorical judgment task, and the right hemisphere was relatively more active during a coordinate judgment task (Kosslyn, Thompson, Gitelman, & Alpert, 1998). Slotnick and Moo (2006) showed a similar trend with increased activation in the left hemisphere during a categorical spatial memory task and increased activation in the right hemisphere for a coordinate spatial memory task.

Another common model of laterality states that the left hemisphere processes information analytically while the right hemisphere processes information configurally.

This theory is an extension of the previous theory, and states that the left hemisphere processes information based on component parts, while the right hemisphere processes information using spatial relations or as a unified whole (Dien, 2008). Classic studies by Yin (1969, 1970), for example, showed that the inversion of faces impaired the recognition abilities of subjects, while the inversion of other objects did not impair their recognition to such a large degree. The recognition of faces seems to rely on right hemisphere spatial processes, and the inversion severely inhibits their recognition while other items that rely on left hemisphere based component/part analysis are inhibited to a much lesser degree.

A fourth laterality model specifies that the left hemisphere is better at handling information and situations that are well rehearsed while the right hemisphere specializes in dealing with new and novel information (Dien, 2008). Several studies have shown that practice can lead to a shift in the lateralization of certain items from the right hemisphere to the left hemisphere. A classic study with melodic recognition found that naïve individuals processed the overall melody with the right hemisphere, while trained musicians seemed to process the information in the left hemisphere (Bever & Chiarello, 1974). This theory, however, has several inconsistencies with other research. First, Bever and Chiarello (1974) actually attribute the differences between left hemisphere and right hemisphere processing to a holistic representation of the melody in naïve listeners and a component representation in the trained musicians. Also, facial recognition studies show that practice leads to a right hemisphere advantage in processing faces (Yin, 1969; 1970). Finally, Gauthier, Skudlarski, Gore, and Anderson (2000) found increased right hemisphere activation of the fusiform face area when experts observed items in their area of expertise as compared to other objects.

Although all of the above mentioned perceptual theories of laterality have merit and substantial research evidence, each one suffers outside of its core domain. The final laterality model to be discussed was designed to offer a theory that can stretch across domains and provide an overarching cognitive structure to help explain perception and information processing as a coherent whole. The Double Filter by Frequency model posits that first, all spatial and auditory frequencies that are important to the task at hand are selected for further processing. Then the left hemisphere has an advantage at processing the relatively high frequency information, while the right hemisphere has an advantage at processing the relatively low frequency information that is passed along (Ivry & Robertson, 1998; Robertson & Ivry, 2000).

The original research that lead to the formation of Double Filter by Frequency theory began as work with the spatial frequency hypothesis, which stated that the right hemisphere had an advantage at processing absolute low frequency information, while the left hemisphere had an advantage at processing absolute high frequency information. Sergent (1982) showed participants a set of target letters to identify in the experiment. They were then shown a series of large letters constructed from smaller letters and were asked to determine if a target letter was present. When the judgment could be made based upon the large letter, and low frequency information, participants were quicker when the information was presented to the left visual field (right hemisphere). Similarly, when the judgment required the processing of the small letter in order to make a decision, participants were quicker when the information was presented to the right visual field (left hemisphere).

Expanding upon the spatial frequency hypothesis, Kitterle, Christman, and Hellige (1990) presented participants with high and low spatial frequency sinusoidal gratings in both the left visual field and right visual field. In separate experiments they discovered that no hemispheric advantage existed for a detection task, but that the predicted right hemisphere advantage for low frequency information and left hemisphere advantage for high frequency information appeared during an identification task. Christman, Kitterle, and Hellige (1991) also showed that the introduction of a relative frequency item (i.e. a high or low spatial frequency from some baseline) could shift the asymmetry in processing that stimulus to either the opposite hemisphere, or eliminate the hemispheric advantage all together. This lack of a detection effect and the effects caused by the introduction of another frequency item into a stimulus set began to point to a relative, instead of absolute, advantage for either hemisphere in the processing of visual information.

In 1993, Ivry and Lebby extended this relative frequency hypothesis into the auditory domain. Over a series of four experiments they presented participants with various stimuli sets that consisted of tones that surrounded an unheard tonal mean (e.g., 192, 195, 198, 202, 205, 208 Hz) and were played monaurally to both the left and right ears. The participants were required to distinguish if the presented tone was above or below the mean of that particular set. Consistent with the relative frequency findings in the visual domain, participants were quicker at discriminating the relatively low frequency tones in the left ear (right hemisphere) and made fewer errors. When discriminating between the relatively high frequency tones, participants were quicker, and made fewer errors, when the information was presented to the right ear (left hemisphere). The last crucial finding from this study was that the absolute frequency did not interact with ear of presentation.

Using the results of the 1993 audition experiment, and the spatial frequency work developed by other researchers (e.g. Christman, Kitterle, & Hellige, 1991; Kitterle, Christman, & Hellige, 1990; Sergent, 1982), Ivry and Robertson developed Double Filter by Frequency theory to account for the various findings within, and across, the previous laterality domains. For example, Double Filter by Frequency theory would reinterpret the findings of Kossyln and colleagues (Kossyln et al. 1989; 1998) by examining the frequencies needed to make the appropriate judgments. In the case of categorical versus coordinate judgments, Ivry and Roberston (1998) would argue that high spatial frequencies are extremely important for making the categorical distinction as the details conveyed make the clear separations between items easier to see. At the same time they inhibit the recognition of the coordinate relationship between the items. Similarly, the low frequency information makes the coordinate judgments easier by allowing the distinct items of the stimulus to stand out.

Although Ivry and Robertson originally intended Double Filter by Frequency to apply to visual and auditory perception and processing, several researchers have worked to extend Double Filter by Frequency into the realm of higher cognitive functions, such as decision making (Corser, Voss, Jasper, & Mytyk, 2013; Gallagher & Dagenbach, 2007; Seta, McCormick, Gallagher, McElroy, & Seta, 2010). Most of this additional work has been conducted within the context of a decision making paradigm known as framing.

Information Framing

Framing can most easily be described as a manipulation of the salience of information. This salient information is often used to drive decisions despite a lack of actual, or objective, change within the presented material. The original manipulation was proposed by Tversky and Kahneman with a paradigm known now as risky choice framing. In risky choice framing, participants are presented with a scenario in which they can make either a risk seeking or risk averse decision. The overall expected utility of the desired outcome is kept the same in both choices, but the salient information is manipulated. This altered salience results in differing perspectives, or "frames of reference," for each condition. For example, Tversky and Kahneman (1981) presented participants with the following scenario:

> Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the program are as follows:

Some participants were then presented with the following decision where the positive frame was made salient:

If Program A is adopted, 200 people will be saved.

If Program B is adopted, there is a 1/3 probability that 600 people will be saved, and a 2/3 probability that no people will be saved.

Which of the two programs would you favor?

Other participants were presented with a decision where the negative frame was made salient:

If Program C is adopted, 400 people will die.

If Program D is adopted, there is a 1/3 probability that nobody will die, and a 2/3 probability that 600 people will die.

Which of the two programs would you favor?

Although program A and program C are identical (i.e. 200 of 600 lives saved is equivalent to 400 of 600 people dying), as are programs B and D, and all four programs have the same expected utility for the number of lives saved (i.e. the expected utility of lives saved in each scenario is 200. In scenarios B and D a 1/3 probability of saving 600 lives is equivalent to 200 lives saved on average), Tversky and Kahneman (1981) noticed a large shift in the direction of one's decision in each frame. When a situation's gains (positive outcomes) are made salient, people tend to be risk averse (Kahneman & Tversky, 1984; Tversky & Kahneman, 1981). In the 1981 study, for example, 72 percent of participants preferred program A (the sure thing or a risk averse option) over program B. In contrast, when a situation's losses (negative outcomes) are made salient, people tend to be risk seeking. When presented with programs C and D, for example, 78 percent of participants chose program D (the probabilistic or risky option).

This work encouraged other researchers to extend framing beyond risky choice into other types of framing (Levin, Schneider, & Gaeth, 1998). One of these other types has become known as attribute framing. In attribute framing, a single attribute or characteristic of an object, event, or piece of information is manipulated in regards to valence. In addition, the dependent variables measure evaluation of the manipulated stimuli instead of asking participants for a direct choice. In early studies Levin (1987), for instance, asked participants to evaluate the fat vs. lean content, the quality (high vs. low), grease content (greasy vs. greaseless), and the taste (bad vs. good) of ground beef that was labeled as either "75% lean" or "25% fat." This single, yet equivalent, label change (or attribute frame) produced a significant shift in the evaluations (or judgments) that participants had about the beef. The beef that was described as "75% lean" was rated as leaner, higher in quality, less greasy, and better tasting, than the "25% fat ground beef". In a follow up study, Levin and Gaeth (1988), provided participants with the same-labeled beef as the previous study, and allowed participants to actually taste the beef. Although the framing effects were reduced with product experience, there were still significant differences on the fat/lean dimension, low/high quality dimension, and the greasy/greaseless dimension when the beef label was presented prior to tasting. The presence of any effects after being exposed to the taste of the actual beef emphasizes the powerful effects that such a simple change in the framing of information can have for behavior.

Jasper, Goel, Einarson, Gallo, and Koren (2001) extended this work and explored the effects of attribute framing by altering the frame of the associated tetratogenic risks of taking allergy medication during pregnancy. In the negative frame condition, pregnant, or soon to be pregnant, women were told: "In every pregnancy, there is a 1-3% chance that a women will give birth to a child who has a major birth defect. This/these drug(s) [insert applicable drug name] has/have not been shown to change that. The positive frame was worded as follows: "In every pregnancy, there is a 97-99% chance that a women will give birth to a child who does not have a major birth defect. This/these drug(s) [insert applicable drug name] has/have not been shown to change that." They found that the associated risk estimates (on a 100 point scale) made by the women involved in the study were significantly higher when they were exposed to the negatively framed message. Also important to note, the ratings were made between 1 and 4 days after the initial presentation of the information, providing evidence that the framed message is not restricted to immediate behavior, but can have longer term effects as well.

Finally, other researchers have expanded the type of framing into what is known now as goal, or message, framing. Levin, Schneider, and Gaeth (1998) describe goal framing as an attempt to enhance the evaluation or persuasion of information by stressing either the positive consequences of performing the behavior (positive frame) or the negative consequences of not performing the behavior (negative frame). A distinguishing feature of goal framing manipulations is that both framing conditions promote the same act. In a classic study, Meyerwitz and Chaiken (1987) showed that the negative frame was more influential than the positive frame in persuading women to perform breast self-examinations.

A few years later, Detweiler, Bedell, Salovey, Pronin, and Rothman (1999) found that the positive frame, as compared to the negative frame, motivated individuals to use sunscreen if they originally did not intend to use it. This has lead to a recent research focus on the differences between the framing effects of detection based behaviors, like the breast self examination above, that seem to be influenced to a greater extent by the negatively framed information and prevention based behaviors, like the sunscreen example, that seem to be influenced to a greater degree by the positively framed information. Important to the scope of this proposal, however, is that the framed information impacts the evaluation and completion of the goal directed behavior.

Hemispheric Influences on Decision Making

Although the content and wording of a message can have a profound impact on an individual's decision processes, underlying hemispheric differences have also been shown to have large, sometimes interactive effects. McElroy and Seta (2004), in one of the first of these studies, set out to explore these differences with risky choice framing. In their first experiment they provided participants with the Asian disease paradigm while simultaneously having them tap a finger on their left or right hand. This finger tapping was believed to elicit activation in the contralateral hemisphere and allow the selected hemisphere to "taint" the decision with its respective processing style. They found that participants who tapped a finger on their right hand, thus inducing left hemisphere activation, did not produce the standard framing effect, while participants who tapped a finger on their left hand, inducing right hemisphere activation, did show the expected choice reversal. This moderation to the framing effect was attributed to the left hemisphere's analytic processing style and the right hemisphere's holistic (contextualizing) processing style. As a follow up, they presented another set of participants with the Asian disease paradigm monaurally to either the left or right ear using headphones. Consistent with their earlier results, participants who heard the framed information auditorily in their right ear (left hemisphere activated) did not show the framing effect, while participants who heard the framed information in their left ear (right hemisphere activated) showed the expected preference reversal.

Jasper, Fournier, and Christman (2014) found similar effects in an attribute framing paradigm where mixed (inconsistent) handed individuals, who are believed to have greater natural access to right hemisphere based processes, were compared to strong (consistent) handed individuals, who rely more on left hemisphere based processes. Here, participants were presented with a laboratory replication of Jasper et al. (2001) where they were asked to provide teratogenic risk estimates for a fictional friend after being exposed to the base rates of having a child without a birth defect (97-99%, positive frame) or a child with a birth defect (1-3%, negative frame). They found that mixed handed individuals experienced more belief updating to the framed information and showed a nominal framing effect while strong handed individuals showed no difference between the conditions. They argued that mixed handed individuals may be driving attribute framing effects.

Finally, McCormick and Seta (2012) used a dichotic listening procedure and exposed participants to a verbal goal framing paradigm adapted from Detweiler et al. (1999). In dichotic listening, participants listen to information in either their left or right ears while white noise is simultaneously played to the opposite ear. It has been shown that the information presented in this manner will then be primarily processed by the contralateral hemisphere. In this study participants experienced a framed message about the benefits of using sunscreen (positive frame) or the dangers of not using sunscreen (negative frame). When the framed information was presented to the right ear (left hemisphere activated), no differences were reported between the positive and negative frames. However, when the framed information was presented to the left ear (right hemisphere activated), a significant framing effect was found. Contrary to the original findings of Detweiler et al. (1999) however, the negative frame produced a greater amount of influence than the positively framed message. Whatever the root cause, it is clear that these hemispheric differences in processing can lead to behavioral changes in each of the three domains of framing.

Double Filter by Frequency Theory and Framing

Gallagher and Dagenbach (2007) also used framing manipulations and developed a procedure to systematically test the decision making effects hypothesized by Double Filter by Frequency theory. They presented participants binaurally with the Asian disease paradigm that was modified to present the framed information at either a relatively high, or relatively low auditory frequency. Within the recordings, there was a primary voice that was filtered to contain only frequencies between 798 Hz to 2411 Hz, and that presented the framed information. There was also a secondary voice that read a string of random words, and was presented at frequencies either above 2411 Hz or below 798 Hz. Lastly, the recordings also contained a track of white noise that was present at all frequency levels. The argument was that the first filtering stage of Double Filter by Frequency would filter out the white noise presented, allowing the primary voice and the secondary voice to be passed along to the second filtering stage. Once at the secondary filtering stage, the relatively high frequency information would be passed to the left hemisphere and the relatively low frequency information would be passed along to the right hemisphere. This would then allow for the left hemisphere and right hemisphere to take predominate roles in processing the framed information dependent on condition. Consistent with the findings of McElroy and Seta (2004), Gallagher and Dagenbach (2007), using an independent X^2 test in each condition, found that no significant framing effect was found when the framed information was presented in a relatively high frequency, but the standard preference reversal was seen when the framed information was presented in a relatively low frequency. Interestingly, when they exposed their findings to a hierarchical binary logistic regression, the results were no longer statistically significant, but the effect size still represented a moderate effect. Although the finding has been replicated multiple times, it is quite likely that the effect of frequency is inherently small and difficult to capture.

Following a similar procedure Seta, McCormick, Gallagher, McElroy, and Seta (2010) exposed participants to an attribute framing paradigm with a primary voice (1985 Hz – 3000 Hz), a secondary voice (above 4470 Hz or below 530Hz), and white noise. The primary voice contained the framed information while the secondary voice contained a string of random words. In this paradigm it is theorized that the white noise will be instantly recognizable as arbitrary to the task at hand and filtered out in the first filtering stage. Because participants are not told which information is important to the task at hand, and the voices are more difficult to discern, it is believed that both the primary and secondary voices will be passed along to the second filtering stage and directed to the respective hemisphere, dependent on condition, . Results showed that when the primary voice was presented in a relatively high frequency no significant framing effect was found, but when the primary voice was presented in a relatively lower frequency, the predicted framing effect was shown. Unfortunately, no known published research has explored the effects of Double Filter by Frequency on goal framing and thus offers an opportunity to expand the depth of knowledge in this specific area.

Hoping to enhance the ecological validity of Double Filter by Frequency, McCormick and Seta (2011) established a new manipulation procedure based on frequency amplification. Participants were exposed to a single primary voice that contained frequencies between 80 Hz and 4080Hz. In the relatively low frequency condition, all of the frequencies between 80 Hz and 2080 Hz were amplified by adding in a second filtered track of the primary voice that contained only the frequencies between 80 Hz and 2080 Hz. In the relatively high frequency condition a second audio track of the primary voice that contained only frequencies between 2080 Hz and 4080 Hz was added. Although diverging from traditional Double Filter by Frequency, the presence of both high and low frequency information allows for differential processing of the message in the respective hemispheres. McCormick and Seta had participants listen to an attribute framing paradigm where ground beef was described as either 85% lean (positive frame) or 15% fat (negative frame) within their new frequency paradigm. Consistent with past research, when the framed messages were played with the relatively high frequencies amplified (increased left hemisphere processing), no discernable framing effect was found. In contrast, when the framed messages were presented with the relatively low frequencies amplified (increased right hemisphere processing), the positive frame resulted in significantly better product evaluations than the negative frame.

Corser, Voss, Jasper, and Mytyk (2013) sought to explore the effects of underlying brain organization with this new procedure. They presented participants with the same framed information as McCormick & Seta (2011), except that the high frequency condition had all frequencies above 2080 Hz amplified, and the low frequency condition had all frequencies below 2080 Hz amplified. Using handedness as a proxy measure for amount of access to right hemisphere based processes, they found that mixed handed individuals, consistent with past research, displayed the framing effect when they heard the information presented with the relatively low frequencies amplified, but not when the relatively high frequencies were amplified. At the same time, strong handed individuals displayed the framing effect when they experienced the information with the relatively high frequency amplified, but showed no framing effect when the low frequencies were amplified. It was argued that mixed handed individuals, who have greater access to right hemisphere based processes, experienced the framing effects when this right hemisphere processing was facilitated by the low frequencies of the message. Strong handed individuals, who are believed to rely more on left hemisphere based processes, only showed the framing effect when left hemisphere processing was facilitated by the relatively high frequencies of the message.

Inconsistency of Methodology and Results

As interesting as these results are, the findings have sometimes been inconsistent. This lack of consistency between methodology and results within the Double Filter by Frequency paradigms, in fact, is the driving force behind the current investigation.

First, the inconsistency of the results across the above studies indicates a further need for an investigation into the mechanisms of Double Filter by Frequency theory.

Three of the previously mentioned studies found evidence for an interaction between relative frequency and frame, such that the framing effect was only experienced when right hemisphere processing was facilitated by the relatively low frequency presentation of information(Gallagher & Dagenbach, 2007; McCormick & Seta, 2011; Seta et al., 2010). However, another one study found no overall effect of relative frequency unless participants' underlying brain organization was taken into account. (Corser et al., 2013).

Next, the methodological inconsistencies between the previous studies could result in the presentation of differing amounts of information across conditions. Gallagher and Dagenbach (2007) and Seta et al. (2010) chose to maintain the frequencies of the main message, while modifying the presence of information with frequency ranges either above or below the main message. This allowed each group to actually hear different frequency ranges overall. Using this methodology it's possible that the presence of the additional information, and not the main message, initiated differential hemispheric processing.

Another methodological concern arose in McCormick and Seta (2011) and Corser et al. (2013). Here, the studies modified a single message to contain amplified low or high frequencies along a linear scale. Because of the logarithmic nature of sound representation in speech production and comprehension, the use of a linear scale could again result in different amounts of information being presented to participants.

Finally, most of the previous work has been conducted on the same attribute framing paradigm (i.e. 85% lean ground beef vs 15% fat ground beef) without sufficient investigation into the generalizability of the phenomenon.
(Corser et al., 2013; McCormick and Seta, 2011; Seta et al. 2010).

In order to accurately assess Double Filter by Frequency theory, the current investigation uses several frequency ranges, each of which incorporates relatively high frequency information and relatively low frequency information. These frequency conditions are designed to separate the effects of relative and absolute frequency. The frequency manipulations will also be given across 3 separate framing paradigms to examine the generalizability of previous findings. Consistent with the Double Filter by Frequency theory, it was hypothesized that all conditions that contain framed information in the relatively low frequency of the overall message would produce a standard framing effect. Conditions that present the framed information in the relatively high frequencies, in contrast, were hypothesized to produce no significant framing effect.

Chapter Two

Method

Participants

There were a total of 275 participants who completed this study at the University of Toledo**.** These participants were drawn from a research pool of introductory psychology students and completed the study in exchange for course credit. Of the 275 participants who completed the study, 4 of the participants were excluded because of a procedural change early in the study, 10 participants were excluded because of an initial error in the program coding, 7 participants were excluded because of a computer error resulting in missing data, 4 participants were excluded because they failed to follow directions, 2 participants were excluded because of an experimenter error during the presentation of materials, and 3 participants were excluded because of health conditions that affected their hearing. The remaining 245 participants were used for the data analyses presented

Setting

This study was completed in a small computer lab that featured 8 separate computer workstations. Participants completed the study using 2010 Apple iMac® and Dell OPTIPLEX 9020 AIO computers. Participants completed the study independently, with up to 3 other participants completing the study at the same time, in the same computer lab. The study materials were presented using Medialab™ v2010 and v2012. The auditory framing paradigms were prerecorded and presented using Audio-Technica ATH-ANC27 QuietPoint® headphones.

Materials and Procedure

Participants first entered the lab and were given an informed consent form. After explanation of the form, and the signed agreement of the participants, they were presented binaurally with three framing paradigms recorded and modified using Audacity 1.3 Beta. The framing paradigms consisted of a primary voice, which contained the framed information, a secondary voice, which contained a random string of spoken words, and a track of white noise.

The frequencies of the primary and secondary voice were manipulated such that all frequencies below 500 Hz and above 8000 Hz were attenuated. This insured that the primary and secondary voices were presented in a total bandwidth of 4 octaves, which was constant across all conditions. The white noise consisted of all frequencies between 0 Hz and 20,000 Hz. In order to produce the relative frequency levels between the primary and secondary voice, each voice was manipulated separately.

In Frequency Condition 1, the primary voice contained frequencies between 500 Hz and 1000 Hz and the secondary voice contained frequencies between 1000 Hz and 8000 Hz. In Frequency Condition 2, the primary voice contained frequencies between 500 Hz and 2000 Hz while the secondary voice contained frequencies between 2000 Hz and 8000 Hz. In Frequency Condition 3, the primary voice contained frequencies between 500 Hz and 4000 Hz, while the secondary voice contained frequencies between 4000 Hz and 8000 Hz. Together these conditions constituted the “relatively low frequency” conditions.

To create the “relatively high frequency” conditions, these orders were reversed. In Frequency Condition 4, the primary voice contained frequencies between 1000 Hz and

8000 Hz, and the secondary voice contained frequencies between 500 Hz and 1000 Hz. In Frequency Condition 5, the primary voice contained frequencies between 2000 Hz and 8000 Hz, while the secondary voice contained frequencies between 500 Hz and 2000 Hz. Finally, in Frequency Condition 6, the primary voice contained frequencies between 4000 Hz and 8000 Hz, while the secondary voice contained frequencies between 500 Hz and 4000 Hz. For a summary of all six frequency conditions refer to Appendix B, Figure 1.

The three separate frequency conditions within the relatively high frequency set and the three separate frequency conditions within the low frequency set were required to adequately assess Double Filter by Frequency theory. First, they allowed for a distinction between the absolute and relative frequency of the message. In accordance with Double Filter by Frequency, the relative frequency of the message should drive the effect, but the possible effects of the absolute frequency need to be properly accounted for. If the relative frequency of the message is driving the effect, as predicted, than there would be no difference between participants responses between conditions in a single set (i.e. the relatively high frequency or relatively low frequency set). If the effect is driven by the absolute frequency, however, participants responses should vary systematically along with the frequency levels within a particular set. Second, by using several different relative frequency ranges, results in accordance with Double Filter by Frequency theory would provide evidence that the differing frequency ranges used throughout previous studies elicited the intended hemispheric processing, and can be directly compared. Finally, the chosen logarithmic set points for the proposed frequency ranges allowed for the modification of comparable octaves of information between the conditions.

Each participant experienced three framing paradigms in a single framing condition (positive or negative) and a single consistent frequency condition. These framing paradigms were presented binaurally and in a random order. First participants listened to a version of the Asian disease problem (either the positive frame, 200 lives will be saved, or the negative frame, 400 people will die), developed for risky choice framing. Next participants heard an attribute framing manipulation in which beef was described as “75% lean” (or “25% fat”). Finally, participants were exposed to a goal framing problem expressing the benefits of using sunscreen (or the consequences of not using sunscreen).

Although not part of the main analysis, the degree of handedness of the participants was also assessed using the Edinburgh Handedness Inventory, whereby participants recorded their hand use for ten common manual activities, such as writing, throwing, and opening jars (Oldfield, 1971). Next, a short questionnaire collected participant’s demographic information. Finally, participants were debriefed about the nature of the study, and thanked for their time. See Appendix C for a complete version of each framing manipulation and the associated dependent variables.

Chapter Three

Results and Analyses

Risky Choice Framing

In the Asian disease problem, participants had a dichotomous choice between a risk averse and a risk-seeking program. To directly test Double Filter by Frequency theory, the frequency conditions were collapsed into the 2 relative frequency conditions of the primary message. The relatively low frequency Condition were comprised of frequency Conditions 1, 2, and 3, while the relatively high frequency Condition was comprised of frequency Conditions 4, 5, and 6. A 2 x 2 factorial logistic regression was run using frame and relative frequency as predictor variables of choice. Wald's test indicated the overall fit of the regression model was a significant predictor of the decision outcome, $\chi^2(3, N=245)=21.80$, $p<0.001$. In this analysis the high frequency presentations were shown to be no different than the low frequency presentations, $\chi^2(1, N=245)=0.08$, $p=0.77$. Similarly, the interaction between relative frequency and frame was also not a significant predictor in the model, $\chi^2(1, N=245)=0.07$, $p=0.79$. The frame of the message, however, was shown to influences participant responses with the positive frame shown as a significant predictor of choice compared to the negative frame, $\chi^2(1, N=245)=11.4$, $p<0.001$. Collapsing across relative frequency, when hearing the message presented in a positive frame 94 participants chose the risk-averse option (75.8%) compared to 30 participants who chose the risk-seeking option (24.2%). When the message was presented in a negative frame, however, 57 participants chose the risk-averse option (47.1%) while 64 participants chose the risky option (52.9%). Participants exposed to the negatively framed message were significantly more likely to choose the risk-seeking option.

Because relative frequency was not a significant predictor in the model, a 2 x 6 factorial logistic regression was run using frame and frequency as predictor variables to investigate the impact of each frequency condition and interaction on choice. Wald's test again indicated the overall fit of the regression model was a significant predictor of the decision outcome, $\chi^2(11, N=245)=33.73, p<0.001$. Within the model, the significant effect of the positive frame when compared to the negative frame remained, $\chi^2(1, N=245)=4.2, p=0.041$. There was no significant overall effect of frequency when compared to frequency Condition 1, which presented the primary voice in the 500-1000 Hz frequency range, $\chi^2(5, N=245)=7.8, p=0.17$. Finally, the interaction between frame and frequency was also non-significant when compared to the interaction terms of negative frame and frequency Condition 1 (primary voice: 500 – 1000 Hz), $\chi^2(5, N=245)=5.4, p=0.37$.

Follow up Wald tests examined differences between individual regression predictor coefficients. There was a significant difference between frequency Condition 2 (primary voice presented in the frequency range of 500-2000 Hz) and frequency Condition 6 (primary voice presented in the frequency range of 4000-8000 Hz), $\chi^2(1, N=83)=4.0, p=0.046$. There was also a significant difference between frequency Condition 4 (primary voice presented in the frequency range of 1000-8000 Hz) and frequency Condition 6, $\chi^2(1, N=82)=5.2, p=0.023$. Finally, this was qualified by a significant interaction between frequency and frame when comparing frequency Condition 4 and frequency Condition 6, $\chi^2(1, N=82)=5.1, p=0.024$. In frequency condition 4 and the positive frame, 16 participants chose the risk averse option (80.0%) while 4 participants chose the risk-seeking option (20.0%). In frequency Condition 4 and the negative frame, 6 participants chose the risk-averse option (28.6%) while 15 participants chose the risk-seeking option (71.4%). In frequency Condition 6 and the positive frame, 14 participants chose the risk-averse option (66.7%) while 7 participants chose the risk-seeking option (33.3%). Finally, in frequency Condition 6 and the negative frame, 13 participants chose the risk-averse option (65.0%) while 7 participants chose the risk-averse option (35.0%). A full list of the model coefficients can be seen in Appendix A, Table 1. A summary of decision outcomes by condition can be seen in Appendix A, Table 2.

For presentation and explanatory simplicity, the risky-choice paradigm was also tested using a 2 X 6 ANOVA with frame and frequency entered as between-subjects independent variables. Participants' choices were dummy coded with 0 representing a risk-free choice and 1 representing a risk-seeking choice. In accordance with the results of the factorial logistic regression, the main effect of frequency was not significant, $F(5, 233)=1.29$, $p=0.269$, $\eta^2_p = 0.027$. The interaction between frame and frequency was similarly non-significant, $F(5, 233)=1.21$, $p=0.306$, $\eta^2_p = 0.025$. Finally, again consistent with previous results, the main effect of frame was significant, $F(1, 233)=1.29$, $p<0.001$, $\eta^2_p = 0.090$. See Appendix B, Figure 2 for the percentage of risk-seeking choices according to frame and primary voice frequency range.

The presence of a significant framing effect replicates previous research, and provides evidence that the paradigm was understood and completed correctly by participants. In sum, participants who experienced a positively framed message were more likely to choose a risk-averse option compared to individuals who experienced a negatively framed message.

Attribute Framing

In the beef attribute framing paradigm, participants rated 75% lean (25% fat) ground beef on four separate evaluative dependent variables, each assessed by a 7-point scale, and anchored by bipolar adjectives related to the variable of concern (greaseless/greasy, lean/fat, good testing/bad tasting, high quality/low quality). The taste and quality measures were reversed scored before analyzing data. This resulted in higher scores on the greaseless/greasy measure corresponding to higher ratings of grease for the beef, higher scores on the lean/fat variable corresponded to higher ratings of fat, higher scores on the good tasting/bad tasting variable corresponded to better ratings of taste, and finally higher scores on the high quality/low quality variable corresponded to better quality ratings.

Again, to directly test Double Filter by Frequency theory, analyses were conducted by collapsing frequency into the two relative frequency conditions (low vs. high). Four 2 x 2 factorial ANOVAs were conducted using frame and relative frequency as independent variables. These analyses yielded no significant main effects or interactions of the relative frequency conditions.

Consistent with the risky-choice framing analyses, the effects of the frequency conditions were then investigated independent of their relative frequency. This was done by computing four 2 x 6 factorial ANOVAs with frame and frequency entered as between-subjects independent variables. There was a marginally significant effect of frame on participants evaluations of grease, $F(1, 233) = 7.352$, $p = 0.070$, $\eta^2_p = 0.014$. Collapsing across frequency conditions, participants exposed to the negative frame reported the beef to be greasier (*M* = 4.107, *SD* = 1.617) than participants exposed to the positive frame (*M* = 3.758, *SD* = 1.370) (See Appendix B, Figure 3).

There was also a significant effect of frame on participants evaluations of fat content within the beef, $F(1, 233) = 17.310$, $p < 0.001$, $\eta^2_p = 0.069$. This main effect was qualified by a significant interaction between frame and frequency, $F(5, 233) = 4.149$, $p = 0.001$, $\eta^2_p = 0.082$. Follow up simple main effects analyses were conducted using the estimated marginal means. These follow up analyses indicated there was a significant difference between the positive and negative frame in frequency Conditions 3, 4, 5 and 6. In frequency Condition 3 ($F(1, 233)=9.090$, $p=0.003$, $\eta^2_p = 0.038$; positive: *M* = 3.00, *SD* = 1.81; negative: *M* = 4.47, *SD* = 1.59), frequency Condition 4 ($F(1, 233)=13.353$, $p<0.001$, $\eta^2_p = 0.054$; positive: *M* = 2.55, *SD* =0 .95; negative: *M* = 4.24, *SD* = 1.55), and frequency Condition 5 ($F(1, 233)=7.266$, $p=0.008$, $\eta^2_p = 0.030$; positive: *M* = 2.85, *SD* = 1.53; negative: *M* = 4.10, *SD* = 2.17), participants rated the beef as fatter when exposed to the negative frame. In contrast, participants in frequency Condition 6 rated the beef as leaner when exposed to the negative frame (*M* = 2.70, *SD* = 1.30) compared to the positive frame (*M* = 3.62, *SD* = 1.53), $F(1, 233)=3.958$, $p=0.048$, $\eta^2_p = 0.017$. Descriptively, the participants exposed to frequency Conditions 3, 4, and 5 experienced a greater standard framing effect compared to participants exposed to frequency conditions 1,2, or 6. These differential responses to the level of frequency across framing conditions can be seen in Appendix B, Figure 4.

Next, there was a marginally significant effect of frequency on participants evaluations of the taste of the ground beef, $F(5, 233) = 2.236$, $p = 0.052$, $\eta^2_p = 0.046$. As seen in Appendix B, Figure 5, participants reported that the ground beef would have tasted better in frequency Conditions 3, 4, and 5, regardless of information frame.

Finally, there was a significant main effect of frame on participants evaluations of quality, $F(1, 233) = 6.727$, $p = 0.010$, $\eta^2_p = 0.028$. This main effect was qualified by a marginally significant interaction between frame and frequency, $F(5, 233) = 2.189$, $p = 0.056$, $\eta^2_p = 0.045$. Follow up simple main effects analyses using the estimated marginal means indicated there was a significant difference between the positive frame and the negative frame for frequency Condition 3 ($F(1, 233) = 7.05$, $p = 0.008$, $\eta^2_p = 0.029$, positive: $M = 5.35$, $SD = 1.31$, negative: $M = 3.94$, $SD = 1.75$) and frequency condition 5 ($F(1, 233) = 5.80$, $p = 0.017$, $\eta^2_p = 0.024$; positive: $M = 5.40$ $SD = 1.19$, negative: $M = 4.19$, $SD = 2.32$).

Similar to the evaluations of fat, participants responded differentially to frequency across the different framing conditions as seen in Appendix B, Figure 6. Participants exposed to frequency Conditions 3 and 5 showed the greatest standard framing effect, while frequency Conditions 1, 2,4, and 6 showed no significant framing effect, or a descriptively reversed framing effect.

In sum, in the attribute-framing paradigm, significant, or marginally significant, effects of frame emerged for 3 of the 4 dependent variables. This replicates previous research, and provides evidence that participants understood the task and completed it correctly. A significant interaction between frequency and frame for participants' evaluations of the fat content and quality of the ground beef also emerged.

Goal Framing

In the sunscreen goal framing paradigm, participants rated their current affect (feelings) in response to the message on 7-point scales anchored by “not at all anxious”/”extremely anxious” and “not at all fearful”/”extremely fearful”. They also rated their behavioral intentions, first by answering “how often do you plan to use sunscreen during daily activities next summer?” on a 7-point scale, anchored by “never”/”always”. As a second measure they also provided their estimate of the number of times they would apply sunscreen during a day at the beach. Next, participants provided their risk estimates of contracting skin cancer (0% - 100%), and how these estimates would change if they did/did not use sunscreen (7-point likert scales anchored by “stay the same”/”decrease dramatically” and “stay the same”/”increase dramatically”). Finally, participants rated their anticipated affect on 7-point scales, using the following four questions: relief from applying sunscreen, unpleasantness from not applying sunscreen, regret from being prevented to use sunscreen, and anxiousness from being prevented from using sunscreen (all anchored by “not at all”/”extremely”). Following the procedure used in Jasper, Woolf, and Christman (2014) the current affect questions were combined into an immediate affect variable; the questions regarding the change in risk estimates were combined into a perceived efficacy variable; and the questions regarding anticipated affect were combined into an anticipated affect variable. The remaining variables were analyzed individually.

In a direct test of Double Filter by Frequency theory, relative frequency and frame were used as between-subjects independent factors in a series of 2 x 2 ANOVAs.

Relative frequency, frame, and the frequency x frame interaction were not a significant predictor in any analyses.

In accordance with the research conducted by Jasper et al. (2014), participants' intentions to use sunscreen prior to the study were recorded as a dichotomous predictor (user vs. non-user) and used in the remaining analyses. To investigate the effects of individual frequency condition, frame, and user status, a series of 2 x 2 x 6 factorial ANOVAs were then conducted using frame, user status, and frequency as independent between-subjects variables.

There was a marginally significant effect of user status on participant's immediate affect, $F(1, 221) = 3.673$, $p = 0.057$, $\eta^2_p = 0.016$. Participants who had previous intentions to use sunscreen reported increased immediate affect ($M = 3.11$, $SD = 1.24$) compared to participants with no prior intention ($M = 2.78$, $SD = 1.51$).

There was a significant effect of user status on participants' perceived efficacy, $F(1, 221) = 13.629$, $p < 0.001$, $\eta^2_p = 0.058$. Participants who held previous intentions to use sunscreen reported greater perceived efficacy ($M = 4.91$, $SD = 1.30$) compared to participants with no prior intention ($M = 4.20$, $SD = 1.63$).

For anticipated affect, there was also a significant effect of user status, $F(1, 221) = 71.270$, $p < 0.001$, $\eta^2_p = 0.244$. Participants who held previous intentions to use sunscreen reported that they would feel greater affect in the future by using, or being prevented from using, sunscreen ($M = 4.47$, $SD = 1.39$) compared to participants with no prior intention ($M = 2.92$, $SD = 1.42$).

Participants' assessed behavioral intentions indicated that individuals with prior intentions to use sunscreen were significantly more likely to say they would apply sunscreen in the future (M = 5.12, SD = 1.43) compared to individuals with no prior intentions (M = 3.35, SD = 1.72), $F(1, 221) = 68.63$, $p < 0.001$, $\eta^2_p = 0.237$. Participants with prior intentions also indicated that they would apply sunscreen more during a typical day at the beach (M = 3.19, SD = 1.77) than participants with no prior intentions (M = 2.64, SD = 2.13), $F(1, 214) = 19.06$, $p = 0.025$, $\eta^2_p = 0.023$.

Finally, participants assessed their risk of contracting skin cancer. This analysis yielded no significant effects of any predictor variables.

The lack of significant effects for frame or frequency in the goal-framing paradigm indicates that participants had some difficultly with the problem. The significant effects of the participants' previous intentions to use sunscreen shows that they relied on their established beliefs and feelings, rather than being influenced by the message. This paradigm was longer, contained more information, and was more complex than the attribute or risky-choice paradigms. If participants were unable to listen to, store, or use the information presented then these factors could have contributed to the lack of effects for the framing and frequency manipulations.

Chapter Four

Exploratory Analyses

After visual inspection of the above analyses, a descriptive pattern emerged, in which standard framing effects were much more likely to occur during frequency Conditions 2 through 5, but were rarely seen in frequency Conditions 1 or 6(see Appendix B, Figures 2 through 6). In this pattern, it appears that some joint aspects of these frequency conditions may be uniquely contributing to the reported effects.

To follow up on these patterns, frequency conditions were collapsed by number of octaves contained within the primary voice. Frequency Conditions 1 and 6 both contained a primary voice constructed from a single octave. Frequency Conditions 2 and 5 both contained a primary voice constructed from two octaves. Finally, frequency Conditions 3 and 4 both contained a primary voice comprised of three octaves.

Risky Choice Framing

A 2 x 3 factorial logistic regression using frame and the number of octaves comprising the primary voice as predictor variables was run. The overall fit of the model was significant, $\chi^2(5, N=245)=27.05, p<0.001$. Within this analysis, the Conditions that contained a primary voice comprised of 3 octaves was a significant predictor of choice outcome compared to the Conditions in which the primary voice was comprised of only a single octave, $\chi^2(1, N=245)=4.5, p=0.034$. In the single octave Condition, 58 participants chose the risk-less option (69%), while 26 participants chose the risky option (31%). In the three octave Condition, 45 participants chose the risk-less option (57.7%), while 33 participants chose the risky option (42.3%).

A follow up 2 x 3 ANOVA using frame and the number of octaves comprising the primary voice as independent between subjects variables was conducted. This analysis indicated that frame alone was a significant predictor of choice outcome, $F(1, 239)=23.69$, $p<0.001$, $\eta^2_p = 0.090$.

Because of the conflicting findings between these statistical analyses, the simple main effects of frame within each octave Condition were calculated. This analysis indicated that there was no difference between the frames when the primary voice was comprised of a single octave, $F(1, 239)=2.418$, $p=0.121$, $\eta^2_p = 0.010$. The effect of frame was significant, however, when the primary voice was comprised of two octaves, $F(1, 239)=8.833$, $p=0.003$, $\eta^2_p = 0.036$, or three octaves, $F(1, 239)=14.926$, $p<0.001$, $\eta^2_p = 0.059$. See Appendix B, Figure 7 for results graphed according to frame and number of octaves comprising the primary voice.

Attribute Framing

A series of 2 x 3 ANOVAs using frame and the number of octaves comprising the primary voice as independent between-subjects variables were conducted to investigate their effects on ratings of grease, fat, taste, and quality.

Their was a marginally significant effect of frame, $F(1, 239)=3.560$, $p=0.060$, $\eta^2_p = 0.015$, and the effect of the number of octaves that comprised the primary voice also approached significance, $F(2, 239)=2.541$, $p=0.081$, $\eta^2_p = 0.021$, on participants evaluations of grease. Descriptively, there was no difference between the positive and negative frame when the primary voice was comprised of a single octave. When the primary voice was comprised of two or three octaves, participants exposed to the negative frame rated the beef as greasier. See Appendix B, Figure 8.

For ratings of fat, there was a significant effect of frame, $F(1, 239)=17.310$, $p<0.001$, $\eta^2_p = 0.068$, with participants exposed to the negative frame rating the beef as containing more fat. This effect was qualified by a significant interaction between frame and the number of octaves comprising the primary voice, $F(2, 239)=7.321$, $p=0.001$, $\eta^2_p = 0.058$. As seen in Appendix B, Figure 9, and evidenced by simple main effects, there was no difference between frames when the primary voice was comprised of a single octave, $F(1, 239)=0.307$, $p=0.580$, $\eta^2_p = 0.001$. There was a significant effect of frame when the primary voice was comprised of two, $F(1, 239)=9.043$, $p=0.003$, $\eta^2_p = 0.036$, or three, $F(1, 239)=21.760$, $p<0.001$, $\eta^2_p = 0.083$, octaves.

Analyses of taste indicated that the octave comprising the primary voice significantly affected participants ratings, $F(2, 239)=4.443$, $p=0.013$, $\eta^2_p = 0.036$. Comparisons of this main effect using independent sample *t*-tests indicated that there was a difference between conditions when the primary voice was comprised of a single octave compared to two octaves, $t(165)=-2.224$, $p=0.028$, $d=-0.346$, or three octaves, $t(160)=-2.922$, $p=0.004$, $d= -0.462$. There was no difference between the two and three octaves conditions $t(159)=-0.577$, $p=0.565$, $d=-0.090$. The ratings of taste by number of octaves comprising the primary voice and frame can be viewed in Appendix B, Figure 10.

Finally, there was a significant main effect of frame on participants ratings of quality, $F(1, 239)=6.762$, $p=0.010$, $\eta^2_p = 0.028$, with participants exposed to the positive frame rating the beef as higher quality. This was qualified by a significant interaction with number of octaves comprising the primary voice, $F(2, 239)=4.569$, $p=0.011$, $\eta^2_p = 0.037$. Follow up simple main effects analyses indicated that there was a significant framing effect when the primary voice was comprised of two, $F(1, 239)=7.411$, $p=0.007$,

$\eta^2_p = 0.030$, or three, $F(1, 239)=7.253$, $p=0.008$, $\eta^2_p = 0.029$, octaves. There was no difference between participants ratings when they were exposed to a primary message comprised of only a single octave. See Appendix B, Figure 11.

Goal Framing

Analyses investigating the relationship between number of octaves in the primary voice, participants' prior intentions to use sunscreen, and the frame of the information yielded no significant effects or interactions besides the main effects of previous intentions that were previously reported.

Chapter Five

Discussion and Conclusion

The overall purpose of the current study was to address several inconsistencies in past research. According to Double Filter by Frequency theory, participants should process the relatively low frequency information of a message primarily in the right hemisphere, while the relatively high frequencies should be processed primarily by the left hemisphere. It was hypothesized that the right hemisphere would engage in contextual processing, and exhibit the standard framing effect. The left hemisphere was hypothesized to engage in analytical processing, and would answer the questions in a more detail-oriented fashion, eliminating the standard framing effect.

Taken together, the results of this study indicate that relative frequency alone may be insufficient to properly study the effects of Double Filter by Frequency Theory. Across two paradigms, the effects of framing were shown to differ across several frequency conditions in which a primary voice contained varying absolute frequency levels, while still remaining relative to a secondary voice. That is, when the primary voice was presented as the relatively low frequencies of the message, it did not produce a standard framing effect. Also inconsistent with hypotheses, when the primary voice was presented as the relative high frequencies of the message, the standard framing effect was not diminished.

This study also addressed the use of different overall frequency ranges in previous studies by presenting every participant with a set frequency range, and adjusting the frequency levels of the primary and secondary voices within this overall range. The presence of standard framing effects in two of the framing paradigms provides evidence that the primary voice was attended to and comprehended. This does help to validate one aspect of the previous Double Filter by Frequency Theory research. Specifically, the presence of the secondary voice in those studies seemed to alter the processing of the primary voice, but was not directly responsible for the observed effects.

Finally, because of the logarithmic nature of sound perception, the stimulus materials in this experiment were created using a logarithmic scale, which was a departure from previous research. Participants were exposed to 4 octaves of frequencies between the primary and secondary voices. In each condition the number of octaves comprising the primary voice (1, 2, or 3), and it's location in the overall band (relatively high, relatively low) differed. Interestingly, exploratory analyses revealed that the number of octaves comprising the primary voice was a significant predictor of participants' responses for many of the tested questions. When participants were presented with the framed message in only a single octave, the framing effect was diminished. When the framed information was presented in a bandwidth of 2 or 3 octaves, however, the standard framing effect was seen. This may indicate that the hemispheric activation purportedly caused by frequency could be more complex than previously theorized. Using the Analytic/Holistic theory of laterality, which has been used at times in conjunction with Double Filter by Frequency, participants in this study responded relatively more analytically at the extremes of the frequency conditions (when the primary voice was presented in a single octave), and thus could have experienced relatively more left hemisphere activation. Conversely, in the middle of the frequency ranges (when the primary voice was comprised of 2 or three octaves), participants responded inline with a more holistic representation of the information, and thus could have experienced greater right hemisphere activation.

This possible difference in hemispheric activation could be the result of the difficulty of the task. When the framed information was presented to participants in only a single octave, it's possible that the task was more difficult, and forced participants to more actively attend to the information. This could, in turn, have lead to deeper, more analytic processing. Because the task may have been easier when the information was presented to participants in 2 or 3 octaves, they may not have attended to the information as actively, which may have facilitated a holistic processing style. It's also possible that the perceptual fluency of the information, which has been shown to influence many judgments and decisions (Oppenheimer, 2008), differed across octaves. It's possible that the information presented in the single octave was less fluent, and participants showed no framing effect in this condition because they could not effectively process the information (or, similar to the depth of processing explanation, the disfluent stimuli could have forced more system two/analytic processing). As the number of octaves increased in the primary voice, the fluency could have similarly increased. This could then have lead to the 2 and 3 octave conditions producing the standard framing effect, and could help underlie the descriptive differences seen between these two conditions. Less interesting, but perhaps more parsimonious, it's also possible that participants simply could not hear the primary voice at all in the single octave conditions, and the diminished framing effect was simply the result of participants' random guessing.

As previously stated, the hypothesized effects of Double Filter by Frequency theory were not seen in this study. Future research should incorporate measures of both absolute and relative frequency of the primary voice to properly assess the complex relationship that has emerged in this study. This can be accomplished by using several frequency ranges to create the primary voice, and then entering each individual condition into the final analyses. The effects of the number of octaves that comprises the primary voice, and their relation to the relative frequencies of the message should also be investigated. This can be accomplished by conducting a study in which a framed message is first presented in several octaves (without a secondary voice) and noting the effects, and then introducing a secondary voice across several octaves (overlapping, relatively higher, relatively lower) and recording any differences from the primary voice alone conditions.

No definitive conclusions can be drawn about Double Filter by Frequency theory from the current investigation, however. First, the paradigms differed between previous research and the study explained above. It's possible that the differences in presentation methods and stimuli creation could underlie the differences in reported effects. Also, according to Double Filter by Frequency theory, if the frequencies of the primary voice alone were interpreted as being important to the task at hand, only this information would have passed through the first filtering stage. This would have resulted in both the left and right hemisphere receiving the framed information, and the lack of a relative frequency effect. One conclusion is warranted, Double Filter by Frequency theory requires additional research before it can be accepted as a unifying theory of lateralized cognition.

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Appendix A

Tables

Table 1

Risky Choice Framing:
Predictors of a Risk-Seeking Choice

	Risk-Seeking Choice		
Variable	Coefficient	Std. Error	Wald's Test (χ^2)
Intercept	-0.2877	0.4410	-0.652
Frequency 2	0.9808	0.6393	1.534
Frequency 3	0.4055	0.6562	0.618
Frequency 4	1.2040	0.6540	1.841
Frequency 5	0.1924	0.6208	0.310
Frequency 6	-0.3314	0.6436	-0.515
Frame	-1.5581	0.7618	-2.045*
Frequency2:Frame	0.1719	1.0045	0.171
Frequency3:Frame	0.3417	1.0408	0.328
Frequency4:Frame	-0.7444	1.0612	-0.701
Frequency5:Frame	0.2672	1.0411	0.257
Frequency6:Frame	1.4840	1.0072	1.473

Note. N=245. Std. Error = Standard Error. Predictors of a risk-seeking choice during the Asian Disease paradigm. Frequency condition 1 and the negative frame were used as comparison points. Frequency2 represents frequency condition 2, etc. Frequency2:Frame represents the interaction between frequency condition 2 and framing, etc.
* $p < 0.05$.

Table 2

Risky Choice Framing:
Decision Outcomes by Condition

Frequency	Frame	Decision Outcome Risk-Averse	Risk-Seeking
500 - 1000	Positive	19 (86.4%)	3 (13.6%)
	Negative	12 (57.1%)	9 (42.9%)
500 - 2000	Positive	14 (66.7%)	7 (33.3%)
	Negative	7 (33.3%)	14(66.7%)
500 - 4000	Positive	15 (75.0%)	5 (25.0%)
	Negative	8 (47.1%)	9 (52.9%)
1000 - 8000	Positive	16 (80%)	4 (20%)
	Negative	6 (28.6%)	15 (71.4%)
2000 - 8000	Positive	16 (80%)	4 (20%)
	Negative	11 (52.4%)	10 (47.6%)
4000 - 8000	Positive	14 (66.7%)	7 (33.3%)
	Negative	13 (65%)	7 (35%)

Notes. Frequency corresponds to the frequency range of the primary voice. Risk-averse and risk-seeking columns report the number (percentage) of choices across individual frequency/frame conditions.

Appendix B

Figures

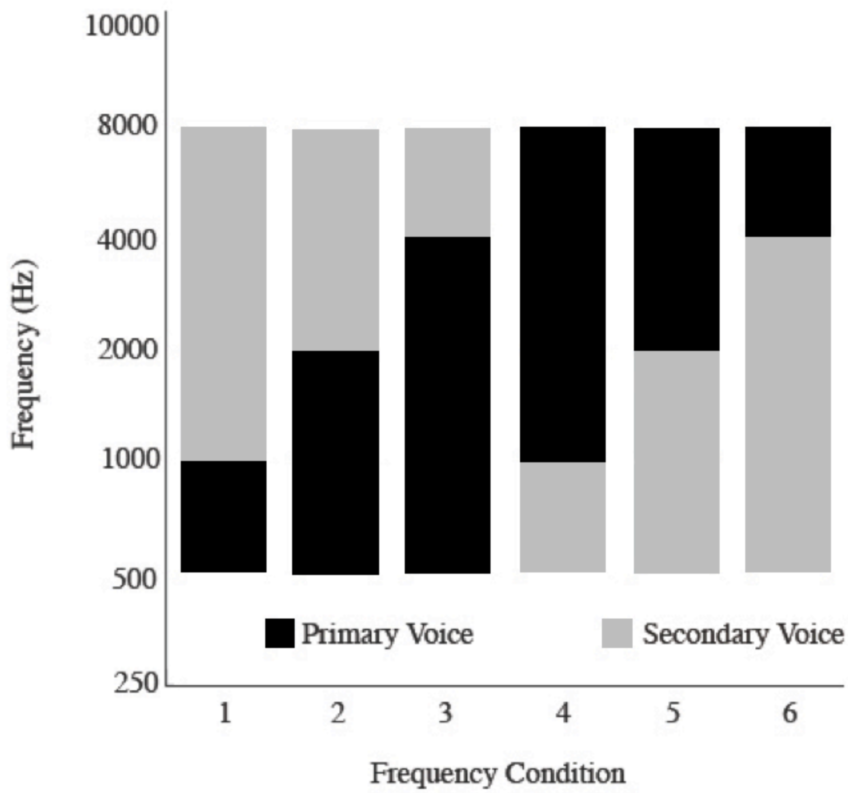

Figure 1. Graphical representation of the frequency conditions studied. All conditions contained frequencies between 500 Hz and 8000 Hz. The relative level of the primary voice, which contained the specific information necessary for each framing problem, was manipulated by the addition of a secondary voice at either higher or lower frequencies. Conditions 1 – 3 together represented the relatively low frequency conditions, while conditions 4 – 6 represented the relatively high frequency conditions.

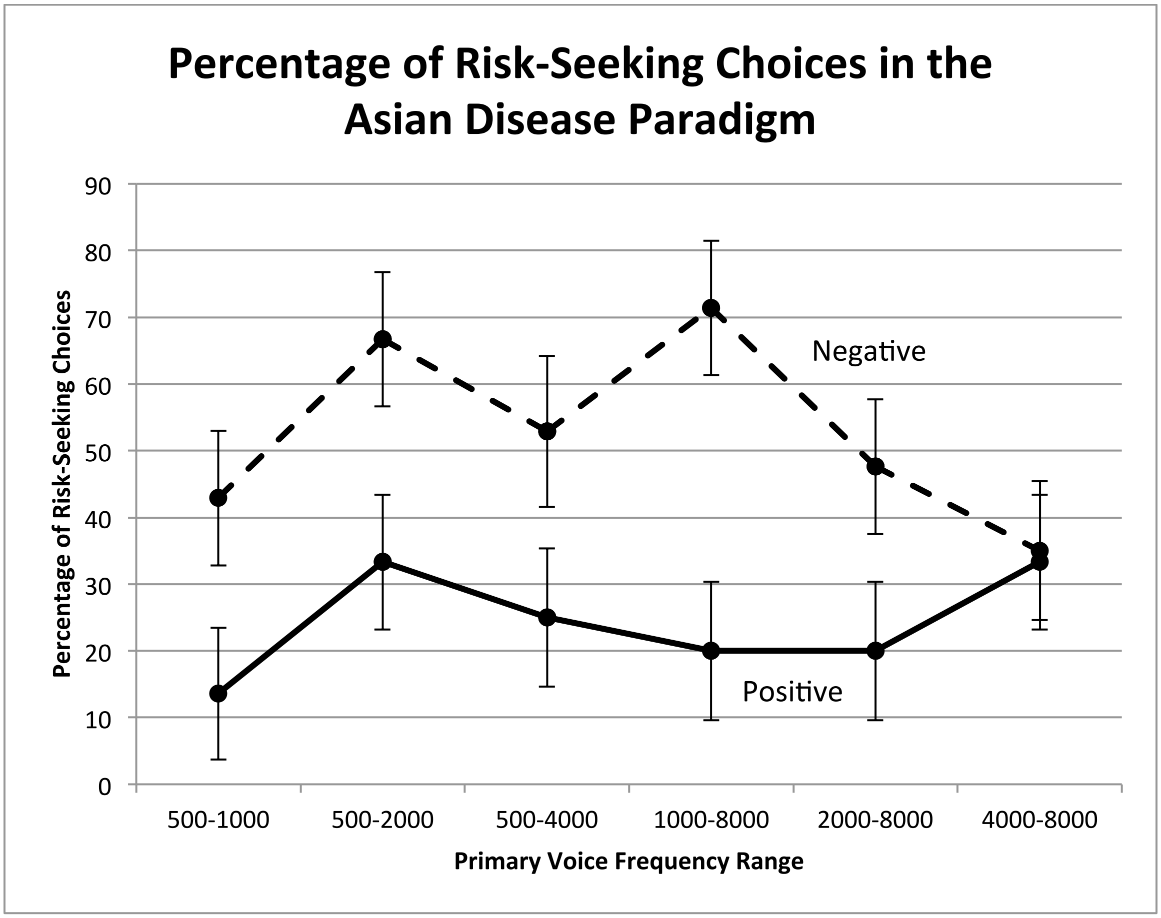

Figure 2. Percentage of risk-seeking choices in the Asian disease paradigm by frequency condition. There was a significant main effect of frame, with participants exposed to the negative frame choosing the risk-seeking option more often. Error bars represent the standard error of the mean when a risky choice was coded as 1 while a riskless choice was coded as 0. This value was then transformed into a percentage.

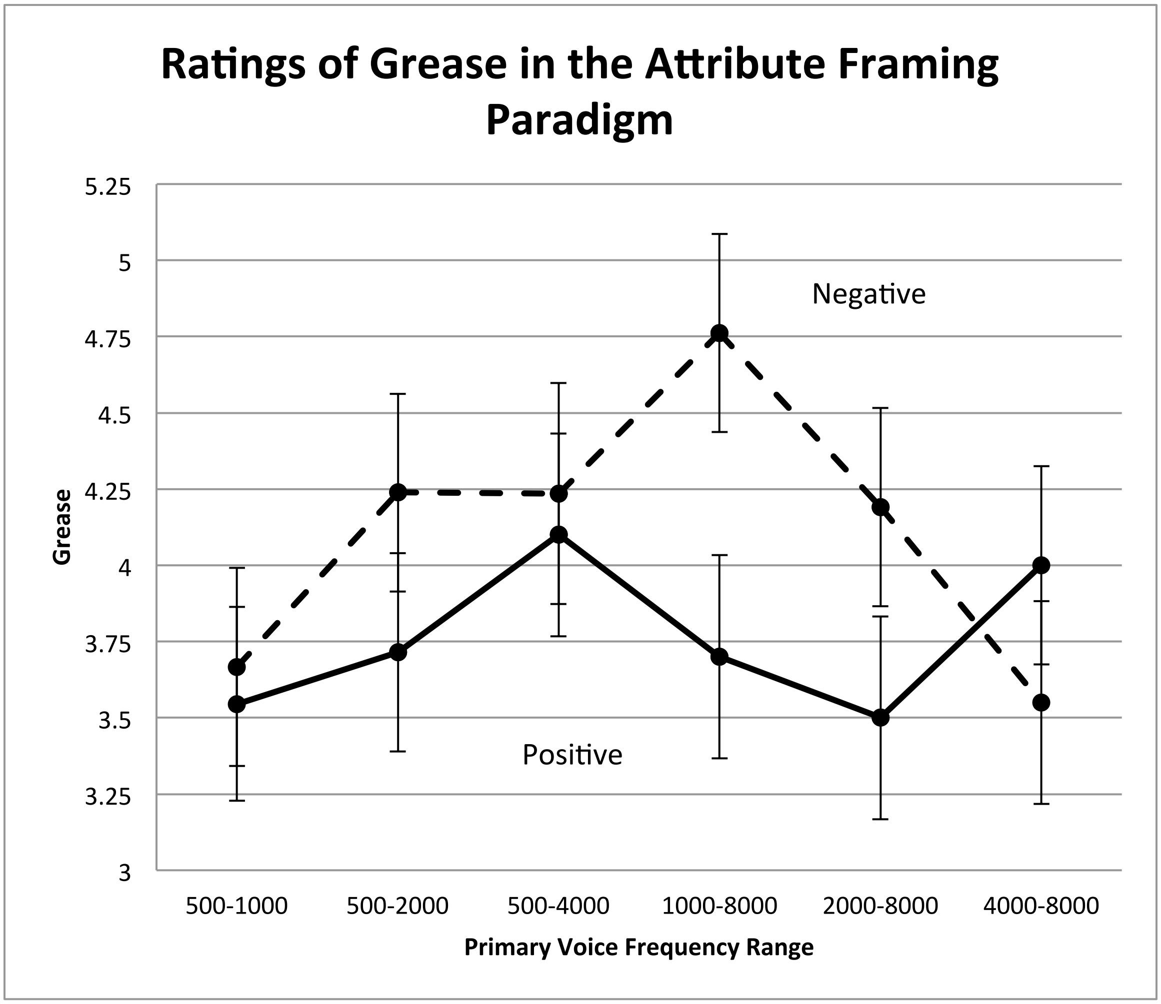

Figure 3. Rating of grease by frame and frequency. Positive and negative labels correspond to the framing condition. Ratings of grease were made on a 7-point likert type scale anchored by grease-less (1) and greasy (7). There was a marginally significant main effect of frame with participants exposed to the negative frame rating the beef as greasier. Error bars represent the standard error of the mean in each condition.

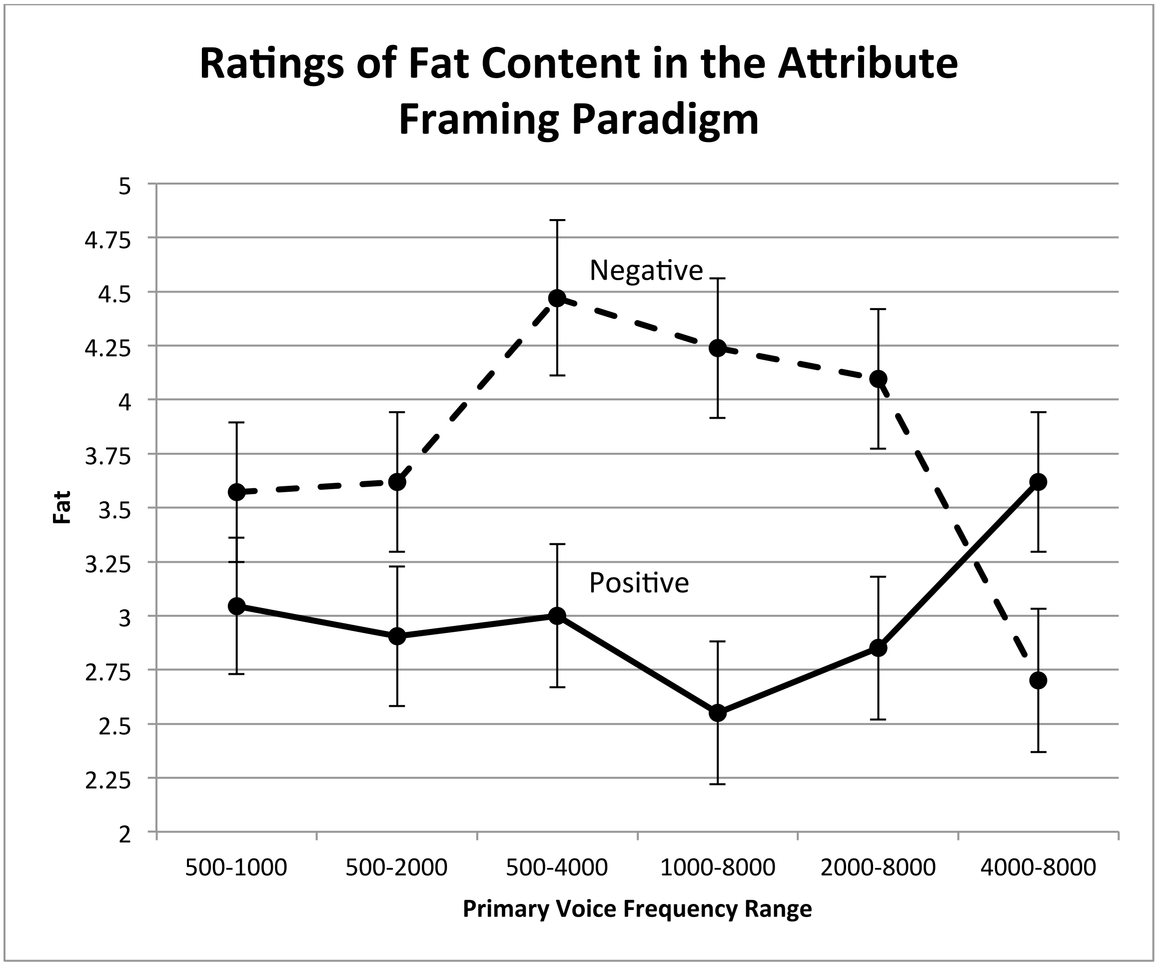

Figure 4. Interaction of frequency and frame for ratings of fat content. Positive and negative labels correspond to the framing condition. Ratings of fat content were made on a 7-point likert type scale anchored by lean (1) and fat (7). There was a significant interaction between frame and frequency, with a significant simple main effect of frame for the following frequencies of the primary voice: 500-4000, 1000-8000, 2000-8000, and 4000-8000. Error bars represent the standard error of the mean in each condition.

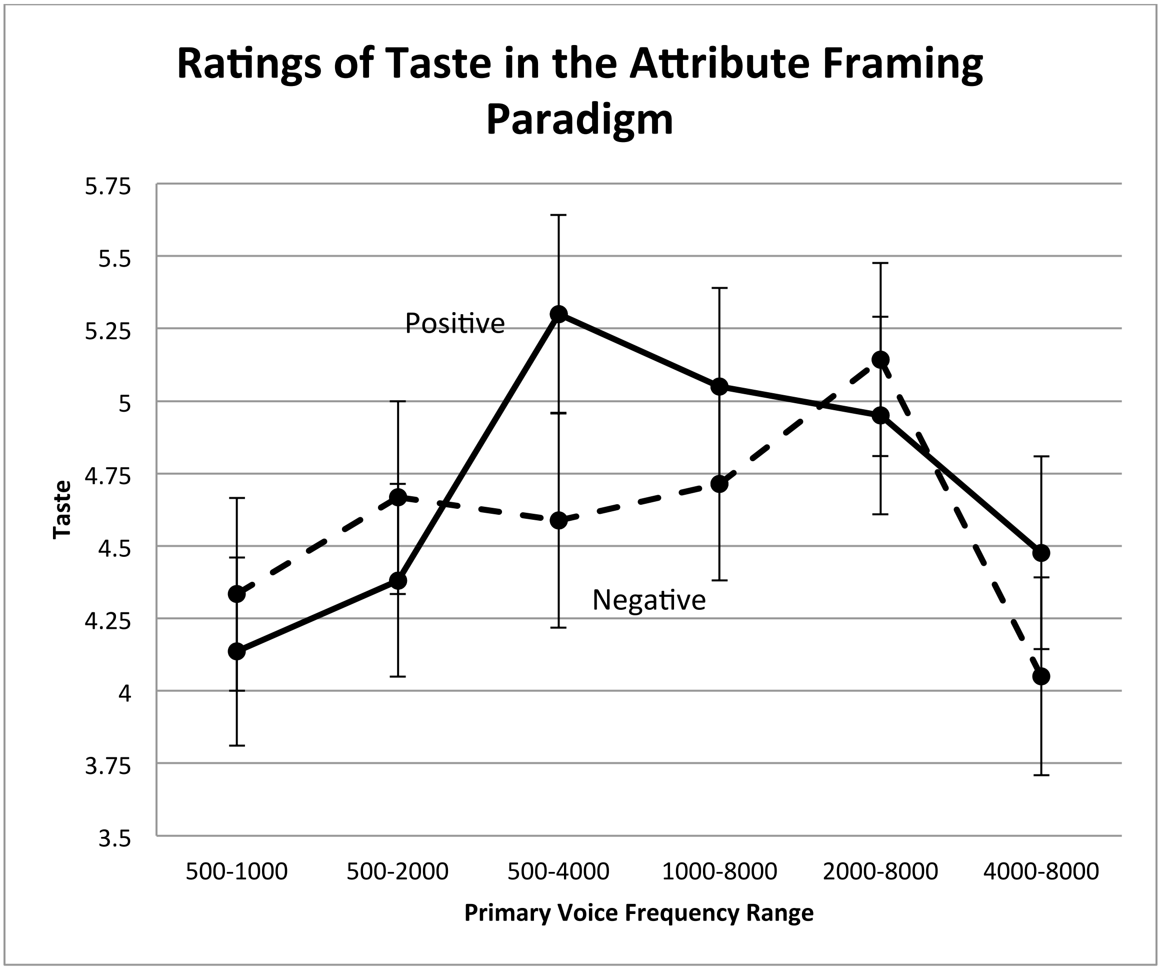

Figure 5. Ratings of taste by frequency and frame. Ratings of taste were made on a 7-point likert type scale anchored by bad tasting (1) and good tasting (7). There was a marginally significant effect of frequency, with participants rating the beef as better tasting in the middle frequency conditions. Error bars represent the standard error of the mean in each condition.

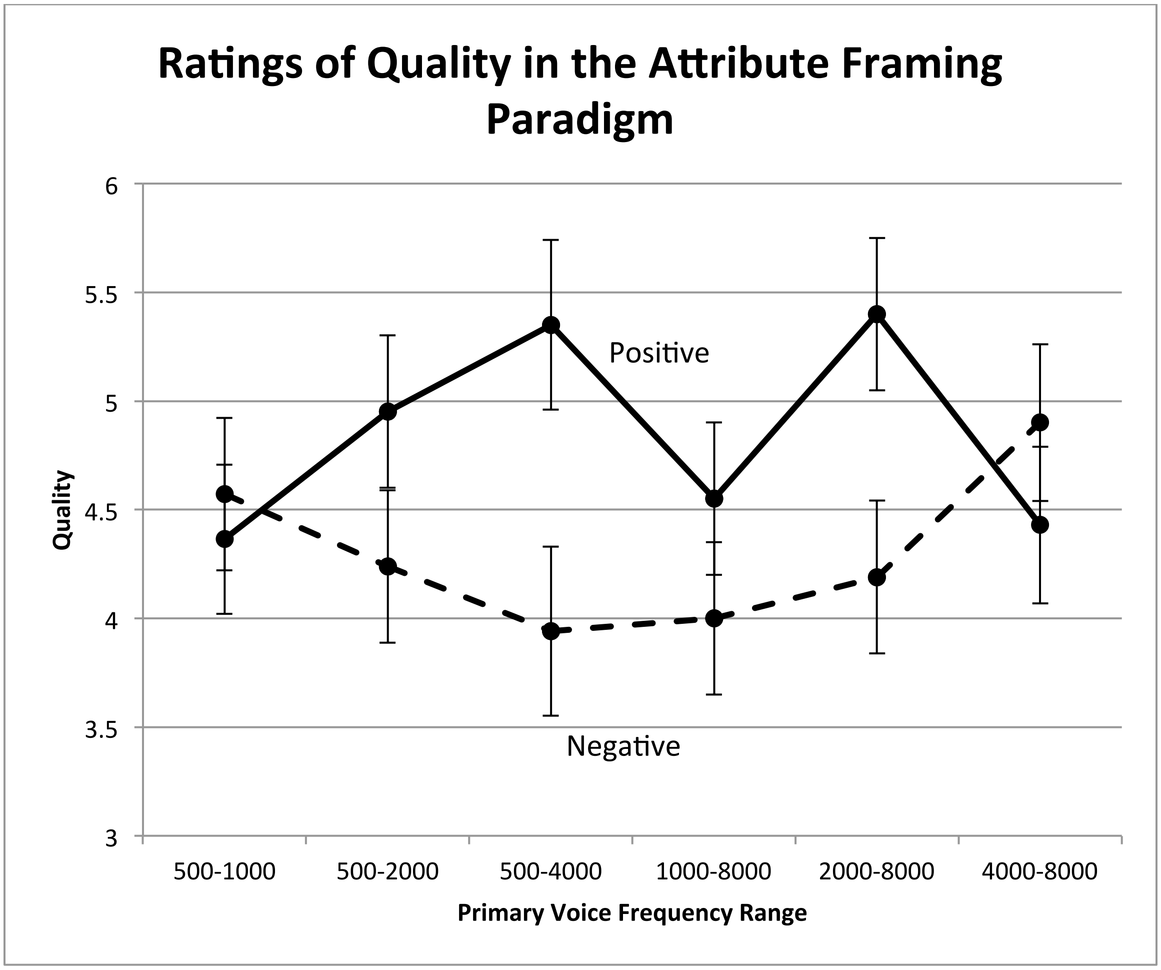

Figure 6. Interaction of frequency and frame for ratings of quality. Positive and negative labels correspond to the framing condition. Ratings of quality were made on a 7-point likert type scale anchored by low-quality (1) and high-quality (7). There was a marginally significant interaction between frame and frequency, with a significant simple main effect of frame for the following frequencies of the primary voice: 500-4000 and 2000-8000. Error bars represent the standard error of the mean in each condition.

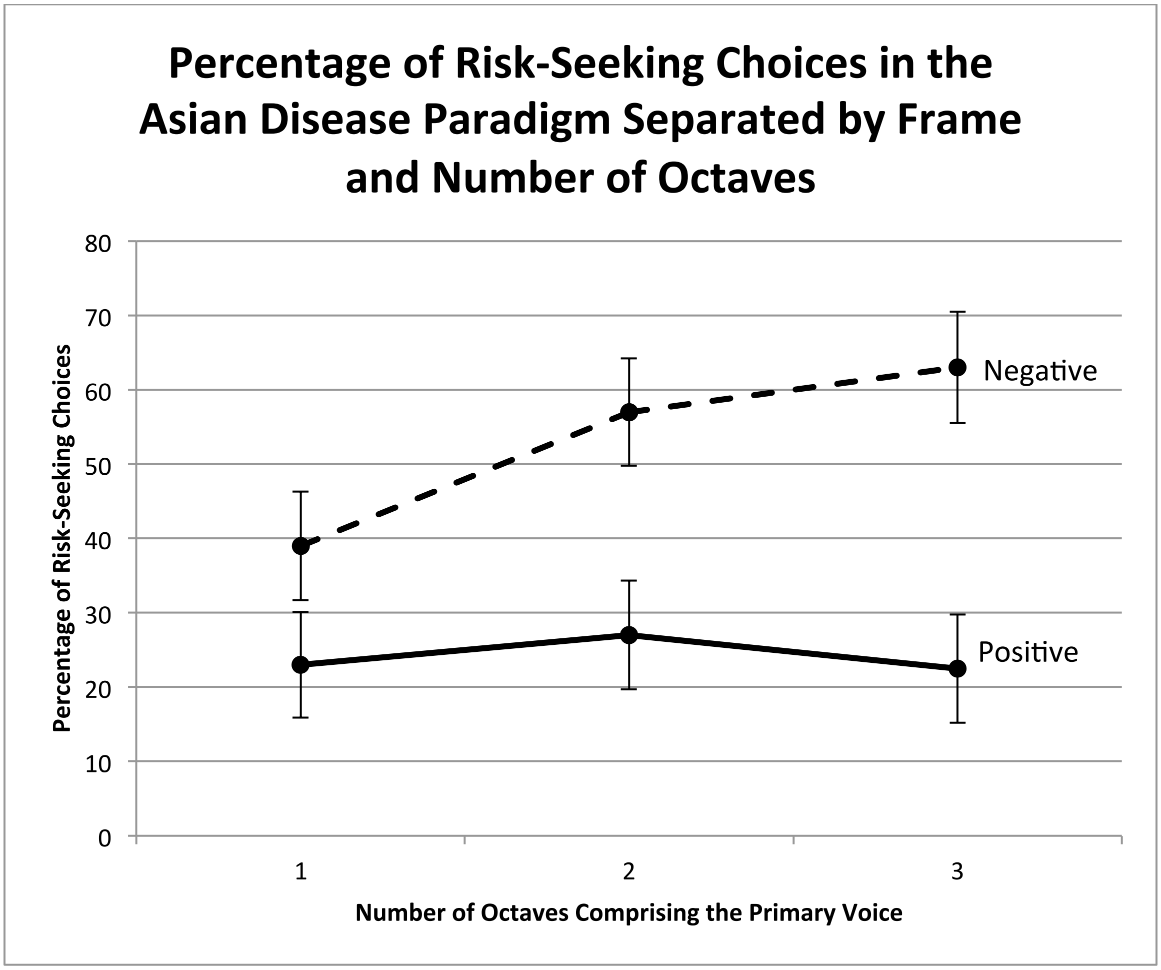

Figure 7. Percentage of risk-seeking choices in the Asian disease paradigm by number of octaves comprising the primary voice and frame. There was a significant effect of frame, with participants in the negative frame choosing the risk-seeking option more likely. Interestingly, in a logistic regression, only the conditions with the primary voice containing 3 octaves represented a significant predictor, regardless of frame. Error bars represent the standard error of the mean when a risky choice was coded as 1 while a riskless choice was coded as 0. This value was then transformed into a percentage.

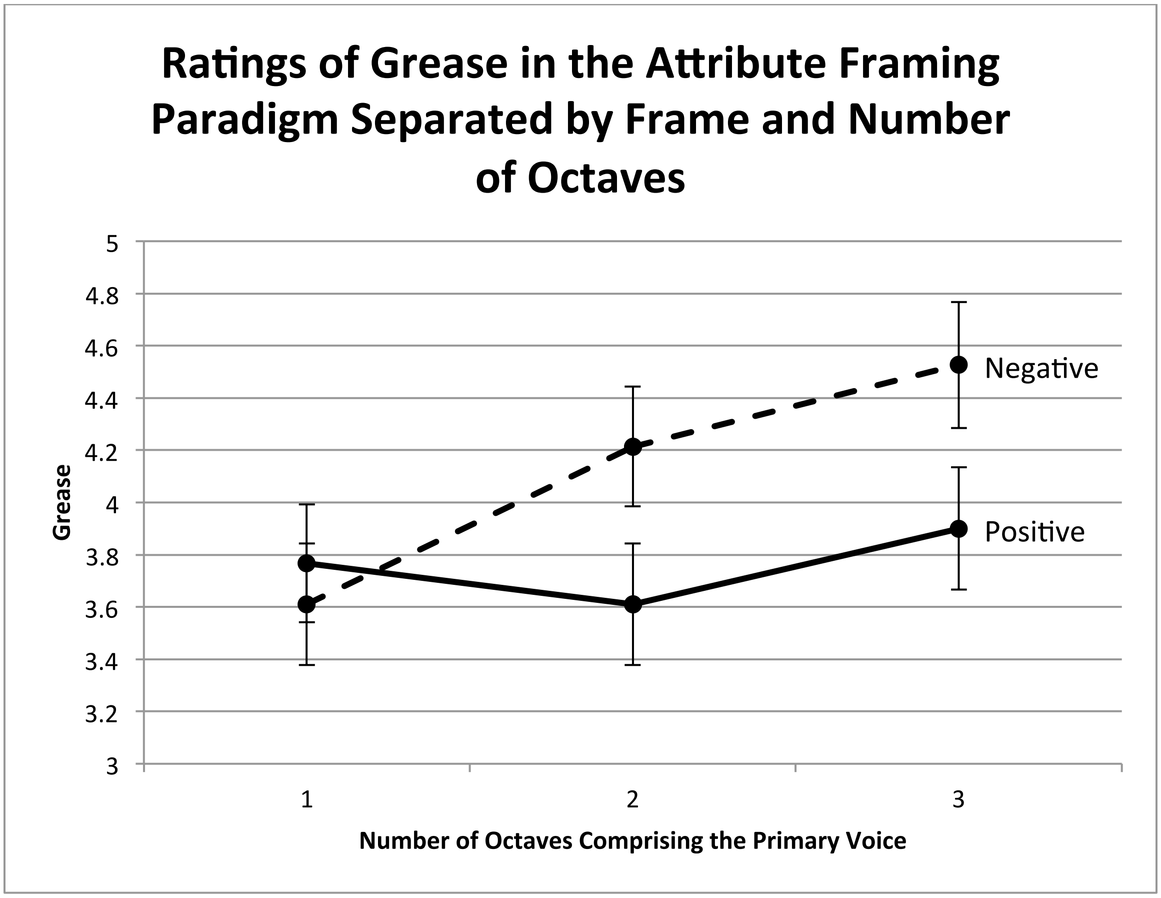

Figure 8. Rating of grease by frame and number of octaves comprising the primary voice. Positive and negative labels correspond to the framing condition. Ratings of grease were made on a 7-point likert type scale anchored by grease-less (1) and greasy (7). The effects of frame and number of octaves comprising the primary voice both approached significance with participants rating the beef as greasier in the negative frame and greasier as the number of octaves in the primary voice increased. Error bars represent the standard error of the mean in each condition.

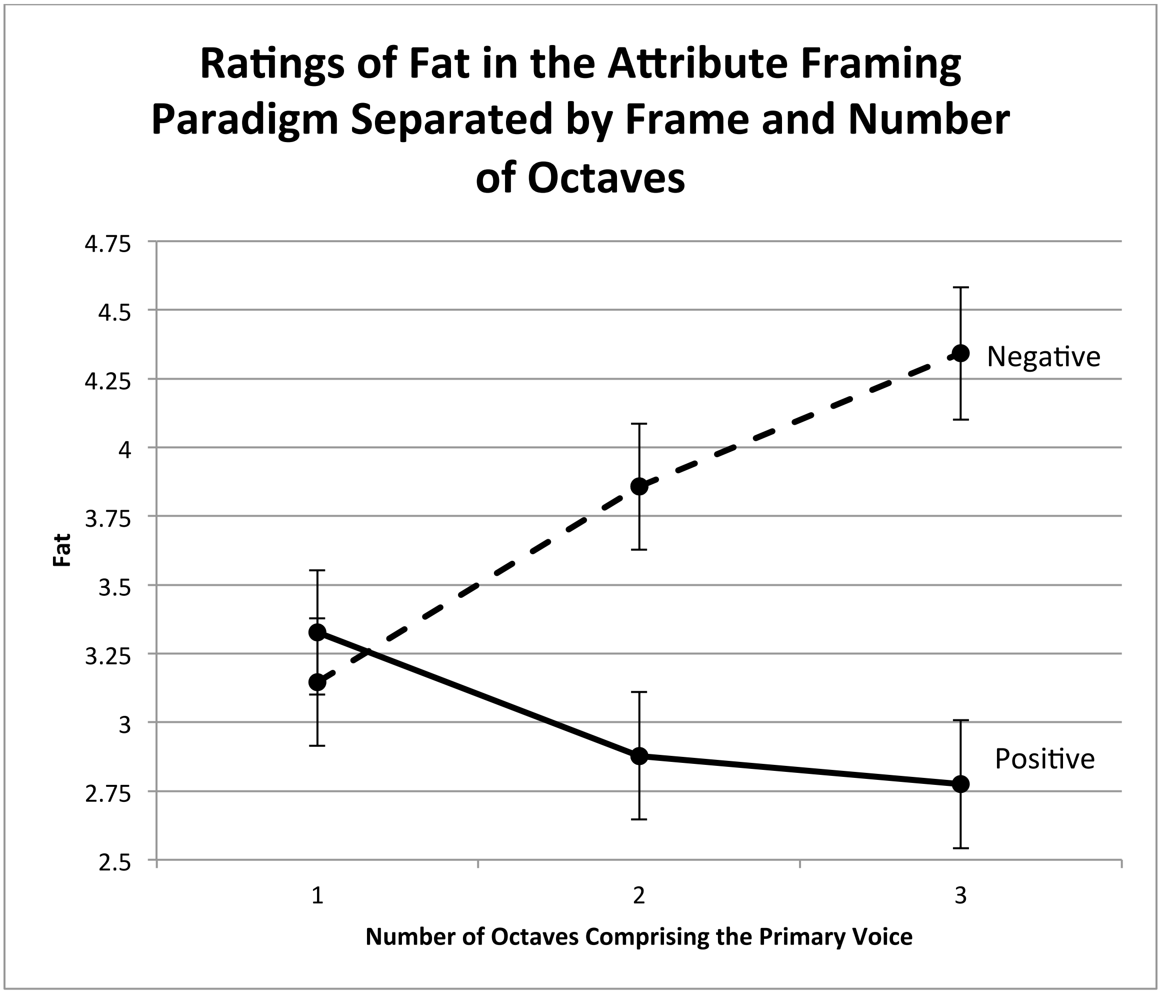

Figure 9. Interaction of frame and the number of octaves comprising the primary voice for ratings of fat content. Positive and negative labels correspond to the framing condition. Ratings of fat content were made on a 7-point likert type scale anchored by lean (1) and fat (7). There was a significant interaction between frame and number of octaves comprising the primary voice, with a significant simple main effect of frame when the primary voice was comprised of 2 or 3 octaves. Error bars represent the standard error of the mean in each condition.

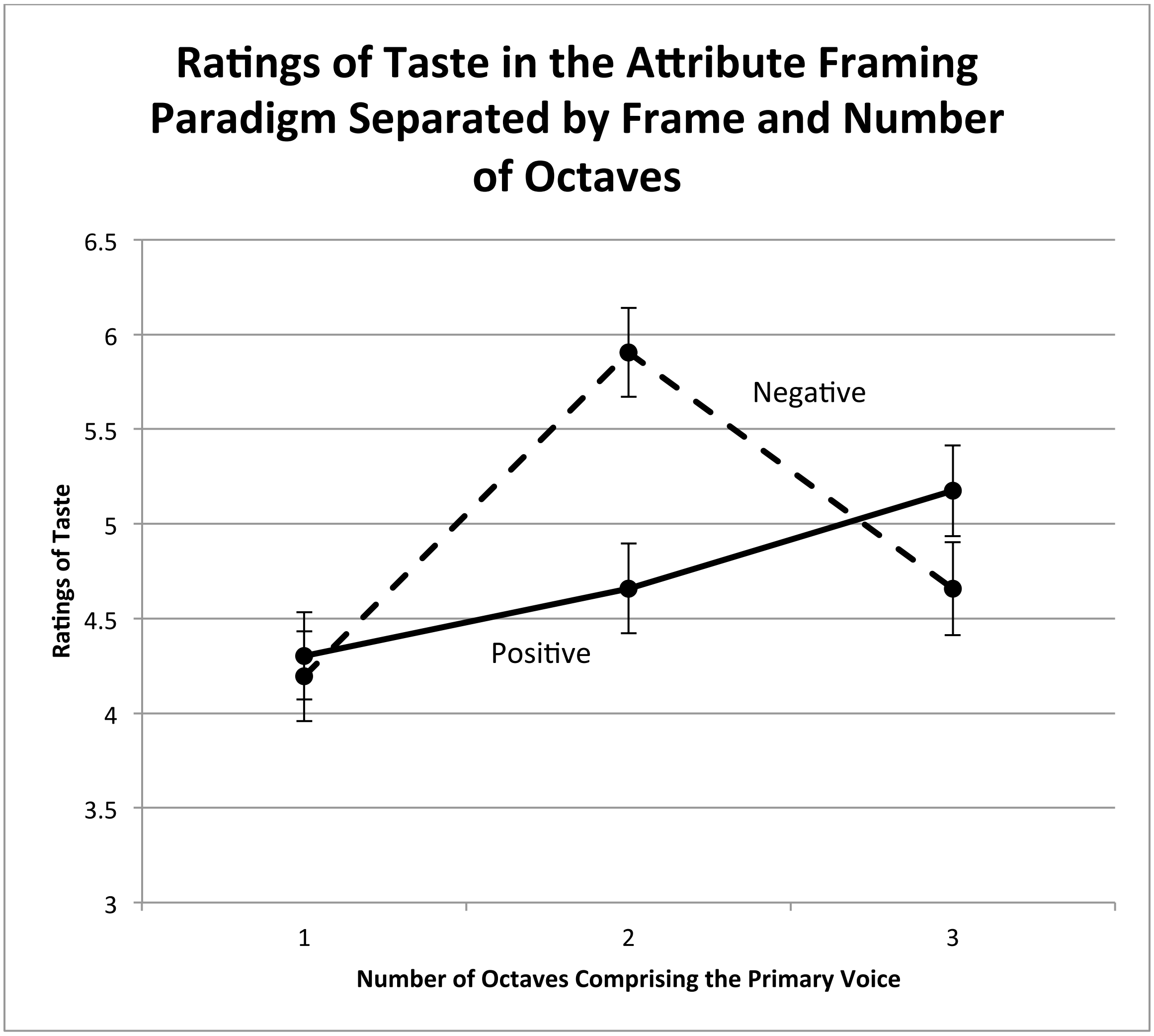

Figure 10. Ratings of taste by frequency and frame. Ratings of taste were made on a 7-point likert type scale anchored by bad tasting (1) and good tasting (7). There was a significant effect of number of octaves comprising the primary voice, regardless of frame. Conditions containing 2 or 3 octaves differed significantly from the conditions containing only a single octave. Error bars represent the standard error of the mean in each condition.

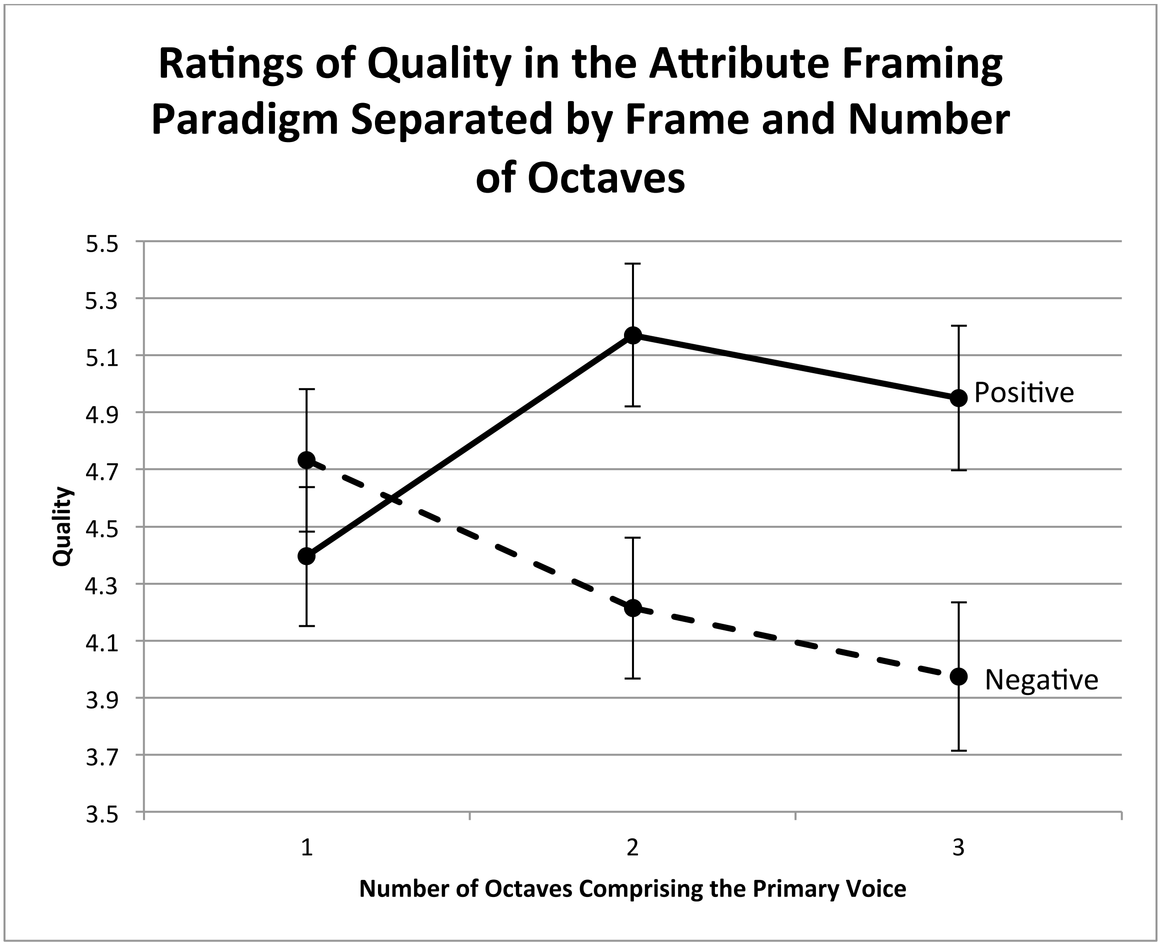

Figure 11. Interaction of frame and the number of octaves comprising the primary voice for ratings of quality. Positive and negative labels correspond to the framing condition. Ratings of quality were made on a 7-point likert type scale anchored by low-quality (1) and high-quality (7). There was a significant interaction between frame and the number of octaves comprising the primary voice, with a significant simple main effect of frame when the primary voice was comprised of 2 or 3 octaves. Error bars represent the standard error of the mean in each condition.

Appendix C

Framing Paradigms

Goal Framing Paradigm

Negative Frame The sun's rays, which are called ultraviolet A and ultraviolet B rays, can be harmful and damage your skin. This leads to early wrinkles, skin cancer, and other skin problems. Being in the sun often over time, even if you don't burn, can lead to skin cancer. A tan is the body's desperate attempt to protect itself from the sun's harmful rays. So, if you expose yourself to the sun, you will risk becoming sick. If you can't protect yourself by staying out of the sun or wearing the right kind of clothing, use sunscreen to help protect you. But don't think that you're completely safe from the sun just because you're wearing sunscreen. If you don't use sunscreen with a sun protection factor, SPF, of 15 or more, you will in- crease your chances of damaging your skin and of bringing on an early death. Put the sunscreen everywhere the sun's rays might touch you, including your ears, the back of your neck, and bald areas of your scalp. Put more on every hour if you're sweating or swimming. Most skin cancers occur on parts of the body that are repeatedly exposed to the sun. These areas include the head, neck, face, tips of the ears, hands, forearms, shoulders, back, chests of men, and the back and lower legs of women. Remember that not using sunscreen increases your risk of skin cancer and prematurely aged skin. Also keep in mind that the lower the SPF you use, the more you will be harmed from the sun's rays. The key to preventing skin cancer is to avoid being in the sun or using sunlamps. If you're going to be in the sun for any length of time, wear clothes made from tight- woven cloth so the sun's rays can't get through to your skin, and stay in the shade when you can. Wear a wide-brimmed hat to protect your face, neck, and ears. Remember that clouds and water won't protect you. 60% to 80% of the sun's rays can get through clouds and can reach swimmers at least one foot below the surface of the water, snow, and white sand. Remember that exposing yourself to the sun is the surest way to get skin cancer. A number of things may put you at higher risk of having skin cancer some day including: fair skin, red or blond hair, light colored eyes, sun burning easily, having many moles, freckles, or birth marks, working or playing outside, extended sun exposure as a child. You will soon be out in the sun—are you not protecting yourself and thus causing damage to your skin?

Positive Frame The sun's rays, which are called ultraviolet A and ultraviolet B rays, can be harmful and damage your skin. This leads to early wrinkles, skin cancer, and other skin problems. Being in the sun often over time, even if you don't burn, can lead to skin cancer. A tan is the body's desperate attempt to protect itself from the sun's harmful rays. So, by protecting yourself from the sun, you will help yourself stay healthy. If you can't protect yourself by staying out of the sun or wearing the right kind of clothing, use sunscreen to help protect you. But don't think that you're completely safe from the sun just because you're wearing sunscreen. If you use sunscreen with a sun protection factor, SPF, of 15 or more, you will increase your chances of keeping your skin healthy and your life long. Put the sunscreen everywhere the sun's rays might touch you, including your ears, the back of your neck, and bald areas of your scalp. Put more on every hour if you're sweating or swimming. Most skin cancers occur on parts of the body that are repeatedly exposed to the sun. These areas include the head, neck, face, tips of the ears, hands, forearms, shoulders, back, chests of men, and the back and lower legs of women. Remember that using sunscreen increases your chances of maintaining healthy, young looking skin. Also keep in mind that the higher the SPF you use, the more you will be protected from the sun's rays. The key to preventing skin cancer is to avoid being in the sun or using sunlamps. If you're going to be in the sun for any length of time, wear clothes made from tight- woven cloth so the sun's rays can't get through to your skin, and stay in the shade when you can. Wear a wide-brimmed hat to protect your face, neck, and ears. Remember that clouds and water won't protect you. 60% to 80% of the sun's rays can get through clouds and can reach swimmers at least one foot below the surface of the water, snow, and white sand. Remember that protecting yourself from the sun is the surest way to prevent skin cancer. A number of things may put you at higher risk of having skin cancer some day including: fair skin, red or blond hair, light colored eyes, sun burning easily, having many moles, freckles, or birth marks, working or playing outside, extended sun exposure as a child. You will soon be out in the sun—will you protect yourself and ensure your skin stays healthy?

Goal Framing Dependent Variables

Below are a number of questions designed to measure your attitudes and beliefs about the sun and sunscreen usage. For each question, please choose the number that best represents how you feel.

1. What is your level of anxiety after reading the pamphlet?

Not at all anxious 1 2 3 4 5 6 7 Extremely anxious

2. How afraid are you of developing skin cancer, prematurely aged skin or both?

Not at all fearful 1 2 3 4 5 6 7 Extremely fearful

3. How often do you plan to use sunscreen during daily activities next summer?

Never 1 2 3 4 5 6 7 Always

4. Suppose next summer you spent the whole day at the beach/pool. What SPF level do you think you would use?

SPF ________

5. How many times do you think you would apply sunscreen during the day?

________ times

6. What do you think your chances are of developing skin cancer? (0% = absolutely no chance of getting skin cancer and 100% = definite chance of getting skin cancer)

________%

7. How do you think your chances of getting skin cancer would change if you protected yourself from the sun?

Stay the same 1 2 3 4 5 6 7 Decrease dramatically

8. If you did not protect yourself from the sun, how do you think your chances of getting skin cancer would change?

Stay the same 1 2 3 4 5 6 7 Increase dramatically

9. How relieved would you feel if you were out in the sun and you applied sunscreen?

Not at all 1 2 3 4 5 6 7 Extremely

10. How unpleasant would you feel if you were out in the sun and failed to apply sunscreen?

Not at all 1 2 3 4 5 6 7 Extremely

11. How regretful would you feel if you were out in the sun and you were prevented from using sunscreen (i.e., you forgot your sunscreen at home or you went to buy some and the store was sold out)?

Not at all 1 2 3 4 5 6 7 Extremely

12. How anxious would you feel if you were out in the sun and you were prevented from using sunscreen (i.e., you forgot your sunscreen at home or you went to buy some and the store was sold out)?

Not at all 1 2 3 4 5 6 7 Extremely

Risk Choice Paradigm

Negative Frame Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of thee consequences of the program are as follows:

If Program A is adopted, 400 people will die.

If Program B is adopted, there is a 1/3 probability that nobody will die, and a 2/3 probability that 600 people will die.

Again, If Program A is adopted, 400 people will die.

If Program B is adopted, there is a 1/3 probability that nobody will die, and a 2/3 probability that 600 people will die. Which of the two programs would you favor?

Positive Frame Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of thee consequences of the program are as follows:

If Program A is adopted, 200 people will be saved.

If Program B is adopted, there is a 1/3 probability that 600 people will be saved, and a 2/3 probability that no people will be saved.

Again, If Program A is adopted, 200 people will be saved.

If Program B is adopted, there is a 1/3 probability that 600 people will be saved, and a 2/3 probability that no people will be saved. Which of the two programs would you favor?

Risky Choice Dependent Variable

Which program do you favor? (Please circle one)

Program A Program B

Attribute Framing Paradigm: Ground Beef

Positive Frame In this brief survey we want to know what associations or thoughts come to mind when making consumer purchases. To collect this information we will ask you to provide your impressions of a consumer product on a series of 7-point scales. Each response can be made between 2 possible adjectives. Such as good tasting or bad tasting. These adjectives appear on opposite sides of the scales. For each scale we want you to indicate the extent to which you associate a purchase of the product with one possible adjective rather than the other. Today, the product we would like you to provide your impressions of is 75% lean ground beef. At this time, please complete the following scales for 75% lean ground beef.

Negative Frame In this brief survey we want to know what associations or thoughts come to mind when making consumer purchases. To collect this information we will ask you to provide your impressions of a consumer product on a series of 7-point scales. Each response can be made between 2 possible adjectives. Such as good tasting or bad tasting. These adjectives appear on opposite sides of the scales. For each scale we want you to indicate the extent to which you associate a purchase of the product with one possible adjective rather than the other. Today, the product we would like you to provide your impressions of is 25% fat ground beef. At this time, please complete the following scales for 25% fat ground beef.

Attribute Frame Dependent Variables

Greasy	1	2	3	4	5	6	7	Greaseless
Bad Tasting	1	2	3	4	5	6	7	Good Tasting
Lean	1	2	3	4	5	6	7	Fat
High Quality	1	2	3	4	5	6	7	Low Quality