THE CONTRIBUTION OF PERCEPTUAL DISFLUENCY IN AUDITORY AND VISUAL MODALITIES TO ACTUAL AND PREDICTED MEMORY PERFORMANCE

A Master's Thesis

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I certify that I have read this thesis and have found that is fully adequate, in scope and in quality, as a thesis for the degree of Masters of Arts

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ABSTRACT

THE CONTRIBUTION OF PERCEPTUAL DISFLUENCY IN AUDITORY AND VISUAL MODALITIES TO ACTUAL AND PREDICTED MEMORY PERFORMANCE

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January 2020

Research has shown that perceptual disfluencies may affect both actual and predicted memory performance. However, the contribution of perceptual disfluency in multiple modalities to actual and predicted memory has not been investigated and different perceptual modalities may affect these variables to varying extents. The current study investigated how disfluency in visual and auditory modalities may influence actual and predicted memory performance. In a set of three experiments, participants were presented with food recipes in visual and auditory modalities through short clips and were asked to remember these recipes for a later memory test. They also made judgments about the memorability of clips during encoding. The clips were presented in an intact form in visual and auditory modalities, or were distorted in one or both of the modalities. Experiment 1 used a within-subjects design with four study-test cycles, where participants were exposed four complete food recipes. Results revealed that only the distortions in the auditory modality lowered participants' memory predictions. Experiment 2 used a between-subjects design, in which participants were continually exposed to the same type of perceptual fluency/disfluency condition. This type of design failed to influence memory predictions. For Experiment 3, unique and unrelated steps from different food recipes were selected to eliminate the effect of logical order between items. When the logical order was eliminated, both visual and auditory disfluencies lowered participants' JOLs, but auditory disfluency affected JOLs more than visual disfluency. Actual memory performance remained unaffected in all three experiments. This study demonstrated that distortions in both modalities jointly affect the JOLs, even though distortions in auditory modality seem to be more effective. The results are discussed in the light of the perceptual fluency hypothesis as well as the use of multiple cues in making memory predictions. When more than one perceptual cue is used, one of the cues might outweigh the other cue under certain conditions.

Keywords: Judgments of Learning, Memory, Metamemory, Modality, Perceptual Fluency

ÖZET

İŞİTSEL VE GÖRSEL KANALLARDAKİ ALGISAL BOZUKLUKLARIN ASIL VE TAHMİN EDİLEN BELLEĞE ETKİSİ

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Yapılan araştırmalar gösteriyor ki algısal akıcılığın bozulması insanların bellek performanslarıyla ilgili tahminlerini ve bazen de asıl bellek performanslarını etkiliyor. Fakat algısal akıcılık birden fazla duyusal kanalda bozulduğu zaman asıl belleğin ve bellek tahminlerinin nasıl etkileneceğini daha önce araştırılmamış bir konudur. Bu araştırma farklı duyusal kanallardaki akıcılığı bozan algısal bozuklukların insanların gelecek bellek performanslarıyla ilgili tahminlerini ve gerçek belleklerini nasıl etkilediğini incelemektedir. Üç deney içinde katılımcılara yemek tarifleriyle ilgili kısa videolar izletilmiştir ve ilerideki bellek testi için bu videoları akıllarında tutmaları istenmiştir. Video kullanarak görsel ve işitsel bilginin aynı anda iletilmesi sağlanmıştır. Ayrıca her videodan sonra gelecek bellek performanslarıyla ilgili tahminde bulunmaları istenmiştir. Videolar ya akıcı halleriyle ya kanallardan biri ya da ikisi birden bozulmuş halde gösterilmiştir. Birinci deneyde denekler için desen kullanılmıştır ve 4 test serisi boyunca tüm katılımcılar 4 farkı yemek tarifine de maruz bırakılmıştır. Sonuçlar sadece işitsel kanaldaki algısal bozukluğun bellek tahminlerini etkilediği göstermiştir ve katılımcıların işitsel kanalın bozuk olduğu durumlardaki bellek tahminleri diğer durumlara göre daha düşüktür. İkinci deneyde kullanılan manipülasyonun denekler arası desen kullanıldığı zaman ne sonuç vereceğine bakılmıştır ve bu desende bellek tahminlerinin değişiklik göstermediği bulunmuştur. Üçüncü deneyde materyaller arasındaki mantıksal sıralama kaldırıldığı bulunan etkinin değişip değişmeyeceği incelenmiştir. Bunun için ilk iki deneyde kullanılan yemek tariflerinden birbirlerinden alakasız adımlar seçilerek katılımcılara izletilmiştir. Mantıksal sıralama kaldırıldığından katılımcıların bellek tahminlerinin hem işitsel hem de görsel kanallardaki algısal bozukluklardan etkilendiği fakat işitsel kanaldaki bozukluğun etkisinin daha fazla olduğu görülmüştür. Katılımcıların gerçek bellek performansları bu üç deneyde yapılan manipülasyonlardan etkilenmemiştir. Sonuç olarak bu araştırma işitsel ve görsel kanallardaki akıcılığı bozan algısal bozuklukların katılımcıların bellek tahminlerini etkilediğini ama işitsel kanaldaki bozuklukların etkisinin daha önemli olduğunu göstermiştir. Tüm bu sonuçlar algısal akıcılık hipotezi ve bellek tahminlerinin oluşumuna katkı sağlayan birden fazla ipucu olabileceği teorisi ile açıklanabilmektedir.

Anahtar sözcükler: Algısal Akıcılık, Bellek, Bellek Tahminleri, Duyusal Kanallar, Üstbellek

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CHAPTER 1

INTRODUCTION

Assume you are watching something on TV or having a skype conversation and audiovisual quality is not good. More specifically, think about a situation in which you can hear the audio perfectly but the display is distorted or vice versa. Would the distortion in one modality distract you and affect your comprehension of the other modality? How do you think these kinds of distortions in different modalities would affect your memory?

1.1. Metamemory and Perceptual Fluency Hypothesis

Being able to answer these questions and being able to evaluate your learning process requires one of the high functioning cognitive skills, called metamemory. Metamemory refers to various types of judgments, beliefs, predictions, and heuristics about how memory operates. These operations involve monitoring, controlling, and regulating memory. They lead people to allocate their cognitive resources effectively during the courses of learning and remembering (Besken, 2016; Koriat & Helstrup, 2007). One method of assessing metamemory is judgments of learning (JOLs). JOLs refer to people’s predictions about their future memory performance in a later memory test (Rhodes, 2015). Research has shown that people rely on numbers of cues and heuristics while making JOLs (Koriat, 1997). However, the accuracy of JOLs cannot be guaranteed and predictions made by using certain cues may not always be consistent with the actual memory performance.

People's predictions about their future memory do not always reflect their actual memory performance. Oppenheimer (2008) argues that people commonly use ease or difficulty associated with a task as a cue for making metacognitive judgments. Usage of these kinds of cues might lead to metacognitive illusions and produce dissociations between actual and predicted memory. Previous research suggests that perceptual fluency is such a cue. A recent hypothesis, which is called the perceptual fluency hypothesis, claims that items that are perceived more easily and fluently at the time of encoding produce higher subsequent memory predictions than disfluent items, which are harder to process. Yet, the ease of perception does not always produce higher memory performance (Rhodes & Castel, 2008). For example, perceptually disfluent materials may reduce metamemory judgments during encoding, even though perceptual fluency does not affect actual memory performance (e.g. Rhodes & Castel, 2008; 2009) or sometimes even increases it (Besken, 2016; Besken & Mulligan, 2013;2014). Dissociations between actual and predicted memory that originate from perceptual fluency manipulations can take place in three different manners.

First, perceptual fluency manipulations might lead to single dissociations between actual and predicted memory by affecting JOLs but not the actual memory performance. Rhodes & Castel (2008) presented small (18) and large (48) font words to their participants and asked them to make predictions about their future memory performance about each word. They found that participants made higher predictions for large words than small ones, but their recall performance was similar across encoding conditions. Similar results are obtained in the auditory domain as well with the loudness manipulation. When participants heard quiet and loud recordings of words over the headphones, participants produced higher JOLs for loud words than quiet ones. Similar to font-size manipulation, participants' actual memory performance was not affected by the loudness manipulation (Rhodes & Castel, 2009). Frank and Kuhlman (2016) used the same manipulation by referring to it as volume effect and found that people gave higher JOL ratings for loud words than quite ones but their memory remained unaffected.

Second, perceptual fluency manipulations might lead to single dissociations between actual and predicted memory by affecting actual memory but not the JOLs. Sungkhasettee, Friedman, and Castel (2011) presented upright and inverted words (rotated 180 degrees) to their participants and collected their JOLs. They found that participants' memory performance was higher for inverted words than upright words, but their JOLs did not differ.

Third, perceptual fluency manipulations may affect both actual and predicted memory performance in opposite directions by leading to double dissociations between them (Besken & Mulligan, 2014; Diemand-Yauman, Oppenheimer, & Vaughn, 2010; Hirshman & Mulligan, 1991) For instance, Besken (2016) used intact or generate pictures created by using a checkerboard mask instead of words and found that participants' JOLs were higher for intact pictures than generate pictures, but their memory performances were higher for generate than intact items (for aggregate JOLs). This result was also replicated in the auditory modality as well. Besken & Mulligan (2014) used an auditory generation manipulation that is based on the generation of silenced sounds in a word and found that JOLs were higher for intact words than generate ones, but memory performance was higher for generate than intact items. In another research, Besken and Mulligan (2013) used perceptual interference manipulation in which they presented a word very briefly and then replaced it with a row of X's and found that people gave higher JOLs for intact words than perceptually masked items, even though their memory performances were higher for perceptually masked items than intact items. Thus, certain perceptual disfluency manipulations improve memory (Mulligan, 1996). In such cases, perceptual disfluency acts a “desirable difficulty” (Björk, 1994; McDaniel & Butler, 2010). However, it is important to note that perceptual disfluency might reduce memory performance as well. Thus, there could be situations in which perceptual fluency manipulations do not cause any illusion and affect the actual and the predicted memory in the same direction. Yue, Castel and Björk (2013) used blurred and clear words in their study and found that participants’ JOLs and memory performances were higher for clear words than blurred ones.

In light of these examples, it can be claimed that the effect of perceptual fluency on JOLs and memory can be different, depending on the type of manipulation used. Thus, perceptual fluency could be considered as an important cue that is frequently used in metamemory research. However, when we consider daily life situations that generally involve multiple cues, assuming that we only focus on one cue undermines the complexity of metacognition (Rhodes, 2015).

1.2. Combining Multiple Cues in Metamemory Research

Research showed that people can combine multiple cues from various sources while making judgments about their cognitive processes; however, it is not clear whether they combine all of them or pick among them (Undorf, Söllner, & Bröder, 2018). Therefore, there two different theoretical hypotheses regarding the cue-utilization in making JOLs. On the one hand, the first hypothesis suggests that when more than one cue is available, people integrate all cues while making JOLs. This idea supported by many studies that manipulated multiple cues such as relatedness and number of study presentation or presentation time (Jang & Nelson, 2005), font size and relatedness (Price & Harrison, 2007), and font format and relatedness (Mueller, Dunlosky, Tauber, & Rhodes, 2014). Furthermore, Undorf, Söllner, and Bröder (2018) showed that number of cues that are being integrated in JOLs could be more than two. In one experiment they found that participants integrated four different cues (number of study presentation, font-size, concreteness, and emotionality) while making JOLs.

On the other hand, the second hypothesis suggests that participants focus on only selected cues and ignore some of the others when making JOLs. Susser and Mulligan (2015), found that participants' JOLs are affected by whether they write a word with their dominant or non-dominant hands, but they are not affected by word frequency. Similarly, Besken (2016) found that participants' JOLs are affected by whether the presented picture is intact or degraded but not affected by the type of preceding contour (matching or mismatching). Moreover, there are also situations that a cue might lose its effectiveness in JOLs when combined with other cues even though it was effective when manipulated in isolation (e.g. Undorf & Erdfelder, 2013).

Taken together, how multiple cues affect JOLs is a controversial issue and there are studies that support both multiple cue-utilization and selective cue-utilization. Furthermore, how multiple cues affect actual memory could change with respect to the selection of the cues that are being combined as well. There could be situations in which a cue affects actual memory when combined with other cues even though it does not have any effect on memory in isolation or vice versa. Undorf, Söllner, and Bröder (2018) manipulated four different cues (number of study presentation, font-size, concreteness, and emotionality) and found that only three of them (number of study presentation, concreteness, and emotionality) affected actual memory (Experiments 1 and 4). However, they also found that in one experiment (Experiment 3) font-size affected actual memory and this result suggests that the effect of a certain cue on memory could be different when combined with other cues.

Examining the effect of multiple cues in metamemory research is really important for understanding the nature of metamemory processes and how we use this cognitive function in our daily lives. However, one important factor that should be taking into consideration is in real life we are usually exposed to more than one modality at a time and collect information from more than one modality concurrently. While watching something, talking with people or participating in interactive activities, we are exposed to both visual and auditory modalities at the same time. Thus, manipulating a cue in different modalities could provide valuable answers about how different cues affect people's metamemory judgments and memory.

1.3.Presentation Modality in Metamemory Research

When we consider the examples of metamemory research that are discussed so far, it can be seen that similar effects can be observed in both visual and auditory modalities; font-size vs. loudness manipulations (Rhodes & Castel, 2008; 2009), and checkerboard masking vs. auditory generation manipulations (Besken, 2016; Besken & Mulligan, 2014). However, to-date very few studies have investigated the effects of presentation modality on metamemory. The reason behind this is mainly due to the assumption that the modality of presentation is more related to memory than metamemory.

Presentation modality is indeed important for memory. In one study, Cohen, Horowitz and Wolfe (2009) found that participants' recognition performance for visually presented stimuli was higher for auditory stimuli even when additional information was added to the auditory stimuli. Participants were presented with sound clips about various scenes in five different conditions; only sound clips, only verbal descriptions, only matching picture, sound clips paired with matching pictures, and sound clips paired with verbal descriptions. Memory performance for the only pictures condition was higher than any other condition, and even pairing sound clips with pictures did not increase memory (Cohen, Horowitz, & Wolfe, 2009). In another study, participants were presented with proverbs that share object similarity or relational similarity either in written condition or spoken condition. Markman, Taylor and Gentner (2007) found that in the presence of relational cues, auditory presentation leads to higher retrieval than visual presentation. Presentation modality has different types of effects on memory span depending on the types of materials that being used. (Watkins & Peynircioğlu, 1983). In another study, participants read words, heard words, or both read and heard words. Results showed that participants' recognition performance was higher for the condition where they only heard the words or used both modalities as compared to the condition in which they only read the words (Conway & Gathercole, 1987). All these studies show that presentation modality may affect actual memory performance.

As claimed before, the effect of modality on actual memory performance is sometimes accompanied by the effect of presentation modality on memory predictions, even though the predictions for modality superiority are inconsistent across studies. For example, Carroll and Korukina (1999) used both text coherence and presentation modality. In their study, participants listened to and read texts that were either ordered or disordered and answered questions about those texts. In the visual condition, participants read the questions. Experimenter corrected their wrong answers by showing a card with the right answer. In the auditory condition, experimenter read the questions and corrected the wrong answers verbally. Following this learning phase, participants made predictions about each question regarding the likelihood of remembering their answers in two weeks. Results showed that participants' JOLs were higher for auditory presentation than visual presentation, regardless of the effect of text coherence. Also, their memory performances were better for heard items than read items as well. In another study, musicians were presented with musical samples in three different ways: visually, auditorily, and both visually and auditorily. Results demonstrated that participants' JOLs were higher for both visually and auditorily presented pieces and only-visually presented pieces than their JOLs for auditorily-presented pieces. However, there was no difference between JOLs for both visually and auditorily presented pieces and JOLs for only visually presented pieces (Peynircioğlu, Brandler, Hohman, & Knudson, 2014).

One important factor for examining the effect of presentation modality on metamemory is creating a setting in which participants are exposed to information coming from different modalities at the same time. Research has also demonstrated that the presentation of information in more than one modality typically increases memory confidence. For example, when participants both heard and read words, they were more confident about their memory for those words than the ones they only heard or read (Conway & Gathercole, 1987). Similarly, musicians' confidence about how well they have learned a piece is higher when the piece was presented both visually and auditorily than pieces presented only auditorily (Peynircioğlu et al., 2014).

1.4. Combining Perceptual Fluency and Presentation Modality

With these in mind, let us consider the daily life example at the very beginning again. While watching a video from the internet or having an online conversation, we combine cues from both visual and auditory modalities for understanding the context. Sometimes we can encounter audiovisual difficulties such that the auditory and the visual attributes of a video might not be synchronous or one of the modalities might be perceptually disfluent. These kinds of audiovisual problems could affect our understanding, therefore it is reasonable to think that they might affect our memory and memory predictions as well. Combining perceptual fluency and presentation modality for metamemory research could provide valuable answers about how different cues affect metamemory judgments and memory. Perceptual fluency and presentation modality are cues that co-occur very frequently in our daily lives. Thus, changing the level of perceptual fluency at multiple modalities, specifically both auditory and visual modalities, might present us with an opportunity to create an experimental setting, similar to daily life situations. However, as discussed before, nearly all metamemory research focuses on only one modality at a time. The main aim of the study to see how perceptual fluency and presentation modality (two different perceptual cues) affect predicted and actual memory when they are combined. To-date, very few studies have investigated the effect of changing perceptual fluency in multiple modalities on metacognitive measures.

One study by Peynircioğlu and Tatz (2018) examined whether presentation modality has any effect on JOLs and how people combine information from two different cues; presentation modality and intensity while making JOLs. For addressing these questions, in one experiment they presented a list that contained 18-pt (small-font) words, 48-pt (large-font) words, quiet recordings of words, and loud recordings of words to their participants in four separate conditions and collected JOLs for each item. They found a main effect of intensity on JOLs, meaning that people gave higher JOL ratings for both large words and loud words. However, there was no main effect of modality on JOLs and no interaction between modality and intensity. Furthermore, they reported that neither intensity nor modality affected recall performance. In another experiment, they combined modality and intensity information and presented items in four separate conditions; small-font/quiet words (no intensity), small-font/loud words (auditorily intense), large-font/quiet words (visually intense), and large-font/loud (doubly intense). They found a main effect of both intensity and modality, but there was no interaction between them. Further analyses revealed that people gave the highest JOLs for the doubly intense condition than any other condition and gave the lowest JOLs for the no intensity condition. However, there was no significant difference between auditorily intense and visually intense conditions. Recall performance remained unaffected in this experiment as well. (Peynircioğlu & Tatz,2018). This study demonstrates that when intensity combined with presentation modality, it affects participants' JOLs, but when manipulated in isolation, only intensity has a significant effect on JOLs but not presentation modality. Furthermore, there is no effect of modality or intensity or combination of these two on recall performance.

1.5. Possible Modifications for Conducting Experiments Comparable to Real Life

In their study, Peynircioğlu and Tatz (2018) used font-size and loudness manipulations that are originally used by Rhodes and Castel (2008; 2009). Loudness and font-size manipulations have been used in many studies for manipulating perceptual fluency (Bjork, Dunlosky, & Kornell, 2013; Frank & Kuhlmann, 2017). These studies typically replicate the original effect: Participants give significantly lower JOLs to small or quiet words than large or loud words.

However, whether these manipulations (especially the font-size manipulation) constitute an example of objective perceptual disfluency or not is a controversial issue. On the one hand, Mueller, Dunlosky, Tauber, and Rhodes (2014) claimed that the effect of font-size manipulation on JOLs is not through perceptual fluency, but it is through participants' prior beliefs about font-size. On the other hand, Yang, Huang, and Shanks (2018) found that perceptual fluency played an important role in the contribution of font-size effect on JOLs by using a continuous identification task.

Besken and Mulligan (2013) argued that the font-size effect could affect JOLs through both perceptual fluency and people's beliefs about font size. However, they highlighted another aspect of the issue and claimed that the range of 18-48 pts is problematic. It is argued that both 18-pt words and 48-pt words are in the fluent range of the print size (Legge & Bigelow, 2011) and 18-pt words are as easy to read as 48-pt words (Undorf, Zimdahl, & Bernstein, 2017). When we consider the written materials that we are exposed to in our daily life, most of them are smaller than 18-pt, but we can read them easily. In experimental settings, 18-pt could be perceptually disfluent when compared with 48-pt words; however, in daily life, the same assumption may not hold. Considering that most information that we are exposed to is written in font-sizes smaller than 18-pt, a word presented in 18-pt font size can even be considered as fluent.

Peynircioğlu and Tatz (2018) refer to font-size and loudness manipulations as intensity manipulations and claim that font-size and loudness illusions depend on manipulating the intensity of the items. With this point of view, using these manipulation does not constitute any problem for examining how combining presentation modality and intensity affect predicted and actual memory performance. Peynircioğlu and Tatz's study reveals how presentation modality and intensity affect the memory predictions and memory. However, it can be argued that font-size manipulation might not be the best option for examining the relationship between objective perceptual fluency and metamemory judgments. Therefore, rather than manipulating intensity, using other manipulations that directly manipulate perceptual fluency might reveal more accurate results regarding the interaction between presentation modality and perceptual fluency.

Studying a higher-level and complex process such as metamemory apart from daily life might prevent us from examining its true nature. Thus, using manipulations that are more common or suitable for everyday situations could advance metamemory research. Some studies use common perceptual problems we might encounter in daily life as perceptual fluency manipulations such as perceptual blurring (Rosner, Davis, & Miliken, 2015), inverted words (Sungkhasetee, Friedman, & Castel, 2011), gradually increasing the size of objects, faces or words that are unrecognizably small (Undorf, Zimdalh, & Bernstain, 2017), inversion and canonicity of objects (Besken, Solmaz, Karaca, & Atılgan, 2019) and auditory generation (intermittently-silenced words) (Castel, Rhodes, & Friedman, 2013; Besken & Mulligan, 2013). Thus, while choosing perceptual (dis)fluency manipulations, it is important to ask about the degree of relevance of the manipulation to daily life. Using manipulations that happen frequently in daily life may provide ecologically more valid results about how metamemory judgments occur for perceptual fluency information presented at multiple modalities.

Another important modification that can done for obtaining results that can reflect real life situations is using more meaningful and complex stimuli. Most of the studies that examines the effect of perceptual fluency in metamemory research, use single words or pictures of single objects as materials. When encoding these kinds of materials people mostly use bottom-up process rather than top-down process. Usage of complex and meaningful materials may increase the effect of top-down processes on metacognitive judgments and could reveal more ecologically valid results for understanding how people make metamemory judgments in real life. Thus, using meaningful and complex materials is important for understanding how top-down processes are involved in metacognitive judgements.

Asking research questions that are relatable to people is a good way to examine the role of metamemory in our daily life. Also, with this kind of questions, the usage of complex stimuli might make more sense. Some studies demonstrate this successfully. One study examined how people are affected from audiovisual problems in settings such as online job interviews. In their study Fiechter, Fealing, Gerrard, and Kornell (2018), examined whether the audiovisual quality of skype interviews affected people's judgments about how hirable a job candidate is or not. In their study, they used fluent skype interviews with high audiovisual quality and disfluent ones with lowered visual resolution, background voices, and pauses. They presented those videos to their participants and asked them to rate how hirable candidates in the videos were. Results showed that audiovisual quality affected participants' judgments: candidates in the fluent videos were rated as more hirable than the candidates in the disfluent videos. This result did not change even when participants were specifically instructed not to make their judgments based on video quality. (Fiecter, Fealing, Gerrard, & Kornell, 2018). Even though this study does not directly examine the effect of audiovisual quality on metamemory judgments or actual memory performance, it provides a good example of the usage of more complex stimuli in an experimental setting.

One issue regarding using more complex materials is the decreased experimental control over the material; however, it should be noted that metamemory is a higher-level cognitive function. While studying higher-level functions, using highly controlled simple materials might prevent us from disclosing the mechanisms behind those functions fully. Metamemory has an important role in learning and in daily-life. Most of the time, we do not try to learn single words or pictures; instead, we encounter complex materials. Therefore, if the materials are prepared carefully, using more complex materials does not necessarily lead to lack of control in experiments. Furthermore, the effect of similar manipulations could be different, depending on whether people are exposed single words or meaningful sentences. For example, a phenomenon called phonemic restoration effect suggest that when certain parts of a speech signal are missing (e.g. replaced with a white noise or cough) people are still able to understand the speech perfectly without being able to pinpoint the exact location of the distortion (Kashino, 2006). However, when single words being used with a similar manipulation called auditory generation manipulation, people easily notice the distortions. Therefore, when top-down processes are involved, it cannot be warranted that the effects of perceptual disfluency on metamemory judgements and the memory will be the same.

Taken together, underlying mechanisms of metamemory processes can be investigated more thoroughly with experiments that can be linked to real life situations. In the current study we aimed to examine how combining perceptual fluency and presentation modality affect memory predictions and memory in an experimental setting which is more compatible with real life. In order to create that kind of an experimental setting, we used complex and meaningful stimuli that would lead to more top-down processes rather than bottom-up processes and perceptual fluency manipulations that can mimic common audio-visual problems.

1.6. The Current Study

Peynircioğlu and Tatz (2018) examined how the combination of two cues; intensity and presentation modality affected JOLs and actual memory by using simple word material and found an effect of intensity but not of presentation modality on JOLs. They also found that memory remained unaffected by these manipulations. However, in the current study, presentation modality was combined with perceptual fluency and resulted in two different cues; visual fluency and auditory fluency. Also, whether more complex and meaningful materials would warrant the same or similar results was an important question. Thus, this study used more meaningful materials in order to look at its effect. As meaningful material, we decided to use short videos. These videos should have certain properties for obtaining the necessary control. First of all, in order to examine whether disfluency in one modality has any effect on other modality or not, the information given from visual and auditory modalities should be the same. The critical question is whether disfluency in one modality affects memory predictions or their memory about other modality regardless of its fluency? To explain further, solely watching or listening to each video should lead to the same inference. One method to make this happen was mimicking an application from real life such as watching a cooking show on television. Cooking is an appropriate task that can meet the demands of this study, because watching or listening to someone prepare a recipe provides nearly the same information. Furthermore, food recipes can be easily manipulated by adding, removing ingredients or steps to obtain control across items.

For the current study, we needed perceptual fluency manipulations that are suitable for complex stimulus in order to examine how the usage of complex stimulus affects memory predictions and actual memory performance. As discussed above, the intensity manipulations that were used in Peynircioğlu and Tatz (2018) study were appropriate for simple and single items. In the current study, for the visual modality, perceptual fluency was manipulated with a glitch effect that distorts the integrity of the video. Glitch effect distorts the stimuli by masking the videos, but how glitch effect masks the videos varies throughout the video in a natural way, so it can be considered as a dynamic manipulation. For the auditory modality, we used an auditory generation manipulation in which the recordings are inter-spliced with silences. It is important to note that both of these manipulations distort the integrity in similar manners. While the glitch effect leads to an intermittent sensation for visual modality, the auditory generation manipulation leads to a similar intermittent sensation in the auditory modality. One advantage of using this type of material is that the disfluencies mimic the disfluencies in real life. For example, a video could have glitches or audio in a Skype call may be intermittent if the internet connection is poor.

The first aim of this study is to investigate the contribution of perceptual fluency in multiple modalities to memory predictions. Accordingly, the second aim of this study is to investigate the effect of combination of two cues, visual fluency and auditory fluency on actual memory performance. The perceptual fluency manipulations that were used in this study are inspired by checkerboard masking used in Besken (2016) and auditory generation used in Besken and Mulligan (2014).

Both checkerboard masking and auditory generation manipulations produce disfluency by violating the integrity of the stimulus. Yet, as the videos are dynamic materials, I used the glitch effect, which violates the integrity of videos across different film squares.

The last aim of this study is examining the effect of list composition when perceptual fluency manipulated in different multiple modalities by using more complex and meaningful stimulus. Susser, Mulligan and Besken (2013) found that the effect of perceptual fluency on metamemory judgments are relative. In other words, people use relative differences while making JOLs. In three different experiments they used three different manipulations for examining the effect of list composition. They used font-size manipulation, auditory generation manipulation, and letter-transposition generation. They had three different participant groups in these experiments; mixed-list group and two pure-lists groups. Perceptual fluency affected JOLs only in mixed-list designs but not in pure-list designs. Peynircioğlu and Tatz's study supports Susser, Mulligan and Besken's (2013) arguments about how relative differences affect JOLs, even when more than one cue is present. They combine presentation modality and intensity both with within-subject design and between subject design. In between-subject design they presented pure lists of small-font/quiet words, small-font/loud words, large-font/quiet words, and large-font/loud words to four groups of participants. In within-subject design they presented a mixed list to all of the participants. They found that participants' JOLs and memory performances did not differ across groups in between list design. In the current study, we examined whether combining perceptual fluency with presentation modality by using different manipulations and using more complex stimulus lead to any differences in the case of list composition's effect on metamemory judgments and memory performance.

CHAPTER 2

EXPERIMENT 1

In Experiment 1 we examined how manipulating perceptual fluency in multiple modalities affects memory predictions and actual memory performance. We used realistic materials and manipulations that mimic common audiovisual problems in daily life. According to previous research that use similar manipulations only in one modality, we hypothesize that perceptual disfluency in one or two of the modalities will lead to higher JOLs for fluent items. Even though the effect of disfluency on memory predictions is well-known, the results for actual memory performance may change. If the effects of auditory generation on memory for sentences is similar to memory for simple word materials, then one should expect higher memory performance when the material is more disfluent, as in line with Besken and Mulligan (2014) and Besken (2016). However, perceptual disfluency manipulations might also be more effective with simple words stimuli than with more complex material. In that case, memory performance should not differ across encoding conditions. In a similar vein of research, Peynircioğlu and Tatz (2018) found that the use of multiple modalities with intensity manipulations did not produce differences for memory performance across encoding conditions.

2.1. Method

2.1.1. Participants

Forty-eight native speakers of Turkish between the ages of 18-30 from the Bilkent University participated in the study. They were compensated with either course credit or a payment of 10 Liras for their participation. Participants reported no problems with their hearing or sight ahead of the experiment. The experiments were designed to detect medium size effect of $d = 0.5$ at $\alpha = 0.05$ with 85% power and the sample size was estimated to be 40 participants through G*power with these parameters. However; 8 participants could not carry out all of the requirements of the experiment and their data had to be excluded: 3 of them did not follow the instructions and 5 other participants were excluded due to the technical problems that are related to the computer. Due to these problems, they were replaced with 8 participants, who were tested in the same conditions.

2.1.2. Materials and Design

Four different kinds of food recipes (one soup, one dessert, one vegetable dish, and one meat dish) were selected from multiple food recipe websites. None of these recipes were very common. Even though these recipes consisted of various steps, they were each revised to have 20 steps. Each step of each recipe was also revised to have either three or four idea units. For example, if the step is “Peel the eggplants and cut them in cubes”, this was considered to have three idea units such as “peeling the eggplant”, “cutting”, “cube-shape”. Complete list of food recipes, along with their idea unit divisions can be seen in Appendix A. Over each consecutive five steps, the number of units were almost always equal. (some groups had one- or two-units difference). All these recipes were filmed in a kitchen with necessary food and cooking equipment.

The design was a 2 (visual fluency: visually intact vs. visually distorted) x 2 (auditory fluency: auditorily intact vs. auditorily distorted) within-subject design. Thus, participants were exposed to food descriptions, which might be completely intact in both modalities, disfluent in one of the two modalities or disfluent in both modalities. For each recipe, participants were exposed to all of these conditions within the same food recipe.

For the visual fluency manipulation, short videos were filmed for each unit with an iPhone 6 camera, resulting in a total of 80 videos for each step of each recipe. Each video had a duration of 15 seconds. Background sounds were muted in all of them. These videos were edited with a program called iMovie (10.1.12) and the resolution for the videos was 1080p (progressive) 60 fps (frames per second). These videos constituted the intact condition (Figure 2.1). Visually disfluent, distorted versions of these videos were created by superimposing an effect called glitch effect on them and adjusting the softness level of the effect to %20 with iMovie (Figure 2.2). In a small pilot study, the distorted versions of the videos were presented to approximately 10 people, ensuring that videos did not feel subjectively fluent, but all the events taking place in the videos could still be identified.

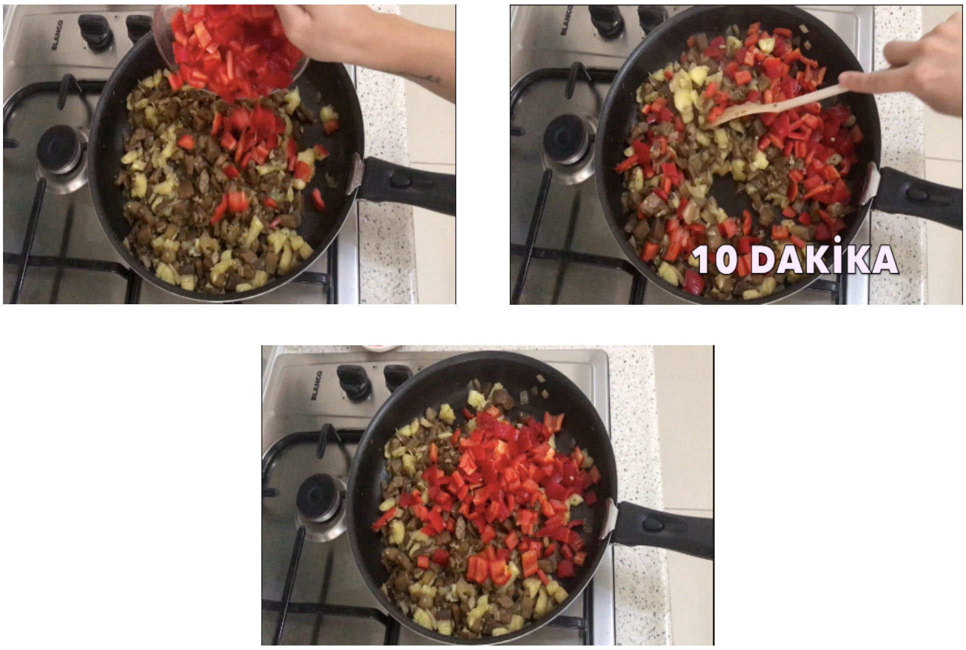

Figure 2.1: Examples for intact video (visually fluent)

Figure 2.2: Examples for distorted video (visually disfluent)

For the auditory fluency manipulation, all steps (sentences) were digitally recorded by a male native speaker of Turkish who does not have any specific regional accent, with the program Logic Pro X (version: 10.2.4). These recordings constituted the intact condition (Figure 2.3). Approximately 10 pilot participants listened to these sentences in their intact condition to ensure comprehensibility. An auditorily disfluent, distorted version of each sentence was created by using an effect called "tremolo" (with 3.29 rate, %100 depth, %60 offset, and %60 symmetry) that replaced %40 of the sentences with silence through Logic Pro X program (Figure 2.4). This effect produced a similar disfluency such as the one that was described in Besken & Mulligan (2013). The only difference was that for the auditory generation manipulation, Besken and Mulligan used words instead of full sentences. In a pilot study, approximately 10 participants listened to the distorted versions of each sentence and ensured that the sentences were identifiable on a vast majority of trials. trials.

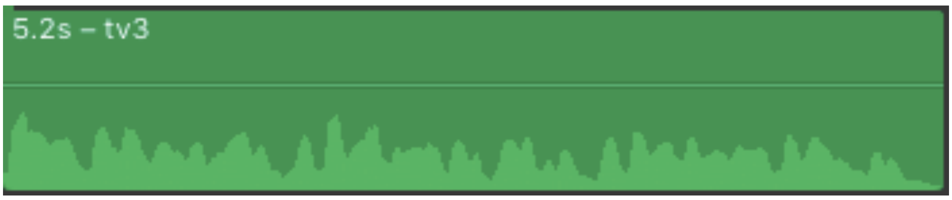

Figure 2.3: Example of intact audio (auditorily fluent)

Figure 2.4: Example of distorted audio (auditorily disfluent)

A 2 (visual modality: intact vs. distorted) X 2 (auditory modality: intact vs. distorted) within-subject design was used in the experiment and the resulting four encoding conditions were created by merging the videos and the sound files. Thus, these four conditions are as follow: intact video / intact audio, intact video / distorted audio, distorted video / intact audio and, distorted video / distorted audio. Each step was produced in all of these conditions and this resulted in a total of 320 videos. For counterbalancing, each recipe was divided into 4 equal parts, each consisting of 5 consecutive videos (steps). Each part was assigned to one of the four conditions such that within a recipe, each participant was exposed to all conditions. Moreover, this was counterbalanced across participants such that each condition seen by an equal number of participants. For example, if one participant exposed to first five steps of a recipe in intact video / intact audio condition, for another participant the first five steps of the same recipe were in another condition. Each participant watched 20 videos from each condition (a total of 80 videos). Thus, each participant received all four recipes under four conditions but the order of conditions across participants and recipes were counterbalanced. Presentation order of the recipes were semi-randomized in two different sequences as well. All counterbalancing and randomizing resulted in eight separate conditions.

All stimuli were presented on a desktop computer using Microsoft PowerPoint Presentation. Each video was placed on a different slide which was set to proceed automatically after 15 s. Videos were displayed in the center of the screen. JOL ratings, distractor task responses, and recall responses were collected in paper-pencil format, each participant was given a booklet that had instructions about where they should fill out.

2.1.3. Procedure

Participants were tested individually on computers. The experiment consisted of four study-distraction-test cycles and each part consisted of three phases: encoding phase, distraction phase, and recall phase. The experimenter gave the instructions at the beginning of each phase and answered the questions if there were any. All of the instructions were presented on the screen as well.

The experiment started with the encoding phase. Participants were informed that they would be presented with 15-second-long videos about the step-by-step preparation of a meal. Participants were specifically informed about the four encoding conditions that these recipes could be presented in. Participants were instructed to watch and listen to every video carefully and try to keep them in their mind for the upcoming memory test. They were informed that after pressing the “enter” key videos will start automatically and after 15 seconds the program will skip to the following slide automatically so they should not press any key and should not skip any video. In the experiment, immediate item-by-item judgments of learning (JOLs) were used. After each video, a JOL-rating screen was displayed. Participants were asked to make a prediction about how well they believe that they will recall that step in a subsequent recall test. For this prediction, a scale from 0 (I don’t think I will remember this at all) to 100 (I will definitely remember this step) was used. Participants were asked to write down their prediction in the box allocated to that video in the booklets that they were given at the beginning of the experiment. After writing down their predictions they were told to press Enter for initiating the next video. These item-by-item JOLs were self-paced.

Encoding phase preceded the distraction phase. Participants were given a 3-min distractor task in which they were asked to solve as many arithmetic problems as they can presented to them in their booklets. Finally, in the recall phase, participants were given a 10-minute free-recall test, in which they were asked to write down everything they could remember from the videos in any order. Participants could end terminate the recall phase before 10 minutes by pressing the enter key. The study-distraction-test cycle was repeated for a total of four times until participants were tested on all food recipes. The experiment took about 75-90 minutes in total.

2.1.4. Coding

Recall responses were coded pertaining to the idea-units that were pre-determined for each step. The coding scheme assumed that remembering an idea-unit without the right context cannot reflect the actual memory performance for the recipe or even the step it belongs. In order to measure memory performance within a context (given that recipes are sequential story-like texts) accesses to an idea-unit with the wrong context were not assigned any points. With this rationale; if an idea unit was written with the right context, a full point was given. If the idea-unit was there, but the context was slightly wrong, a half point was given; however, if the context was completely wrong, no points were given for that unit. For example, in one recipe, preparing a cake involves a step in which eggs are scrambled with sugar and in the following step, milk and oil is added to this mix. If a participant wrote scrambling eggs and milk, a half point was given to these idea units because the idea units are right, but the order (therefore the context) is not completely right. If a participant wrote scrabbling eggs with vanilla (which is an idea unit from the same recipe but not related to cake part), no point was assigned for adding vanilla, because the context was completely irrelevant to this recipe.

Furthermore, half of a point was given if a participant recalled an idea that had a similar logic as the original unit. For example, if someone wrote “mixing” instead of “scrambling”, a half point was given, because mixing and scrambling have similar visual quality and a similar logic, but they are not exactly the same action. Another example could be recalling an idea unit such as “small pieces” instead of “cube-shaped pieces”. In this case, the visual appearance is again the same, but the participant failed to remember the auditorily coded word “cube-shaped pieces”. Thus, “small pieces” is given only half point. In certain cases, when the same concept is expressed with different words that completely mean the same thing, participants were assigned full-points due to language-specific use. For example, writing down “to put it into the oven” (fırına vermek) instead of “to cook it in the oven” (fırında pişirmek) was assigned full points, because in Turkish, these different usages have the exact meaning and show that participants actually remember that unit correctly even though they did not recall the information verbatim. Detailed list for coding can be seen in Appendix B.

2.2. Results

All descriptive statistics are presented in Table 2.1. For this and all subsequent analyses, the alpha level was set at .05. Descriptive statistics for JOL ratings were calculated by taking the mean of each participant’s JOL ratings for each condition and were submitted to a 2 (auditory fluency: intact vs. distorted) X 2 (visual fluency:

intact vs. distorted) repeated measures ANOVA. The analyses yielded a significant main effect for auditory fluency on mean JOL ratings, $F(1, 39) = 15.35$, $MS_e = 32.13$, $p < .001$, $\eta_p^2 = .28$. Videos in intact audio condition ($M = 74.49$, $SE = 2.53$) received higher JOLs than videos in distorted audio condition ($M = 70.98$, $SE = 2.50$). However, the main effect of visual fluency was not significant, $F(1, 39) = 3.75$, $MS_e = 26.22$, $p = .060$, $\eta_p^2 = .09$. Furthermore, there was no interaction of auditory fluency and visual fluency on JOLs, $F(1, 39) = .415$, $MS_e = 19.7$, $p = .523$, $\eta_p^2 = .01$.

For calculating descriptive statistics for recall performance, first recall proportion for each item (sentence) was calculated. This was done by dividing the number of recalled idea units to the total number of idea units for each item. After that mean of each participant's recall proportion for each condition was calculated. All descriptive statistics are presented in Table 2.1. As with JOLs, the proportion correct recall was submitted to a repeated measures ANOVA. Recall performance was neither affected by auditory fluency, $F(1, 39) = 1,32$, $MS_e = .018$, $p = .256$, $\eta_p^2 = .03$ nor visual fluency, $F(1, 39) = 1.67$, $MS_e = .009$ $p = .204$, $\eta_p^2 = .04$. There was no interaction of auditory fluency and visual fluency on recall, $F(1, 39) = .02$, $MS_e = .01$ $p = .893$, $\eta_p^2 = .00$.

Additionally, a one-way repeated measures ANOVA was conducted with all the four measures (intact video/intact auditory, distorted video/intact audio, intact video/ distorted auditory, and distorted video/distorted audio), because all four conditions might have independent contribution to the main affect. The main effect of condition for JOL ratings was significant, $F(3, 117) = 7.69$, $MS_e = 26.02$ $p < .001$, $\eta_p^2 = .16$. Post-hoc pairwise Bonferroni comparisons showed that JOL ratings for intact video /

intact auditory condition (*M* = 75.5, *SE* = 2.37) were significantly higher than distorted video / distorted auditory condition (*M* = 70.42, *SE* = 2.58), *p* = .003 and intact video / distorted auditory condition (*M* = 71.53, *SE* = 2.54), *p* = .001.

The main effect of condition for recall performance was not significant with the one-way repeated ANOVA, $F(3, 117) = 1.09$, $MS_e = .012$, $p = .356$, $\eta_p^2 = .03$.

Table 2.1: Mean JOL ratings and proportions of recalled idea-units in Experiment 1. (Standard deviations can be seen in the parentheses)

	Intact video / Intact audio	Intact video / Distorted audio	Distorted video / Intact audio	Distorted video / Distorted audio
Experiment 1				
JOL	75.50 (14.99)	71.54 (16.11)	73.48 (17.70)	70.42 (16.27)
Recall	.64 (.15)	.62 (.18)	.61 (.15)	.59 (.17)

2.3. Discussion

In the current experiment, participants were presented with videos in which they were exposed to the same information from visual and auditory modalities varying in fluency. Results showed that participants' JOLs were significantly affected by the disfluency manipulation in the auditory modality. However, the effect of visual fluency on JOLs was not significant. Thus, participants gave higher JOLs for the videos with intact audio than the videos with distorted audio, regardless of the visual qualities of the videos. These results suggest that auditory fluency has more influence on metacognitive judgments than visual fluency when both of these modalities are combined for this specific manipulation. However, these results were not prevalent for the actual memory performance of the participants. The disfluency manipulation did not influence the actual recall of the participants neither in visual nor auditory modality.

One-way repeated measures ANOVA showed that participants gave significantly higher JOLs when both of the modalities were intact than when both of the modalities were distorted and only auditory modality was distorted. We can see the dominant effect of auditory fluency on JOLs from these results as well.

This result pattern is slightly different than what Peynircioğlu and Tatz (2018) found in their corresponding experiment (Experiment 4). First of all, they found a significant main effect of visual fluency (they called it intensity) on JOLs as well. Furthermore, with one-way repeated measures ANOVA they found that participants gave significantly higher JOLs for doubly intense condition (when both modalities were intact) than any other condition and JOLs for not-intense condition (when both modalities were disfluent) was significantly lower than any other condition as well. Similar to the current experiment, they did not find any significant difference between the auditory-intense (distorted video / intact audio condition in this study) and visually-intense (intact video / distorted audio condition in this study) conditions. These differences can be due to the usage of more complex stimuli and disfluency manipulations instead of simple word materials and intensity manipulations.

Experiment 1 showed that when participants were presented with both modalities at the same time their metacognitive judgments are more sensitive to disfluency in the auditory modality. This might have various reasons. First, when we think about the common audiovisual resources in our daily lives, it can be claimed that information mostly delivered from the auditory modality. For example, in news programs most of the time important information presented vocally by the anchorman and some recapitulatory visuals accompany in the background. A similar case is relevant for cooking shows as well; all steps are explained vocally, but the same information is not always presented visually. Thus, participants might have paid more attention to the problems in the audio than the video, influencing their JOLs. However, this is just an assumption because whether participants were aware of the disfluency in the auditory modality more than the disfluency in visual modality cannot be known. Furthermore, there are also situations that the visual information is more important than auditory information such as watching a football or a basketball match. Therefore, the obtained results could be specific to the cooking example.

Another reason might be the type of visual fluency manipulation employed in the study. The validity of the auditory generation manipulation was demonstrated in some previous research (Besken & Mulligan, 2014; Susser, Mulligan, & Besken, 2013). However, the effect of glitch effect manipulation on JOLs was not tested before. Even though it was tested with a pilot study, it might be insufficient for manipulating the visual fluency in a proper study setting. Furthermore, even if it has an effect on JOLs on its own, combining it with auditory fluency might reduce its effect on JOLs. Previous research showed that some cues might lose its effect on JOLs when combined with another cue (Undorf & Erdfelder, 2013). Lastly, the difference between the durations of sound recordings and videos might be one of the reasons. The duration of the videos was 15 seconds but the sounds in the videos were not longer than 4 seconds. Even though the information given from two modalities was the same; explaining a step auditorily is shorter than explaining it visually. Thus, this difference might make participants more vulnerable to distortions in the auditory modality. Also, they might have got used to the distortion in the visual modality due to its duration.

Memory results were different than what we have expected. We expected that the perceptual fluency manipulations used in this experiment could act as a desirable difficulty and create a double dissociation between JOLs and memory performance. This assumption was based on other experiments which used similar manipulations and found higher JOLs for fluent items but better memory performance for disfluent items. In visual modality, Besken (2016) used checkerboard masking for manipulation perceptual fluency. Checkerboard masking is similar to glitch effect manipulation used in this experiment. Both of these manipulations violate integrity of the stimuli, but while checkerboard masking is more appropriate for static materials, glitch effect is more appropriate for dynamic materials. Besken (2016) found that participants gave higher JOLs for intact items while their memory performances are better for distorted ones. Nonetheless, this results pattern was there only when aggregate JOLs were used. In the current study item-by-item JOLs were used so memory result for visual modality might be due to this factor.

However, memory result for auditory modality was surprising. Besken and Mulligan (2014) used auditory generations manipulation and found that participants gave higher JOLs for intact items even though their memory were better for distorted ones when either aggerate or item-by-item JOLs were used. In the current experiment memory performance did not differ for intact and distorted item. This suggests that using realistic materials with specific perceptual fluency manipulations that are used in this study does not lead to increased memory performance for neither distorted or intact items. Manipulating perceptual fluency in multiple modalities might be the main reason. Giving information from both visual and auditory modalities induces more top-down processes than bottom-up processes and in turn this factor might reduce the possible memory differences that could result from perceptual disfluencies. In other words, the use of meaningful materials might also increase memory performance in general by making participants to use more top-down processes and eliminate the difference that could be caused by perceptual disfluency manipulations. Memory findings were similar to Peynircioğlu and Tatz's findings. This suggest that using complex materials or/and current perceptual fluency manipulations does not necessarily affect memory performance.

CHAPTER 3

EXPERIMENT 2

Experiment 1 showed that perceptual disfluency manipulations produce differences across encoding conditions for memory predictions when within-subject design is used. In within-subjects design, participants are exposed to all conditions, which allows them to notice the relative differences between encoding conditions. However, it cannot be warranted that the same results would be valid with a between-subjects design, because in that design participants do not have the opportunity to compare different encoding conditions and they may habituate to that single encoding condition. In fact, Susser, Mulligan, and Besken (2013) tested auditory generation manipulation in terms of list composition, and they found that participants' JOLs and memory performances did not differ across encoding conditions when a between-subjects design was used. Similarly, Peynircioğlu and Tatz (2019) found no difference between JOLs and memory performances when they presented words auditorily and visually in high or low intensities. In Experiment 2, I used a between-subjects design to investigate whether these types of disfluency differences are eliminated when participants are not exposed to other types of information. In line with previous research, I hypothesized that a between-subjects design would eliminate the differences across conditions for both actual and predicted memory.

3.1. Method

3.1.1. Participants

Eighty native speakers of Turkish between the ages of 18-30 from the Bilkent University participated in the study. They were compensated with either course credit or a payment of 10 Liras for their participation. All participants reported normal or corrected-to normal hearing and sight. The sample size was determined according to Peynircioğlu and Tatz's (2018) related experiment.

3.1.2. Materials, Design, and Procedure

The materials were identical to Experiment 1. However, the design was different. Instead of a within-subjects design, a 2 (visual modality: intact vs. distorted) X 2 (auditory modality: intact vs. distorted) between-subject design was used in Experiment 2. Each participant was presented with only one condition throughout the experiment (all 80 videos).

The procedure was nearly identical to Experiment 1 with only one difference in the instructions of encoding phase. Participants were not informed about all four conditions and only told that there could be (or not) disfluencies in visual or/and auditory modalities. The distractor and the recall phases were identical to Experiment 1.

3.2. Results

Descriptive statistics were calculated by taking the mean of JOL ratings for each participant. All descriptive statistics are presented in Table 3.1. A 2 (auditory fluency: intact vs. distorted) X 2 (visual: intact vs. distorted) ANOVA showed no main effects for auditory fluency, $F(1, 76) = .02$, $MS_e = 220.02$, $p = .875$, $\eta_p^2 = .00$, and for visual fluency, $F(1, 76) = 1.35$, $MS_e = 220.02$, $p = .247$, $\eta_p^2 = .02$, on mean JOL ratings. Also, there was no interaction between them on JOLs, $F(1, 76) = .68$, $MS_e = 220.02$, $p = .413$, $\eta_p^2 = .01$.

As in Experiment 1, recall performance was affected neither by auditory fluency, $F(1, 76) = .29$, $MS_e = .02$, $p = .594$, $\eta_\rho^2 = .004$ nor visual fluency, $F(1, 76) = .39$, $MS_e = .02$, $p = .538$, $\eta_p^2 = .005$. There was no interaction between them on recall, $F(1, 76) = .00$, $MS_e = .02$, $p = .98$, $\eta_p^2 = .00$.

One-way repeated measures ANOVA showed that there were no differences between the four conditions in terms of JOL ratings $F(3, 76) = .69$, $MS_e = 220.02$ $p = .563$, $\eta_\rho^2 = .03$ and recall $F(3, 76) = .22$, $MS_e = .02$, $p = .880$, $\eta_\rho^2 = .01$ as well.

Table 3.1: Mean JOL ratings and proportions of recalled idea-units in Experiment 2. (Standard deviations can be seen in the parentheses)

	Intact video / Intact audio	Intact video / Distorted audio	Distorted video / Intact audio	Distorted video / Distorted audio
Experiment 2				
JOL	78.05 (14.42)	80.26 (12.71)	76.91 (14.77)	73.66 (17.11)
Recall	.64 (.13)	.63 (.11)	.62 (.15)	.61 (.12)

3.3. Discussion

As expected, perceptual disfluency manipulation in auditory and visual modality did not produce differences across different encoding conditions for actual and predicted memory, when a between-subject design was used. Thus, when relative differences were not available to participants within the experiment, perceptual disfluency did not create differences for JOLs or recall. This result pattern shows that the effect of perceptual fluency on metamemory judgments is relative even when perceptual fluency manipulated in different modalities. In their study, Peynircioğlu and Tatz found the same results when they combined intensity with presentation modality in a between-subjects design. Moreover, Susser, Mulligan, and Besken (2013) used auditory generation manipulation with between-subject design and found that participants' JOLs did not differ for intact and generate words. The current study shows that using different perceptual fluency manipulations (glitch effect and auditory generation) and more complex stimuli did not change this result pattern, at least for these specific manipulations.

CHAPTER 4

EXPERIMENT 3

Two critical factors might have contributed to the findings in Experiments 1 and 2. The first factor was the story-like sequence between items. Since we used food recipes, there was a logical order across items. When there is a story-like structure, participants may potentially refer to their scripts about cooking, which in turn might have affected both participants' JOLs and their retrieval cues for recalling information in the free-recall test. The second factor was the number of common idea units between recipes. Even though the selected recipes were for different types of foods (a desert, a soup, a meat dish, and a vegetable dish), there were some common idea-units between them, because variety of dishes involve certain common steps or ingredients. For example, garlic is a very common ingredient for dishes in general and three of the recipes involved garlic in them. Idea-units about garlic were similar between these recipes. Another example is baking; the oven was used in all of the recipes in different ways, but the idea-unit of "baking" was common across the recipes. Therefore, this factor might have increased participants' confidence and memory performance about those items. Thus, the primary goal of Experiment 3 was to investigate whether removing sequence (logical order) and the repetition across the steps would reduce the effect of general knowledge about cooking for actual and predicted memory performance. For reducing the effect of sequence within the recipes and eliminating the logical order across the items, 32 independent and unique steps were chosen from the 4 recipes that had been used in Experiments 1 and 2. By doing so, the effect of story-like sequence was eliminated. This selection reduced the possible contribution of general knowledge about cooking to both memory predictions and the actual memory test, because selected items were unique and did not involve common steps that one should expect in a random recipe. Finally, using random steps from previous recipes reduced the number of common idea-units to a minimum number. If perceptual disfluency manipulations affect memory predictions regardless of the story structure, one should still observe differences across encoding conditions, with lower predictions for the more disfluent condition.

In Experiment 1 we examined how combining visual fluency and auditory fluency cues affects people's memory predictions and memory performances. We tried to create an experimental setting comparable to daily life. For that purpose, we used more complex materials and manipulations that mimics common audiovisual problems in daily life. According to previous research that use similar manipulations only in one modality, we hypothesize that perceptual disfluency in one or two of the modalities will lead to lower JOLs for the disfluent items. Even though the effect of disfluency on memory predictions is well-known, the results for actual memory performance may change. If the effects of auditory generation on memory is similar for sentences to simple word materials, then one could expect higher memory performance when the materials are more disfluent, as in line with Besken and Mulligan (2014) and Besken (2016). However, perceptual fluency manipulations might also be more effective with simple words stimuli than with more complex material. In that case, memory performance should not differ across conditions. Peynircioğlu and Tatz (2018) also found that use of multiple modalities with intensity manipulations did not produce differences for actual memory performance in general.

4.1. Method

4.1.1. Participants

Forty native speakers of Turkish between the ages of 18-30 from the Bilkent University participated in the study. They were compensated with either course credit or a payment of 10 Liras for their participation. All participants had any problem with hearing or sight. The sample size was determined according to the Experiment 1.

4.1.2. Materials, Design, and Procedure

The design was a 2 (visual fluency: visually intact vs. visually distorted) x 2 (auditory fluency: auditorily intact vs. auditorily distorted) within-subject design which was identical to Experiment 1. Thus, just like Experiment 1, there were 4 conditions: intact video / intact auditory, intact video / distorted auditory, distorted video / intact auditory and, distorted video / distorted auditory.

32 steps were chosen from a total of 80 steps from the recipes used in Experiment 1 and 2. These chosen videos did not have any logical order across them and did not

have the same ingredients. Also, number of common idea-units across them was almost zero (e.g. no common idea-units regarding the ingredients). This selection resulted in a total of 128 videos (32 videos for each condition). Four of these videos used for primacy and recency items (first two and last two), leaving 28 videos as target items. The list of chosen items, along with their idea unit divisions can be seen in Appendix C. 28 videos were divided into four sets of 7 videos for each condition. Each participant was exposed to all conditions and watched 7 target videos from each condition (total of 28 videos). Total number of idea-units for each set were almost always equal. (due to counterbalancing some groups had one- or two-units difference). These four sets of 7 videos were counterbalanced across participants such that all sets were presented to an equal number of participants in each condition. None of the videos was followed by a video of the same condition. For example, if a video presented in intact video / intact audio condition the following video was presented in a condition other than that. Moreover, no consecutive videos from the same recipe followed each other. Thus, the contexts of the all videos within the same set were different than each other. This was important for reducing the consecutiveness across the recipe steps. Presentation order of the videos was semi-randomized through two different lists as well. Counterbalancing and randomization resulted in eight separate conditions.

The procedure was similar to Experiment 1 with one exception; there was only one cycle with three phases: encoding, distraction, and recall. Instructions of these three phases were the same as Experiment 1. The experiment took about 25-30 minutes in total. The coding of the memory test was conducted according to the rules and criteria that were previously used Experiment 1.

4.2. Results

All descriptive statistics are presented in Table 4.1. A 2 (auditory fluency: intact vs. distorted) X 2 (visual fluency: intact vs. distorted) repeated measures ANOVA with the JOL ratings as the repeated factor showed a significant main effect of auditory fluency on mean JOL ratings, $F(1, 39) = 33.55$, $MS_e = 102.88$, $p < .001$, $\eta_p^2 = .47$. Videos in intact audio condition ($M = 69.95$, $SE = 3.19$) received higher JOLs than videos in distorted audio condition ($M = 60.67$, $SE = 3.3$). The main effect of visual fluency was statistically significant as well, $F(1, 39) = 13.79$, $MS_e = 79.63$, $p < .001$, $\eta_p^2 = .26$. Videos in intact video condition ($M = 67.92$, $SE = 3.11$) received higher JOLs than videos in distorted video condition ($M = 62.69$, $SE = 3.32$). Furthermore, the interaction of auditory fluency and visual fluency on JOLs was significant, $F(1, 39) = 7.6$, $MS_e = 67.78$, $p = .009$, $\eta_p^2 = .17$.

Since the interaction between auditory fluency and visual fluency on JOLs was significant, in order to determine the direction of the interaction four paired sample t-tests conducted. The difference between the mean JOL ratings of the intact video / intact audio condition ($M = 74.36$, $SE = 21.41$) and the intact video / distorted audio condition ($M = 61.49$, $SE = 20.66$) was statistically significant; $t(39) = 5.56$, $p < .001$. The difference between the mean JOL ratings of the distorted video / intact audio condition ($M = 65.54$, $SE = 20.95$) and the distorted video / distorted audio condition ($M = 59.84$, $SE = 22.52$) was also statistically significant; $t(39) = 3.20$, $p = .003$. The difference between the mean JOL ratings of the intact video / intact audio condition and the distorted video / intact audio condition was statistically significant as well; $t(39) = 4.24$, $p < .001$. However, the difference between the mean JOL ratings of the intact video / distorted audio condition and the distorted video / distorted audio conditions was not significant; *t*(39) = .95, $p = .350$.

The mean proportion correct recall for each participant was submitted to a 2x2 repeated-measures ANOVA with auditory and visual fluency as repeated factors. As in Experiment 1, the main effect of auditory fluency on recall, $F(1, 39) = .00$, MS_e =.01, $p = .981$, $\eta_p^2 = .00$ and the main effect of visual fluency on recall, $F(1, 39) =$ .51, $MS_e = .02$, $p = .478$, $\eta_p^2 = .01$ were not significant. There was no interaction of auditory fluency and visual fluency on recall, $F(1, 39) = .00$, $MS_e = .02$, $p = .786$, $\eta_p^2 = .00$.

Additionally, a one-way repeated measures ANOVA was conducted with all the four measures (intact video/intact auditory, distorted video/intact audio, intact video/ distorted auditory, and distorted video/distorted audio). The main effect of condition for JOL ratings was significant, $F(3, 117) = 20.23$, $MS_e = 83.42$, $p < .001$, $\eta_p^2 = .34$. Post-hoc pairwise Bonferroni comparisons showed that JOL ratings for Intact video / intact auditory condition ($M = 74.37$, $SE = 3.39$) were significantly higher than intact video / distorted auditory condition ($M = 61.49$, $SE = 3.27$); $p < .001$, distorted video / intact auditory condition ($M = 65.53$, $SE = 3.31$); $p < .001$, and distorted video / distorted auditory condition ($M = 59.83$, $SE = 3.56$); $p < .001$. Also, mean JOL ratings for distorted video / intact auditory condition was significantly higher than distorted video / distorted auditory condition, $p = .016$. All other pairwise comparisons revealed no differences across conditions.

The main effect of condition for recall performance was not significant with the one-way repeated ANOVA either, $F(3, 117) = .20$, $MS_e = .018$, $p = .892$, $\eta_p^2 = .00$.

Table 4.1: Mean JOL ratings and proportions of recalled idea-units in Experiment 3. (Standard deviations can be seen in the parentheses)

	Intact video / Intact audio	Intact video / Distorted audio	Distorted video / Intact audio	Distorted video / Distorted audio
Experiment 3				
JOL	74.36 (21.41)	61.49 (20.66)	65.54 (20.95)	59.83 (22.52)
Recall	.29 (.13)	.30 (.17)	.32 (.18)	.31 (.16)

4.3. Discussion

Results of Experiment 3 showed that participants' JOLs were significantly affected by the disfluency in both auditory and visual modalities. As in Experiment 1, participants gave higher JOLs for the videos with intact audio than the videos with distorted audio. In addition, participants' JOLs were also significantly higher for the visually intact videos than visually distorted ones. This result differs from the findings in Experiment 1. As in Experiment 1 and 2, the memory performance of the participants remained unaffected. The single dissociation between JOLs and memory performance was valid for both of the modalities.

An important difference between Experiments 1 and 3 was in Experiment 3 we found an interaction between auditory fluency and visual fluency on JOLs, meaning that the disfluency in one modality affected participants' JOLs for differently across the levels of the other modality. In other words, when one of the modalities was disfluent (either auditory or visual) participants' JOLs were lower than the condition in which both modalities were fluent. When auditory modality was fluent, participants gave higher JOLs compared to the condition which both modalities were disfluent. However, when visual modality was fluent, it did not change participants' JOLs compared to the condition in which both modalities were disfluent. These findings provide support for Experiment 1, because in Experiment 1 auditory modality was the only factor that produced differences across encoding conditions. For this experiment, both auditory and visual factors produced memory prediction differences, but the interaction showed that the disfluency in auditory modality affected JOLs more.

The main reason behind these differences across Experiment 1 and 3 are most probably caused by the presence of the logical order between items and the repetition of certain idea units. Elimination of the story-like sequence within each recipe reduces the effect of general knowledge about cooking. These modifications reveal a clearer picture of how JOLs may be affected from perceptual disfluency manipulations across modalities, when there is no logical sequence and prior knowledge is not available to build on. However, these modifications did not change the memory performance results across studies. Memory performance remained unaffected in both Experiment 1 and 3. This result shows that usage of complex stimuli does not affect memory even when logical order between items removed. Furthermore, how glitch effect and auditory generation manipulations affects memory performance do not depend on logical order across items. These specific manipulations do not act as a desirable difficulty when perceptual fluency manipulated in multiple modalities regardless of the relationship between items.

Experiment 3 is more similar to Peynircioğlu and Tatz in terms of its structure (2018), because their items were not connected to each other in logical order. When logical order was eliminated, Experiment 3 revealed results similar to Peynircioğlu and Tatz (2018): The mean JOL ratings for intact video / intact audio condition were higher than any other condition, and there was no difference between mean JOLs ratings for intact video / distorted auditory condition and distorted video / intact auditory condition. Different than their findings, in the current experiment, JOLs for distorted video / distorted audio condition were not lower than all of the conditions. The mean JOL ratings for distorted video / distorted audio condition was only lower than intact video / intact audio and distorted video / intact auditory conditions, but it was not significantly different than intact video / distorted auditory. Memory performance remained unaffected in both of these experiments. This shows that, using more complex materials or specific manipulation being used in this experiment do not necessarily creates double dissociation between JOLs and memory. Since there is no difference between Peynircioğlu and Tatz's (2018) results and Experiment 3 results in terms of memory performance, it can be claimed that combination of different cues is more important for memory predictions. Manipulation of perceptual fluency in multiple modalities might have reduced the possible effect of complex materials or perceptual fluency manipulations (glitch effect and auditory generation) on memory.

It can be argued that using meaningful materials with visual and auditory disfluency manipulations produced JOL differences across encoding conditions for both types of modalities without affecting the memory performance. However, the effect of auditory fluency on JOLs was more dominant. Furthermore, the interaction between auditory fluency and visual fluency on JOLs showed that disfluency or fluency in one modality can affect participants' JOLs about the other modality. These results could be more useful for understanding the mechanisms underlying people's metamemory processes.

CHAPTER 5

GENERAL DISCUSSION

5.1. Summary and Interpretation of Results and Theoretical Explanations

The current study examined how disfluency cues from both auditory and visual modalities influence predicted and actual memory. Results showed that disrupting perceptual fluency of materials through visual and auditory modalities lower memory predictions without influencing actual memory. In a set of three experiments, short clips that describe how to prepare four different food recipes (step by step) were presented visually and auditorily to the participants. Participants were asked to watch and listen to these clips carefully and try to remember them for a later memory test. Also, participants were asked to make judgments about how well they will remember each clip (item-by-item JOLs). The clips were presented in 4 different conditions; intact video / intact audio, intact video / distorted audio, distorted video / intact audio, and distorted video / distorted audio. Experiment 1 showed that auditory fluency affects metacognitive judgments, but visual fluency does not influence it when both of these modalities are combined for this specific manipulation. However, actual memory performance remained unaffected. Experiment 2 examined the effect of list composition with a between-subject design. Neither memory predictions nor actual memory differed across conditions, as expected. Lastly, Experiment 3 examined whether the logical order between items and repetition of some idea-units moderates the effect of perceptual fluency on multiple modalities. Results showed that these two factors act as moderator cues and when they are eliminated, both visual and auditory disfluency influence JOLs. Furthermore, there was an interaction between auditory disfluency and visual disfluency on JOLs. The interaction between them showed that the effect of auditory fluency is more dominant than the effect of visual fluency on JOLs, as in Experiment 1. Similar to Experiment 1 and 2, recall remained unaffected in Experiment 3.

These results can be explained by perceptual fluency hypothesis which states people make higher memory predictions for fluent items, compared to less fluent or disfluent items (Rhodes & Castel, 2008). This hypothesis also claims that people's memory predictions might not necessarily reflect their actual memory performance, meaning that certain perceptual fluency manipulations could lead to dissociations between memory predictions and memory (Rhodes & Castel, 2008). In the current study, we can see such a dissociation even though perceptual fluency manipulated in multiple modalities by using more meaningful and complex materials. Furthermore, in this study, perceptual fluency was manipulated by creating disfluency rather than increasing the fluency (intensity). Participants gave higher JOL ratings for fluent items compared to disfluent ones, but their memory performance did not differ for these items. Similar result patterns can be seen in many other studies that manipulated perceptual fluency by increasing fluency (font-size manipulation, loudness manipulation) (e.g. Frank & Kuhlman, 2017; Rhodes & Castes, 2008; 2009; Peynircioğlu & Tatz, 2018; Yang, Huang, & Shanks, 2017) or by creating disfluency (auditory generation manipulation, checkerboard masking, changing stimulus size) (e.g. Besken & Mulligan, 2014; Besken, 2016; Undorf, Zimdahl, & Bernstein, 2017).

One of the aims of this study was examining how people utilize available cues while making metamemory judgments. As discussed before, there were two theoretical hypotheses about how cues are being utilized in JOLs. Multiple cue hypothesis argues that people integrate all available cues while making JOLs. Selective-cue hypothesis, on the other hand, argues that people select some or one of the cues and ignore the others while making JOLs. In the current study, we directly manipulated two cues; auditory disfluency and visual disfluency. Experiment 1 showed that when both visual and auditory cues were presented simultaneously, only the auditory cues significantly affected participants' JOLs. However, in Experiment 1 there were also other cues that might have moderated the observed effect. Those moderator cues were the logical order between items and the repetition of some idea-units.

Investigating the effect of logical order or the effect of repetition was not the main purpose of the current study. However, the effort for creating a well-controlled experimental setting that is related to daily life and usage of realistic materials led to a story-like structure between items. Thus, in a way, the logical order and the repetition was a methodological by-product for this specific manipulation. We realized that the logical order between the items and the repetition of some items may act as moderator cues that might have direct or indirect influences on memory predictions and actual memory performance. It was reasonable to think that when these two moderators are combined with auditory disfluency and visual disfluency, they might change the pattern of results. That is why Experiment 3 examined the effect of logical order between items and the effect of repetition of certain items. Results showed that both of these factors were important moderators indeed. When they were eliminated, participants' JOLs were significantly affected by both auditory and visual cues.

It can be claimed that these results provide support for both of the hypotheses. Results suggest that participants might select some of the cues and ignore the others when different moderator cues were also available to them. Also, participants might integrate all of the cues if the moderator cues are no longer present. Thus, these results showed that when making JOLs, how people select among cues might change when the available cues are different. In Experiment 1, when logical order and repetition factors were present participants used auditory cues and ignored visual cues while making JOLs. However, in Experiment 3 when those factors were eliminated, participants used both auditory and visual cues. Nevertheless, in both Experiment 1 and Experiment 3, the effect size of auditory disfluency manipulation is higher than the effect size of visual disfluency. Whether the participants were aware that they were more vulnerable to disfluencies in auditory modality is unknown, but there could be some reasons behind it.

One reason is that auditory information could be more important for cooking than visual information (cooking shows on TV). However, there could be also situations that the opposite is valid for the same example (short cooking videos on the internet that do not have any sound). This suggests that the theme of cooking produces this result when the current manipulation is being used. Another reason for the dominance of auditory disfluency over visual disfluency could be the intensity of the perceptual fluency manipulations employed in the study. The validity of glitch effect manipulation could be of concern, even though the pilot studies showed that the glitch effect was sufficient for participants to have a feeling of subjective disfluency. However, Experiment 3 showed that the glitch effect manipulation is sufficient for manipulation the visual fluency. However, its influence on JOLs might be lower than auditory generation manipulation.

The last reason for different modalities to have differential effects on JOLs could be the duration difference between videos and sound recordings. This difference might affect the degree of disfluency between these manipulations. For this study, the information that comes from auditory and visual modalities should be the same, but this led to a duration difference between sound recordings and videos. For example, the sound clips lasted for 5 seconds on average, but the information was always presented for 15 seconds in the visual modality. This problem could be eliminated by using a different theme than cooking without reducing the complexity of materials.

Similar to the current study, Peynircioğlu and Tatz also examined how people combine cues from auditory and visual modalities and found that modality itself did not have any effect on participants' JOLs. However, when visual intensity and auditory intensity cues were available, participants integrated these cues while making JOLs. They claim that their findings demonstrate the complexity of metamemory processes and support the assumption that a higher level of processing contributes to the metamemory predictions. Furthermore, they showed that memory predictions could be affected by the combination of multiple cues. More importantly, one of these cues might lose its effect on JOLs partly or entirely if the other one is not present (Peynircioğlu & Tatz, 2018). Results of the current study and results of Peynircioğlu and Tatz are different; however, both studies suggest that people do not have one stable strategy for cue combination. How people integrate cues or select cues could be different according to the manipulation they are exposed to.

Another aim of this research was to examine the effect of list composition when perceptual disfluency is manipulated in multiple modalities by using more realistic and meaningful materials. In line with the previous research, when relative differences across encoding conditions were not readily available to the participants, perceptual disfluency did not lead to any disassociation between JOLs and recall (e.g. Susser, Mulligan, & Besken, 2013; Peynircioğlu & Tatz, 2018). Combining multiple cues and using more meaningful materials did not change this pattern. The current study created an experimental setting that was comparable to daily life by using more complex materials and a theme (cooking), but the effect of list composition did not change. This result suggests that the availability of relative perceptual differences across encoded information is important in real life as well.

Across three experiments many factors affected memory predictions; however, memory performance remained unaffected. The glitch effect and auditory generation manipulations used in this study were inspired by checkerboard masking (Besken, 2016) and auditory generation (Besken & Mulligan, 2014) (single words) manipulations. Previous studies showed that disfluencies generated through checkerboard masking and auditory generation manipulations act as desirable difficulties and lead to double disassociations between JOLs and memory. In light of these results, a similar pattern was expected in the current study. However, the dissociations between JOLs and memory occurred in Experiments 1 and 3 were single disassociations. Reducing perceptual disfluency in auditory and visual modalities did not affect memory in the current manipulations. This result can be explained by the difference between the usage of top-down and bottom-up processes in these experiments. Using single words or pictures would induce more bottom-up processes and this factor might increase the effect of used disfluency manipulations on actual memory. However, in the current study video materials lead to more top-down processes and this might reduce the effect of perceptual disfluency manipulations.

The memory results of the current study suggest that when the information comes from multiple modalities, the possible effect of perceptual disfluency on memory may not be observed. Participants might benefit from both of the modalities even when one of them or both of them were disfluent, just like in real life. Desirable difficulties might lose their efficiency when information comes from multiple modalities. Therefore, in the real-life concept of desirable difficulty might be more related to the context of the learned materials than the perceptual features of those materials. Moreover, the usage of meaningful material might provide the opportunity of using prior knowledge in the memory test. Thus, participants might predict some of the items and this might affect the memory results independently from the effect of perceptual disfluency manipulations.

5.2. Limitations and Further Studies

In the current study, the sequence or repetition was not manipulated directly. Thus, their influence on JOLs might be different if the information does not come from different modalities and if perceptual fluency was not manipulated order might have triggered employment of other factors such as activation of prior knowledge. The story-like structure between items might have led participants to use their general knowledge about cooking more in the recall test or while making memory predictions. Thus, elimination of logical order affects JOLs by preventing JOLs to be built on prior knowledge as well. One might test whether logical order itself is a direct cue that can affect JOLs and memory in isolation or not can be examined only by manipulating the order in recipes. The same recipes could be presented to the participants in randomized order or with their original order without manipulating the perceptual fluency (only the intact video / intact audio versions of the videos). Results obtained through this kind of manipulation might advance literature regarding how different cues are utilized in JOLs and memory performance.

Eliminating the logical order between items might have also reduced the effect of common idea-units between items. For example, when one uses onion in multiple steps of a recipe, onion might potentially act a cue for recall for the next step of the recipe. Thus, when this common idea unit is eliminated, the effect of visual and auditory information on JOLs might have changed. It is reasonable to think that common idea-units might affect actual memory performance, as it does JOLs. However, Experiments 1 and 3 are not comparable for actual memory performance, as Experiment 1 contains four study-test cycles, whereas Experiment 3 only has one study-test cycle. Thus, we cannot know that for sure so whether the existence of common-idea units or logical order has a direct influence on recall. Further research should investigate the effects of logical order on both JOLS and recall in a systematic manner.

The current study did not examine the effect of list-composition when logical order between items was eliminated. In previous research about list-composition, there was no logical order or story-like structure between items (e.g. Peynircioğlu & Tatz, 2018; Susser, Mulligan, & Besken, 2013). Further studies could investigate the effect of list composition on JOLs and memory with the current experimental setting.

5.3. Practical Implications and Conclusions

In conclusion, this study demonstrated that perceptual disfluency has an influence on memory predictions even though it does not affect actual memory. Participants' JOLs were negatively affected by perceptual disfluencies in both modalities when there was no logical order between items or no repetition of some items. When there was a logical order and repetition only auditory disfluency significantly affected JOLs. Thus, when a procedural task such as cooking explained to participants both auditorily and visually, participants thought that auditory disfluencies could affect their memory more even though their actual memory was not affected by the manipulation.

Lastly, this study demonstrated that it is possible to conduct experiments that are compatible with real life. In order to create such an experimental setting, we used complex, meaningful materials and cooking as a theme. Other themes could be found. The findings of this study can be explained by the perceptual fluency hypothesis (Rhodes & Castel, 2008) and cue combination theories (Undorf & Söllner, & Bröder, 2018). One of the aims of this study was showing the convenience of using complex and meaningful material in metamemory research for obtaining results that are more comparable with daily life. We believe that this study managed this aim successfully. There are many databases for obtaining simple materials but finding resources for complex materials is not that easy. Databases for complex materials could be created by conducting more research that uses such materials and this might lead to more extensive use of complex and meaningful materials that are well controlled.

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APPENDICES

APPENDIX A. FOOD RECIPES AND IDEA UNIT DIVISIONS (EXP 1 & 2)

A.1. Fransız Usulü Mantarlı Soğan Çorbası

1. Soğanları soyup piyazlık (ince uzun) doğrayın.
    - Soğan soymak
    - Soğan doğramak
    - Piyazlık
2. Sarımsakları soyup rendeleyin.
    - Sarımsağı soymak
    - Sarımsağı rendelemek
3. Mantarları yemeklik (küçük küçük) doğrayın
    - Mantar doğramak
    - Yemeklik
4. Tencereyi ocağa alıp tereyağını koyup eritin
    - Tereyağı koymak
    - Tereyağını eritmek
5. Soğan ve sarımsakları ekleyip karıştırın
    - Soğan eklemek
    - Sarımsak eklemek
    - Karıştırmak
6. Mantarları ekleyip soğanlar kahverengiye dönene kadar kavurun
    - Mantar eklemek
    - Kavurmak
    - Soğanların kahverengiye dönmesi
7. Şekeri ekleyip 3 dk. karıştırarak kavurun
    - Şekeri eklemek
    - 3 dakika
    - Karıştırarak kavurmak
8. Unu ekleyip 5 dakika daha karıştırarak kavurun
    - Un eklemek
    - 5 dakika
    - Karıştırarak kavurmak
9. Su ekleyip topaklanması gidene kadar karıştırın
    - Su eklemek
    - Topaklanma gidene kadar (topaklanmadan)
    - Karıştırmak
10. Krema ekleyip karıştırın
    - Krema eklemek
    - Karıştırmak
11. Son olarak tuz ve karabiberi ekleyip karıştırın
    - Tuz eklemek
    - Karabiber eklemek
    - Karıştırmak
12. Kısık ateşte 10 dk. daha kaynatın

- Kısık ateş
- 10 dakika
- Kaynatmak

13. Ateşten alıp kaselere paylaştırın
    - Ateşten almak
    - Kaselere paylaştırmak
14. Baget ekmekleri dilimleyin
    - Ekmek dilimlemek
    - Baget
15. Kaselerin içine birer dilim ekmek koyup çorbayı tamamen çekip ıslanana kadar bekleyin
    - Kaselere bir dilim ekmek koymak
    - Çorbayı çekip ıslanması
    - Beklemek
16. Kaşar peynirini rendeleyin
    - Kaşar peyniri rendelemek
17. Kaselere bir dilim ekmek daha koyup üstteki ekmeğin üzerine rendelenmiş peynirleri serpin
    - Bir dilim ekmek koymak
    - Peynir serpmek
18. Fırın tepsisinin içine su koyup çorba kaselerini tepsiye yerleştirin
    - Fırın tepsisine su koymak
    - Çorba kaselerini tepsiye yerleştirmek
19. 180 derecede önceden ısıtılmış fırında peynirler eriyip kızarana kadar pişirin
    - 180 derece
    - Önceden ısıtılmış fırın
    - Peynirlerin eriyip kızarması
    - Fırında pişirmek
20. Fırından çıkarıp üzerlerine pul biber ve kekik serperek servis edin
    - Pul biber serpmek
    - Kekik serpmek
    - Servis etmek

A.2. Deniz Köpüğü Tatlısı

1. Şerbet için su ve şekeri tencereye koyun
    - Şerbet
    - Tencereye su koymak
    - Tencereye şeker koymak
2. Orta ateşte şeker eriyene kadar karıştırarak pişirin
    - Orta ateş
    - Şekerin erimesi
    - Karıştırarak pişirmek
3. Kendi halinde 10 dk. daha kaynatıp altını kapatın ve soğumaya bırakın
    - 10 dakika
    - Kaynatmak
    - Altını kapatmak
    - Soğutmaya bırakmak
4. Kek için bir kaba yumurtaları kırıp şekeri ekleyin ve çırpın
    - Kek
    - Yumurtaları kırmak
    - Şeker eklemek
    - Çırpmak
5. Süt ve sıvı yağı ekleyerek çırpın
    - Süt eklemek
    - Tereyağı eklemek
    - Çırpmak
6. Galeta ununu ve kabartma tozunu ekleyerek spatula ile karıştırın
    - Un eklemek
    - Galeta un
    - Kabartma tozu eklemek
    - Spatulayla karıştırmak
7. Ekmekleri ufalayıp elde ettiğiniz ekmek kırıklarını ekleyerek karıştırın
    - Ekmekleri ufalamak
    - Ekmek kırıntısı eklemek
    - Karıştırmak
8. Cevizleri ezip ezdiğiniz cevizleri ekleyerek karıştırın
    - Cevizleri ezmek
    - Cevizleri eklemek
    - Karıştırmak
9. İncirleri küçük küçük doğrayın
    - İncir doğramak
    - Küçük
10. Doğranmış incirleri ve hindistan cevizini ekleyip karıştırın
    - Hindistan cevizi eklemek
    - İncirleri eklemek
    - Karıştırmak
11. Fırına girebilen bir kabı yağlayıp karışımı içine dökün ve iyice yayın
    - Kabı yağlamak
    - Karışımı dökmek
    - Karışımı yaymak

12. 180 derece fırında 25 dakika pişirin
    - 180 derece
    - 25 dakika
    - Fırında pişirmek
13. Muhallebi için bir tencereye unu ve şekeri koyup karıştırın
    - Muhallebi
    - Tencereye un koymak
    - Tencereye şeker koymak
    - Karıştırmak
14. Ardından süt ve yumurtayı ekleyip çırpın
    - Süt eklemek
    - Yumurta eklemek
    - Çırpmak 3
15. Orta ateşte sürekli karıştırarak pişirin
    - Orta ateş
    - Sürekli karıştırarak
    - Pişirmek 2
16. Ateşten alıp tereyağı ve vanilyayı ekleyin
    - Ateşten almak
    - Tereyağı eklemek
    - Vanilya eklemek
17. 10 dakika boyunca üzerinin kabuk bağlamaması için çırpın
    - 10 dakika
    - Üzerinin kabuk bağlamaması
    - Çırpmak
18. Keki fırından alıp ılımasını bekledikten sonra şerbeti üzerine gezdirin
    - Keki fırından almak
    - ılımasını beklemek
    - Üzerinde şerbet gezdirmek
19. Kekin üzerine muhallebiyi döküp düzleştirin ve muhallebinin üstüne hindistan cevizi serpin
    - Muhallebi dökmek
    - Düzleştirmek
    - Hindistan cevizi serpmek
20. Dolaba koyup iki saat dinlendirdikten sonra servis edin.
    - Buzdolabına koymak
    - 2 saat
    - Dinlendirmek
    - Servis etmek

A.3. Tavuk Volovan

1. Milföyleri kırıp dört adet kare milföy elde edin.
    - Milföy kırmak(bölmek)
    - Kare milföy elde etmek,
    - 4 adet
2. Bir yumurtanın sarısını ve beyazını ayırın
    - Yumurtanın sarısını ve beyazını ayırmak
3. Kare milföylerden birini alıp çatal yardımı ile delikler açın ve kenarlarına yumurta beyazı sürün.
    - Bir milföy parçasını (kare) almak
    - Çatalla delikler açmak
    - Yumurta beyazı sürmek
4. Diğer 3 milföy karesinin orta kısmını kare şeklinde kesin
    - 3 milföy
    - Ortalarını kesmek
    - Kare şeklinde
5. Her birine yumurta beyazı sürerek üst üste yerleştirin ve en üst kısmına yumurta sarısı sürün
    - Yumurta beyazı sürmek
    - Üst üste koymak
    - Yumurta sarısı sürmek
    - En üste
6. Önceden ısıtılmış 180 derece fırında 25 dakika kadar pişmeye bırakın.
    - 180 derece
    - Önceden ısıtılmış
    - Fırında pişirmek
    - 25 dakika.
7. Tavukları küçük küçük doğrayın.
    - Tavuk doğramak
    - Küçük
8. Soğanları soyup yemeklik doğrayın.
    - Soğan soymak
    - Soğan doğramak
    - Yemeklik
9. Sarımsakları soyup ince ince kıyın
    - Sarımsak soymak
    - Sarımsak kıymak
    - Ince
10. Chili biberi yuvarlak doğrayın
    - Biber doğramak
    - Yuvarlak
    - Chili biber
11. Tavayı ocağa alıp soğanları ve sarımsakları ekleyin ve kavurun
    - Soğan eklemek
    - Sarımsak eklemek
    - Kavurmak
12. Mantarları yemeklik doğrayın

- Mantar doğramak
- Yemeklik

13. Doğradığınız tavukları, chili biberleri ve mantarları ekleyip karıştırın
    - Tavuk eklemek
    - Biber eklemek
    - Mantar eklemek
    - Karıştırmak
14. Karabiber ve tuzu ekleyip pişirin
    - Karabiber eklemek
    - Tuz eklemek
    - Pişirmek
15. Beşamel sos için bir tencereyi ocağa alıp içinde tereyağını eritin.
    - Beşamel sos
    - Tencerede tereyağı eritmek
16. Eriyen tereyağının içerisine un ekleyip 3 dk. kavurun
    - Un eklemek
    - 3 dakika
    - Kavurmak
17. Üzerine süt ve tuz ekleyip hızlıca karıştırın
    - Süt eklemek
    - Tuz eklemek
    - Hızlıca karıştırmak
18. Tavuklu yemeği beşamel tenceresine ekleyip karıştırın
    - Tavuk yemeğini eklemek
    - Karıştırmak
19. Milföyü fırından çıkarıp orta kısmını hazırladığınız karışım ile doldurun.
    - Fırından çıkarmak
    - Orta kısmını doldurmak
20. Üzerine pul biber ve karabiber serpip servis edin
    - Pul biber serpmek
    - Karabiber sermek,
    - Servis etmek

A.4. Ratatouille Kabak Sandal

1. Tencereyi ocağa alıp su ve zeytinyağı koyun
    - Tencereye su koymak
    - Zeytinyağı koymak
2. Kinoayı ve tuzu ekleyip kapağını kapatarak 10 dk. pişirin
    - Kinoa eklemek
    - Tuz eklemek
    - Kapak kapatmak
    - 10dakika
    - Pişirmek
3. Piştikten sonra ocaktan alıp soğumaya bırakın
    - Ocaktan almak
    - Soğumaya bırakmak
4. Kabakları boyuna ikiye kesip ortalarını çıkarın
    - Kabakları kesmek
    - Boyuna ikiye
    - Ortalarını çıkarmak
5. İçlerini sıvı yağ ile yağlayıp pul biber serpin
    - Sıvı yağ ile yağlamak
    - Pul biber serpmek
6. Fırında 190 derecede kabaklar yumuşayana kadar (çatal batırarak kontrol edebilirsiniz) pişirin,
    - 190 derece
    - Fırında pişirmek
    - Kabakların yumuşaması
7. Soğanları soyup yemeklik doğrayın
    - Soğan soymak
    - Soğan doğramak
    - Yemeklik
8. Sarımsakları soyup ince ince kıyın
    - Sarımsak soymak
    - Sarımsak kıymak
    - İnce
9. Patlıcanları soyup küp küp doğrayın.
    - Patlıcan soymak
    - Patlıcan doğramak
    - Küp küp
10. Kapya biberleri küçük küçük doğrayın
    - Biber doğramak
    - Kapya biber
    - Küçük
11. Tavayı ocağa alıp sıvı yağı koyup yağı kızdırın
    - Tavaya sıvı yağ koymak
    - Kızdırmak
12. Soğan ve sarımsakları ekleyip soteleyin
    - Soğan eklemek
    - Sarımsak eklemek

- Sotelemek

13. Patlıcanları ekleyip hafifçe kızarana kadar pişirin
    - Patlıcan eklemek
    - Pişirmek
    - Kızarana kadar
14. Kapya biberleri ekleyip 10 dakika daha pişirin
    - Biber eklemek
    - Pişirmek
    - 10 dakika
15. Son olarak tuz ve karabiber ekleyip karıştırın
    - Tuz eklemek
    - Karabiber ekleme
    - Karıştırmak
16. Karışımı ateşten alıp fırından çıkan kabakların içine koyun
    - Ateşten almak
    - Kabakların içine koymak
17. Kaşar peynirini rendeleyip karışımın üzerine serpin
    - Kaşar rendelemek
    - Peynir serpmek
18. Fırına koyup 180 derecede kaşarlar eriyene kadar pişirin.
    - Fırında pişirmek
    - 180 derece
    - Kaşarların erimesi
19. Soğuyan kinoanın içine sirke ve nar ekşisi koyup karıştırın
    - Sirke koymak
    - Nar ekşisi koymak
    - Karıştırmak
20. Bir servis tabağına önce kinoayı, üzerine de pişmiş kabakları koyup servis edin
    - Kinoayı koymak
    - Kabakları koymak
    - Servis etmek

APPENDIX B. DETAILED LIST OF CODING RULES

If the written answer has a similar logic and visual quality as the original unit but not exactly the same unit; **half point was given to those answers.**

Original unit: Karıştırmak
- Kavurmak
- Sotelemek
- Pişirmek

Original unit: Kavurmak
- Karıştırmak
- Sotelemek

Original unit: Piyazlık doğramak
- Halka
- İnce
- Yarım daire

Original unit: Yemeklik
- Küp küp

Original unit: Kahverengiye dönene kadar
- Pempeye dönmesi
- Kırmızılaşması
- Renk alması
- Kararması

Original unit: Çırpmak
- Karıştrmak

Original unit: Küçük doğramak
- Küçük
- Küp

Original unit: Chili biber
- Kırmızı

Original unit: Kapya biber
- Kırmızı

Original unit: Kızarana kadar pişirmek
- Kavrulana kadar
- Kahverengi olana kadar

If the written answer has exactly the same meaning as the original unit but the expressed in different words due to language- specific use; **full point was given to those answers.**

Original unit: Fırında pişirmek

- Fırınlamak
- Fırına koymak
- Fırına vermek
- Fırına atmak
- Fırına sürmek
- Fırında tutmak
- Bekletmek
- Fırında ısıtmak

Original unit: Kahverengiye dönene kadar

- koyulaşması

Original unit: Çorbayı çekip ıslanması

- Emmesi
- Çekmesi

Original unit: Çırpmak

- Mikserle karıştırmak

Original unit: Üstünün kabuk bağlamaması

- Üstünün sertleşmemesi
- Üstünün pütürlenmemesi
- Tabakalaşmaması
- Kaymak tutmaması
- Üstünün katılaşmaması

Orginal unit: Düzleştirmek

- Yaymak
- Düzgün bir şekilde sürmek
- Eşit dağıtak
- Üzerini kaplamak

Original unit: Dinlendirmek

- Bekletmek
- Soğumaya bırakmak

Original unit: Kızarana kadar pişirmek

- Rengi gidene kadar
- Kararana kadar
- Renk alana kada

Original unit: Küçük doğramak

- Ufak

APPENDIX C. FOOD RECIPES AND IDEA UNIT DIVISIONS (EXP 3)

1. Soğanları soyup piyazlık doğrayın
    - Soğan soymak
    - Soğan doğramak
    - Piyazlık
2. Soğan ve sarımsakları ekleyip soteleyin
    - Soğan eklemek
    - Sarımsak eklemek
    - Sotelemek
3. Chili biberi yuvarlak doğrayın
    - Biber doğramak
    - Yuvarlak
    - Chili biber
4. Mantarları ekleyip soğanlar kahverengiye dönene kadar kavurun
    - Mantar eklemek
    - Kavurmak
    - Soğanların kahverengiye dönmesi
5. Su ekleyip topaklanması gidene kadar karıştırın
    - Su eklemek
    - Topaklanma gidene kadar
    - Karıştırmak
6. Krema ekleyip karıştırın
    - Krema eklemeK
    - Karıştırmak
7. Baget ekmekleri dilimleyin
    - Ekmek dilimlemek
    - Baget
8. Kaselerin içine birer dilim ekmek koyup çorbayı tamamen çekip ıslanana kadar bekleyin
    - Kaselere bir dilim ekmek koymak,
    - Çorbayı çekip ıslanması
    - Beklemek
9. 180 derecede önceden ısıtılmış fırında peynirler eriyip kızarana kadar pişirin
    - 180 derece
    - Önceden ısıtılmış fırın
    - Peynirlerin eriyip kızarması
    - Fırında pişirmek
10. Orta ateşte şeker eriyene kadar karıştırarak pişirin
    - Orta ateş
    - Şekerin erimesi
    - Karıştırarak pişirmek
11. Kek için bir kaba yumurtaları kırıp şekeri ekleyin ve çırpın
    - Kek
    - Yumurtaları kırmak
    - Şeker eklemek
    - Çırpmak
12. Cevizleri ezip ezdiğiniz cevizleri ekleyerek karıştırın

- Cevizleri ezmek
- Cevizleri eklemek
- Karıştırmak

13. İncirleri küçük küçük doğrayın
    - Incir doğramak
    - Küçük
14. Galeta ununu ve kabartma tozunu ekleyerek spatula ile karıştırın
    - Un eklemek
    - Galeta unu
    - Kabartma tozu eklemek
    - Spatulayla karıştırmak
15. Muhallebi için bir tencereye unu ve şekeri koyup karıştırın
    - Muhallebi
    - Tencereye un koymak
    - Tencereye şeker koymak
    - Karıştırmak
16. Ardından süt ve yumurtayı ekleyip çırpın
    - Süt eklemek
    - Yumurta eklemek
    - Çırpmak
17. Ateşten alıp tereyağı ve vanilyayı ekleyin
    - Ateşten almak
    - Tereyağı eklemek
    - Vanilya eklemek
18. Kare milföylerden birini alıp çatal yardımı ile delikler açın ve kenarlarına yumurta beyazı sürün.
    - Bir milföy parçasını (kare) almak
    - Çatalla delikler açmak
    - Yumurta beyazı sürmek
19. Beşamel sos için bir tencereyi ocağa alıp içinde tereyağını eritin.
    - Beşamel sos, tencerede tereyağı eritmek 2
20. Üzerine pul biber ve karabiber serpip servis edin
    - Pul biber serpmek
    - Karabiber sermek
    - Servis etmek
21. Patlıcanları soyup küp küp doğrayın.
    - Patlıcan soymak
    - Patlıcan doğramak
    - Küp küp
22. Patlıcanları ekleyip hafifçE kızarana kadar pişirin
    - Patlıcan eklemek
    - PişirmeK
    - Kızarana kadar
23. Kabakları boyuna ikiye kesip ortalarını çıkarın
    - Kabakları kesmek
    - Boyuna ikiye
    - Ortalarını çıkarmak
24. İçlerini sıvı yağ ile yağlayıp pul biber serpin

- Sıvı yağ ile yağlamak
- Pul biber serpmek

25. Fırında 190 derecede kabaklar yumuşayana kadar (çatal batırarak kontrol edebilirsiniz) pişirin
    - 190 derece
    - Fırında pişirmek
    - Kabakların yumuşaması
26. Kaşar peynirini rendeleyip karışımın üzerine serpin
    - Kaşar rendelemek
    - Peynir serpmek
27. Kinoayı ve tuzu ekleyip kapağını kapatarak 10 dk. Pişirin
    - Kinoa eklemek
    - Tuz eklemek, kapak kapatmak
    - 10d
    - Pişirmek
28. Soğuyan kinoanın içine sirke ve nar ekşisi koyup karıştırın
    - Sirke koymak
    - Nar ekşisi koymak
    - Karıştırmak
29. Fırına girebilen bir kabı yağlayıp karışımı içine dökün ve iyice yayın
    - Kabı (borcam) yağlamak
    - Karışımı dökmek
    - Karışımı yaymak
30. Sarımsakları soyup rendeleyin
    - Sarımsağı soymak
    - Sarımsağı rendelemek
31. Unu ekleyip 5 dakika daha karıştırarak kavurun
    - Un eklemek
    - 5 dk
    - Karıştırarak
    - Kavurmak
32. Dolaba koyup iki saat dinlendirdikten sonra servis edin.
    - Buzdolabına koymak
    - 2 saat
    - Dinlendirmek
    - Servis etmek