אוניברסיטת בר-אילן
המחלקה לבלשנות וספרות אנגלית

הצעת מחקר לתואר שני

ההשפעה של פסוקיות מנהלות-ציפיות
על עיבוד משפטים צפויים ובלתי-צפויים בעברית

מוגש על ידי

הדר אלטשולר-פרנקל

ת"ז 315657601

מנחות

פרופ' מיכל בן-שחר

המחלקה לבלשנות וספרות אנגלית

והמרכז הרב תחומי לחקר המוח

אוניברסיטת בר אילן

ד"ר יעל גרינברג

המחלקה לבלשנות וספרות אנגלית

אוניברסיטת בר אילן

פברואר 2020

Department of English Literature and Linguistics

Thesis Proposal for a Master's Degree

The Effect of Mirative Clauses on Online Processing of Expected and Unexpected Sentences in Hebrew

Submitted by

Hadar Altshuler-Frenkel

ID 315657601

Advisors

Prof. Michal Ben-Shachar

Department of English Literature and Linguistics

and The Gonda Brain Research Center

Bar Ilan University

Dr. Yael Greenberg

Department of English Literature and Linguistics

Bar Ilan University

February 2020

Table of Contents

Abstract

A well-established effect in psycholinguistic research is the effect of word expectedness on online reading of sentences, often referred to as the predictability effect (Rayner and Well, 1996; Ditman, Holcomb & Kuperberg, 2007; Staub, 2015). Recently, this effect has been found to be influenced by specific expressions such as negation, connectives and counterfactuals (Nieuwland & Kuperberg, 2008; Nieuwland, Ditman & Kuperberg, 2010; Nieuwland & Martin, 2012; Xiang & Kuperberg, 2015). Here, we aim to test whether the predictability effect is modulated by expectation-managing phrases known in linguistic typology as miratives. Miratives are linguistic elements which encode surprise or unexpectedness (DeLancey, 1997; Rett, 2012), but little is known about them beyond a theoretical perspective. The present study seeks to assess whether mirative expressions nullify, or even invert, the expectations of the reader. To this end, we will measure the effect of two variables – mirativity and expectedness –in a 2X2 design. We will first attempt to replicate the predictability effect in Hebrew. We expect to find that mirative clauses (e.g., "*I was surprised that*"), when appearing at the beginning of a sentence, serve as a warning signal that the content of the sentence will be unexpected. Therefore, an unexpected word encountered in the context of a mirative clause will evoke shorter reading times relative to the same word in a neutral context. Further, we will assess the interaction between mirativity and expectedness, namely, whether the predictability effect is significantly modulated by the existence of a mirative clause. This study aims to begin bridging the gap between the linguistic encoding of surprise using mirative notions and the behavioral manifestations of surprise, within an online sentence processing framework.

2. Background

2.1. Language and Prediction

Making predictions about upcoming events is an essential aspect of our daily lives. Bar (2009) has gone as far as saying that prediction is a fundamental component underlying the brain's operation. Consequently, a widely demonstrated effect in psycholinguistic research is that readers use the available context to actively predict upcoming linguistic information and test those predictions against the incoming input (e.g., Federmeier, 2007; Huettig, 2015; Kuperberg & Jaeger, 2016).

One result of this on-line prediction mechanism is that unpredictable words often take longer time to read than predictable words, as seen in self-paced reading tasks and eye-tracking studies (Rayner and Well, 1996; Dambacher, Kliegl, Hofmann & Jacobs, 2006; Ditman, Holcomb & Kuperberg, 2007; Matsuki, Chow, Hare, Elman, Scheepers & McRae, 2011; Staub, 2015). A neural manifestation of semantic predictability has been found via electrophysiological studies, and involves an ERP component referred to as N400 (Kutas & Hillyard, 1980, 1984). N400 is a negative peak occurring

four hundred milliseconds after the onset of a meaningful stimulus, and has been found to correlate with a word's predictability; the less likely a word is to appear in a given context, the higher N400 amplitude it elicits (Kutas & Federmeier, 2011). Predictability can be calculated by word co-occurrence statistics and transitional probabilities (McDonald & Shillcock, 2003a), and the relationship between word predictability and reading times has been found to be logarithmic (Smith & Levy, 2013).

To better understand what we mean by an 'unpredictable' word, take the sentences in (1), based on Marslen-Wilson (1988).

(1) a. John carried the guitar.

b. John slept the guitar.

c. John buried the guitar.

d. John broke the guitar

In 1(a), the word "guitar" seems perfectly acceptable as a continuation of the sentence, both syntactically and semantically. In 1(b), however, the word "guitar" violates the subcategorization frame of the verb "sleep", resulting in a semantic anomaly (Marslen-Wilson, 1988). In sentence 1(d), the word "guitar" can be considered implausible or unpredictable (Roland, Yun, Koenig, & Mauner, 2012), because the probability of seeing the word "guitar" after the verb "broke" is relatively low. This probability is usually measured through a cloze probability task or through statistical word associations (Delaney-Busch, Morgan, Lau & Kuperberg, 2017). Crucially, this does not mean that the sentence in 1(d) is odd or unexpected, but simply that it is less predictable or stereotypical.

In contrast to 1(d), 1(c) is not only unpredictable but also **unexpected**. Intuitively speaking, based on our world knowledge, most people would consider burying a guitar to be something bizarre or unlikely, whereas breaking a guitar is merely something which is **less likely** to occur than other alternatives. Sentences of the type in 1(c), deemed "pragmatically anomalous" by Marslen-Wilson (1988), will be the type used in this thesis' experiment. To avoid confusion with sentences of the type in 1(d), we will refer to these sentences as unexpected, not unpredictable, and to the predictability effect as an expectedness effect, indicating that we refer to sentences which are not only unpredictable but also pragmatically anomalous and surprising, given real-world knowledge.

2.2. Moderators of Expectedness Effects on Reading Time

The effect of a word's expectedness on reading time has been found to be influenced by different linguistic factors, such as frequency and semantic association between predictable and unpredictable word pairs (Federmeier & Kutas, 1999; Demberg & Jeller, 2008; Roland, Yun, Koenig & Mauner, 2012). The effect of expectedness on reading time has also been found to be modulated by specific pragmatic expressions such as scalar quantifiers (Nieuwland, Ditman & Kuperberg, 2010), counterfactuals (Nieuwland & Martin, 2012), negation (Nieuwland & Kuperberg, 2008) and

connectives (Xiang & Kuperberg, 2015). The proposed study will test the effect of expressions that encode surprise, in order to see how they influence reading times of expected and unexpected words. Expressions that encode surprise, known in linguistic typology as miratives, reflect a mismatch between expectation and reality (Aikhenvald, 2012). We seek to assess whether online response times will differ as a function of a sentence's expectedness (i.e., whether it includes an expression which is unexpected in the context) as well as its mirativity (i.e., whether it includes an expression that overtly expresses surprise). The content of the sentences will include either an expected noun or an unexpected one, so that the expectation-managing particle will be either matched or mismatched to the expectedness of this word, as seen in (2):

(2) a. **I saw that** the king put a **crown** on his head on the way to the castle.

b. **I was surprised** that the king put a **crown** on his head on the way to the castle.

c. **I saw that** the king put a **mop** on his head on the way to the castle.

d. **I was surprised that** the king put a **mop** on his head on the way to the castle.

As can be seen, sentences 2(a) and 2(b) include a noun which is expected in the content of the sentence ("*crown*"), whereas 2(c) and 2(d) include an unexpected noun ("*mop*"). Sentences 2(a) and 2(c) include a neutral clause ("*I saw that*"), and 2(b) and 2(d) include a mirative one ("*I was surprised that*").

We expect longer online reading times for the unexpected words compared to the expected words across mirativity conditions (a main effect of expectedness, in line with Ditman, Holcomb & Kuperberg (2007)), as well as longer reading times for target words in sentences with a mirative clause than with a neutral one, regardless of expectedness (a main effect of mirativity, in line with Rasenberg, Rommers & van Bergen (2019)). Additionally, we seek to assess the interaction between mirativity and expectedness. We hypothesize that the response to unexpected words will be faster under the mirative contexts, compared to the neutral contexts. Mirativity might have the opposite effect on expected words, such that an expected word in a mirative context would in fact take longer to process compared to the same word in a neutral context.

This interaction between expectation-managing discourse markers and expectedness has been previously examined by Rasenberg, Rommers and van Bergen (2019). Participants read dialogues with expected/unexpected endings, that were preceded by either the term "*indeed*" (marking expectedness) or "*actually*" (marking unexpectedness). No behavioral or neural evidence of an interaction between the two discourse markers ("*actually*" / "*indeed*") and the two possible endings (expected/unexpected) was found (Rasenberg, Rommers & van Bergen, 2019). Our study will utilize a paradigm of Self Paced Reading (Swets, Desmet, Clifton & Ferreira, 2008; Ditman, Holcomb & Kuperberg, 2007; Breznitz, Demarco, Shammi & Hakerem, 1994), in order to obtain an on-line perspective of expected vs. unexpected sentence processing. We will present the surprise-encoding

clauses in the sentence-initial position, leaving at least three words between the expectation-managing clause and the expected or unexpected target noun. This decision is based on the assumption that the integration of new information – leading to the ability to make predictions based on it – is not immediate, and timing is a factor in determining the extent to which prediction mechanisms are involved in the processing of linguistic input (Wlotko & Federmeier, 2015; Chow, Lau, Wang & Phillips, 2018).

2.3. Mirativity – A Linguistic Perspective

The study's motivation for testing the effect of surprise-related clauses stems from the concept of mirativity. Mirativity, the linguistic encoding of surprise or unexpectedness, is a term that was introduced to linguistic typology in 1997 by Scott DeLancey. DeLancey, an American Linguist studying Tibeto-Burman languages in India, suggested that there exists a unique grammatical category conveying information about "the status of the proposition with respect to the speaker's overall knowledge structure" (DeLancey, 1997, p.32). DeLancey labeled this category mirativity, claiming that it is distinct from other grammatical categories and can be found in many different languages (DeLancey, 1997), basing his argument on the classification of surprise as a universal emotion (Ekman, 1992, 1997).

An example from Dickinson (2000) can help illustrate the essence of mirativity. The example is taken from Tsafiki, a language spoken in Ecuador by a tribe of around 2,000 ethnic Tsáchila people.

(3) a. *tse Carlosbe inte fa**yo**e tse*

1FEM Carlos=ASSOC DEM=LOC arrive.here-CONGR-DECL

'I've come here (before) with Carlos.'

b. *Carlosbe tse inte fa**i**e*

1FEM Carlos=ASSOC DEM=LOC arrive.here-NCONGR-DECL

'I've come here (before) with Carlos! (I just realized it).'

(Dickinson, 2000, p. 399).

The difference between (3)a and (3)b is the affix **yo/i**. The particle **i** changes the meaning of the sentence from one which is uttered simply as a fact, to one which contains an element of unexpectedness or surprise. Therefore, the particle **i** can be considered to be a mirative one (Rett & Murray, 2013).

2.4. Mirativity and Prediction

Over the years, the scope of mirativity has been expanded from morphological markers to other linguistic means that encode surprise, such as an exclamational intonation (e.g. "look at that" vs. "look at that!"), exclamative particles (e.g. "Boy", "Wow!"), and adverbials (e.g. "unexpectedly") (Rett, 2012; Aikhenvald, 2012).

Several attempts have been made to find a unified semantic formulization that encompasses all different linguistic manifestations of surprise (Aikhenvald, 2012; Peterson, 2013). One recent endeavor, made by Simeonova (2015), claims that there exists a mirative operator which presupposes a set of alternatives ordered on a contextually salient scale of expectations; the ordering on the scale is not objective but rather relativized to the context and to the speaker uttering the sentence. If there exists at least one alternative which is more expected (less surprising) than the prejacent, the sentence can be considered surprising (Simeonova, 2015).

Notice, however, that this characterization of mirativity is too weak for our purposes. Going back to the sentences in (1), according to this formulization, both 1(c) and 1(d) are considered surprising. However, on an intuitive level, sentence 1(d) is not surprising at all. Although we chose to narrow the empirical study to sentences that encode higher degrees of unexpectedness, e.g., 1(c), we will also pursue ways to characterize them precisely, in order to properly distinguish them from sentences of the type seen in 1(d). The empirical framework to be utilized in this study can pave the way for making more fine-grained distinctions in the realm of mirativity, as well as gaining a clear-cut picture of the connection between mirativity and the behavioral measurements of surprise.

3. Objectives

The main objectives of the proposed study are as follows:

- Understanding the role that mirative clauses have on online reading times and the role that expected/unexpected words have on online reading times, as well as the interaction between the two.
- Assessing whether the above-mentioned effects are modulated by working memory and/or verbal abilities.

Through these objectives, we aim to gain more insights into the on-line predictive mechanisms used during sentence processing in Hebrew, as well as learning more about the behavioral manifestations of Hebrew sentences that encode mirativity.

4. Hypotheses

The hypotheses of the study are as follows:

1. **Main effect of predictability:** Reading times for unexpected target words will be longer than for expected words (Rayner and Well, 1996; Dambacher, Kliegl, Hofmann & Jacobs, 2006), and this increase might continue for two to three words following the unexpected word (Wlotko & Federmeier, 2015; Chow, Lau, Wang & Phillips, 2018).

2. **Main effect of mirativity:** A mirative marker (*'I was surprised that'*) will cause an increase in overall reading time for the sentences in which it occurs, relative to a neutral marker (*'I saw that'*) (Rasenberg, Rommers & van Bergen, 2019).
3. **Interaction between predictability and mirativity:** Response times to unexpected words will decrease in the context of a mirative marker, compared to a context of a neutral marker. Response times to expected words will not decrease, and might possibly even increase, in the context of a mirative marker, compared to a context of a neutral marker.
4. **Correlation with verbal abilities and working memory:** We expect to find a correlation between the size of the effects described in 1-3, and working memory / verbal abilities (Traxler, Long, Tooley, Johns, Zirnstein, & Jonathan, 2012; Baddeley & Hitch, 2017), such that participants with higher working memory and verbal ability scores will display larger effect sizes compared to participants with lower working memory and verbal ability scores.

5. Methods

5.1. Participants

We will recruit 60 participants, ages 18-45. Studies that employ the paradigm to be used in this study – Self Paced Reading - generally recruit between 20 to 30 participants (Ditman, Holcomb & Kuperberg, 2007; Jackson & Roberts, 2010; Jegerski, 2013). However, this study aims to find an effect that was previously not found in psycholinguistic literature (Rasenberg, Rommers & van Bergen, 2019), so we decided to take a larger sample size to ensure adequate statistical power. In addition, the predictability effect (Ditman, Holcomb & Kuperberg, 2007) which we are hoping to replicate has not yet been reported in Hebrew, so there are no baseline measures for comparison, hence the need for a relatively large number of participants. Participants will be native speakers of Hebrew, with no previous diagnosis of reading disorders (dyslexia, dysgraphia) or attention disorders (ADD, ADHD). Participants will receive reimbursement in the form of gift cards or coupons for their participation in the study, and will give their informed consent before participating. The study has received approval from the Ethics Committee of the Faculty of Humanities at Bar Ilan University.

5.2. Design and Stimuli

The experiment will incorporate a 2X2 design with 20 Hebrew sentences in each condition, resulting in 80 experimental items. Eighty filler sentences will be presented along the experimental ones, leading to a total of 160 sentences (see Table 1 for examples of each experimental condition).

The first manipulated variable will be the type of clause at the beginning of the sentence. As a surprise-encoding marker, we will use a Hebrew clause with an emotive factive verb encoding surprise on the side of the speaker, taking a sentential complement, where this complement will

contain the (expected or unexpected) target word. Sentences with a mirative marker will begin with the phrase *huftati she* (*'I was surprised that*'), whereas sentences with a neutral discourse marker will begin with the phrase *ra'iti she* (*'I saw that'*).

The second variable will be the unexpectedness of the sentence. In surprising sentences, one word will be unexpected in the context of the sentence, whereas in non-surprising sentences this word will be replaced with a neutral word that does not cause a pragmatic anomaly.

Mirative clause, expected word	הופתעתי שהמלך שם על הראש כתר בדרך לארמון. *Huftati ʃe ha-melex sam al ha-roʃ kova ba-derex la-armon.* 'I was surprised that the king put a crown on his head on the way to the castle'.
Mirative clause, unexpected word	הופתעתי שהמלך שם על הראש מגב בדרך לארמון. *Huftati ʃe ha-melex sam al ha-roʃ magav ba-derex la-armon.* 'I was surprised that the king put a mop on his head on the way to the castle'.
Neutral clause, expected word	ראיתי שהמלך שם על הראש כתר בדרך לארמון. *ra'iti ʃe ha-melex sam al ha-ros keter ba-derex la-armon.* 'I saw that the king put a crown on his head on the way to the castle'.
Neutral clause, unexpected word	ראיתי שהמלך שם על הראש מגב בדרך לארמון. *ra'iti ʃe ha-melex sam al ha-ros magav ba-derex la-armon.* 'I saw that the king put a mop on his head on the way to the castle'.

Table 1. Examples of the four conditions of the experiment.

In order to determine the degree to which words are unexpected in different contexts, we conducted a pre-test in which 20 participants voluntarily filled a questionnaire asking for their judgments on 30 pairs of sentences. Participants were asked to decide whether the last word of each sentence is surprising or not surprising based on the context of the sentence, on a Likert scale of 1-7. Of these pairs, 20 were chosen for the experiment, based on a cutoff point of <2.1 for the non-surprising sentences and >5.6 for the surprising ones. In addition, eighty filler sentence were created, making sure that their average length and vowel length are not significantly different than the length of experimental items. Filler sentences include anywhere between three to thirteen words, in order to distract participants from the nine-word structure of the experimental sentences.

5.3. Procedure

5.3.1. Screening

Upon arrival, participants will be asked to fill out a form to ensure they fulfill the study's criteria of participation. Participants will also fill out a questionnaire checking hand dominance (Edinburgh

Handedness Inventory; Oldfield, 1971). Left handers will not be excluded from this experiment but handedness data may be entered in the analysis as a covariate, in order to assess its contribution.

5.3.2. Self Paced Reading Task

The main experiment in this study will utilize a Moving-Window Self Paced Reading (SPR) task, a paradigm which has been found to closely resemble gaze durations (Just and Carpenter, 1982). In this paradigm, sentences are viewed one word at a time, and participants must press a button in order for the next word to appear on the screen. This enables participants to read the sentences in their own pace, and enables the researchers to receive real-time information about participants' reading speed (Jegerski, 2013).

Stimuli will be presented on a computer screen. Participants will be seated approximately 60 cm from the screen and asked to read the instructions. They will then view three practice items and proceed to the first forty sentences of the study. Each trial will begin with a central fixation point appearing on the screen for 1,500 milliseconds, followed by the first word of the sentence. Participants will need to press the keyboard's space bar for the next word to appear. The last word of each sentence will be followed by a 1,000 milliseconds interstimulus interval of a blank screen, after which the next fixation point will appear.

In total, 160 sentences will be presented, including eighty experimental sentences and eighty fillers. The experiment will be divided into four blocks of forty sentences each, with block order randomized between participants. The order of sentences inside each block will be pseudo-randomized, making sure that no two sentences of the same quadruple appear consecutively, and no more than two sentences of the same condition are presented in a sequence. The first three sentences of every block will always be filler sentences, giving participants a short warm-up before the experimental sentences. See Appendix A for examples of sentences and fillers.

After every five sentences, a comprehension question regarding the last sentence will appear on the screen, and participants will have to choose one of two answers, by pressing the keys "1" or "2". The purpose of the comprehension questions is to make sure participants are paying attention to the sentences rather than simply pressing buttons as fast as possible. Stimulus presentation and response collection will be controlled by the E-prime 2.0 software (Psychology Software Tools, Inc.).

5.3.3. Additional Verbal Tasks

In addition to the main SPR experiment, participants will be asked to complete three other tasks, to assess their reading speed and working memory abilities. These abilities may interact with the SPR task performance, beyond the effect of the variables manipulated in the study (Traxler, Long, Tooley,

Johns, Zirnstein, & Jonathan, 2012; Baddeley & Hitch, 2017). See appendix B for the stimuli of the three tasks.

a. Text Reading: Participants will be asked to read aloud a two-paragraph informational text in Hebrew. After reading the text, they will answer four comprehension questions about the text without a time limit. Reading times of the text, as well as response time and accuracy to the questions, will be measured.

b. Speeded Word Reading (taken from Shatil, 1997): Participants will be asked to read aloud a list of Hebrew words as fast as they can. They will be given one minute, after which they will be asked to stop. The number of words read accurately will be measured.

c. Verbal Word Span (taken from Friedmann and Gvion, 2008): The experimenter will begin by reading aloud a list of three words; if the participant recalls the words correctly, the experimenter will then read a list of four words, etc. The task will end after the participant makes a mistake on two consecutive lists. The measurement to be obtained from this task is the maximum consecutive number of words the participant was able to accurately recall.

The three tasks will be presented between each block of SPR trials, in order to prevent adaptation to the sentence types and structures presented in the SPR task. The entire session is expected to last between 30 to 40 minutes.

5.4. Data analysis

The SPR task will produce reaction time measures for each word in each sentence, as well as reaction times and accuracy for the comprehension questions.

Reaction time to target words will be entered into a linear mixed-effects model. Each sentence will include three words to be analyzed: The expected/unexpected target word (e.g. *crown/mop* from Table 1), and the two words that follow it, in case a spillover effect occurs and the words following the unexpected word also take longer to read (Jegerski, 2013; Ditman & Kuperberg, 2007). A separate model will be created for each of the three words.

The model will include Clause Type (mirative /non-mirative) and Expectedness (expected word / unexpected word) as fixed factors, and Block, Trial and Length of Sentence as control variables. A stepwise model selection approach will be taken to determine the most appropriate models for the data. Statistical analyses of the data will be conducted using SPSS (IBM Corp., 2016). In addition, Pearson's correlation coefficients will be calculated between participants' SPR data and their scores on the three additional tasks, to see whether any correlations exists between the reading times of expected/unexpected words, general reading speed and working memory abilities.

6. Preliminary Results

A pilot of the study was conducted in which three participants (M=25, 1 female) participated voluntarily. Participants answered comprehension questions correctly 88.3% of the time (SD=7.8), indicating that they were paying attention throughout the task.

RTs as a function of expectedness (sentences with expected vs. unexpected target words) are displayed in Figure 1. Mean Response Times to words as a function of mirativity (sentences beginning with "*It surprised me that*" vs. "*I saw that*") are shown in Figure 2. As can be seen in both Fig. 1 and Fig. 2, virtually no differences were found between the different conditions in the three words that precede the target word (T-3, T-2 and T-1). Small differences only began to emerge after the target words.

Regarding the main effect of expectedness (Fig. 1), sentences with expected target words had shorter RTs to their final word (M=355.85, SD=23.84) than sentences with unexpected target words (M=395.03, SD=37.34). Regarding the main effect of mirativity (Fig. 2), differences in RTs between mirative/neutral conditions were seen after the mirative expression (T-3), such that sentences with mirative clauses (M=259.3, SD=19.72) had shorter RTs than sentences with neutral clauses (M=273.94, SD=15.86). However, differences were not seen for target words or for any of the words following target words (T, T+1 and T+2).

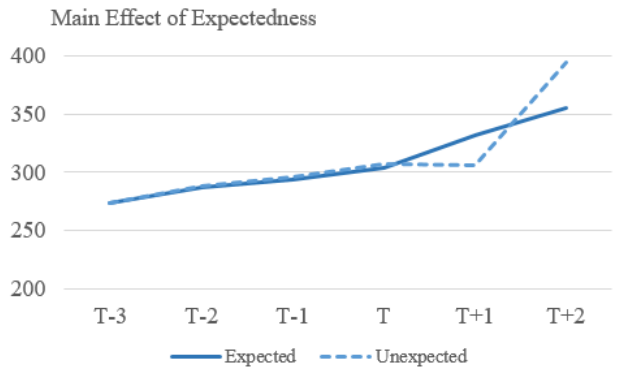

Figure 1. Mean RTs (in milliseconds) to sentences with expected target words (e.g., "*crown*") vs. unexpected target word (e.g., "*mop*"). T-3 marks the first word to be analyzed, T marks the target word (expected/unexpected), and T+2 marks the final word of the sentence.

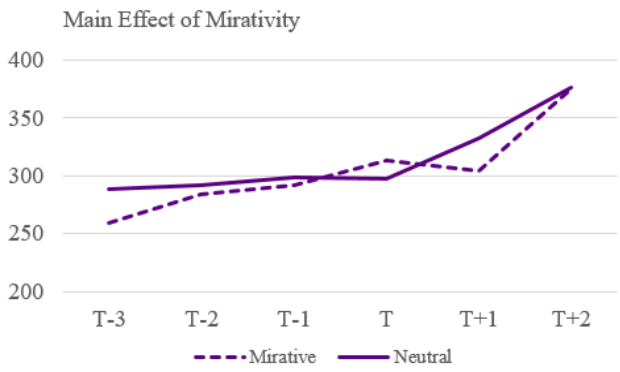

Figure 2. Mean RTs (in milliseconds) to sentences with mirative clauses ("*I was surprised that*") vs. neutral clauses ("*I saw that*"). T-3 marks the first word to be analyzed, T marks the target word (expected/unexpected), and T+2 marks the final word of the sentence.

Additionally, a small interaction between mirativity and expectedness was seen in the final word of the sentence (see Figure 3). In the final word, mean RTs for sentences with neutral clauses and unexpected target words (M=400.9, SD=24.51) were higher than for sentences with mirative clauses and expected target words (M=389.1, SD=20.84). Conversely, RTs for sentences with neutral clauses and expected target words (M=351.8, SD=20.53) were shorter than in sentences with mirative clauses and unexpected target words (M=359.8, SD=20.83).

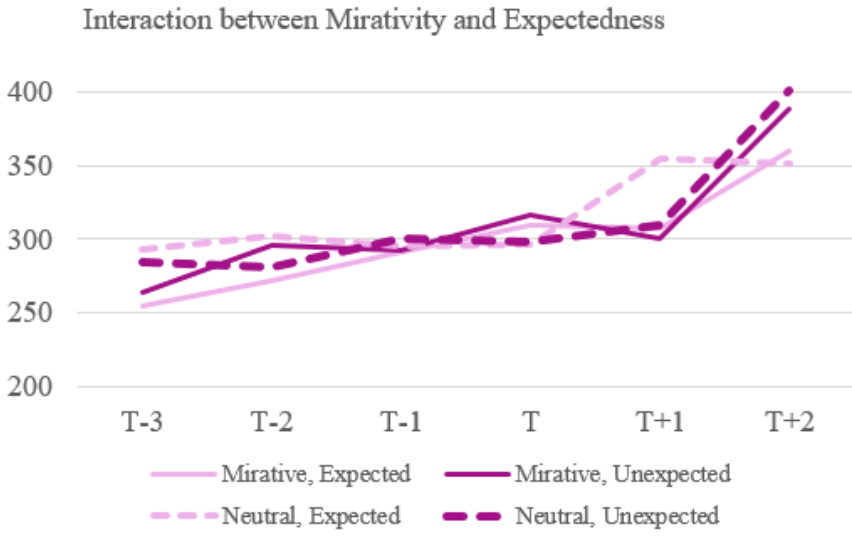

Figure 3. Mean RTs (in milliseconds) to sentences with mirative/neutral clauses ("*I was surprised that*" vs. "*I saw that*") and expected/unexpected target words (e.g. "crown" vs. "mop"). T-3 marks the first word to be analyzed, T marks the target word (expected/unexpected), and T+2 marks the final word of the sentence.

Regarding the three additional verbal tasks, the following results were obtained. For the text reading task, participants took an average of 68s (SD=14.6) to read the text and made no mistakes of mispronouncing words. Out of the four comprehension questions, the mean number of questions answered correctly was 3.37 (SD=.47), and the average time participants attempted to answer each question was 23s (SD=4.2). For the speeded word reading task, the average number of words participants were able to accurately read out loud was 94.7 (SD=8.7), and the average number of pronunciation errors participants made was 1.3 (SD=.47). Lastly, for the verbal word span task, the average maximum number of words participants were able to recall correctly was 5.7 (SD=.47). Data of the three task scores is displayed in Table 2. As more data will be acquired, we will be able to correlate the scores of these tasks with the RTs of the SPR task, checking to see whether any of the scores show a relationship to participants' SPR data.

#	Gender	Age	Text Reading Task Time (s)	Speeded Reading Task Number of Words	Verbal Span Task Maximum Span
1	F	23	61	85	5
2	M	27	54	106	6
3	M	23	88	93	6

Table 2. Behavioral measurements for the text reading, speeded reading and verbal span tasks.

7. Conclusions

The results of the pilot study demonstrate – on a very small-scale – a replication of the established effect of expectedness on reading times (Dambacher, Kliegl, Hofmann & Jacobs, 2006; Ditman, Holcomb & Kuperberg, 2007). The fact that no differences between conditions were visible at the beginning of the sentences, up until the target words, can support the notion that the expected/unexpected target words affected reading times. The results seen in Figure 3 might also indicate a trend towards the study's hypothesis of an interaction between mirativity and expectedness. Both the expectedness effect and the interaction with mirativity were only visible on the final words of the sentences, perhaps aligning with Matsuki, Chow, Hare, Elman, Scheepers and McRae (2011), who report finding an expectedness effect only two words after the target word.

The small number of participants in this pilot study is not enough to conduct any statistical analyses, and many more participants will be needed in order to obtain reliable results with adequate statistical power. Nevertheless, this seems like a promising start for the study's aim of providing a bridge between the linguistic encoding of surprise and the behavioral manifestations of predictability, while gaining new insights about the two phenomena along the way.

Bibliography

Aikhenvald, A. Y. (2012). The essence of mirativity. *Linguistic Typology*, *16*(3), 435-485.

Baddeley, A. D., & Hitch, G. (2017). Working memory. *Exploring Working Memory*. Routledge, 43-79.

Bar, M. (2009). Predictions: a universal principle in the operation of the human brain. *Philosophical Transactions of The Royal Society 364*, 1181–1182.

Breznitz, Z., Demarco, A., Shammi, P., & Hakerem, G. (1994). Self-paced versus fast-paced reading rates and their effect on comprehension and event-related potentials. *The Journal of Genetic Psychology*, *155*(4), 397-407.

Chow, W. Y., Lau, E., Wang, S., & Phillips, C. (2018). Wait a second! Delayed impact of argument roles on on-line verb prediction. *Language, Cognition and Neuroscience*, *33*(7), 803-828.

Dambacher, M., Kliegl, R., Hofmann, M., & Jacobs, A. M. (2006). Frequency and predictability effects on event-related potentials during reading. *Brain research*, *1084*(1), 89-103.

DeLancey, Scott. (1997). Mirativity: The grammatical marking of unexpected information. *Linguistic Typology*, *1*, 33–52.

Delaney-Busch, N., Morgan, E., Lau, E. F., & Kuperberg, G. R. (2017). Comprehenders Rationally Adapt Semantic Predictions to the Statistics of the Local Environment: a Bayesian Model of Trial-by-Trial N400 Amplitudes. *Proceedings of the 39th Annual Meeting of the Cognitive Science Society*, 283-289.

Demberg, V., & Keller, F. (2008). Data from eye-tracking corpora as evidence for theories of syntactic processing complexity. *Cognition*, *109*(2), 193-210.

Dickinson, Connie. (2000). Mirativity in Tsafiki. *Studies in Language*, *24*(2), 379-422.

Ditman, T., Holcomb, P. J., & Kuperberg, G. R. (2007). An investigation of concurrent ERP and self-paced reading methodologies. *Psychophysiology*, *44*(6), 927-935.

Ekman, P. (1992). An argument for basic emotions. *Cognition & Emotion*, *6(*3-4*)*, 169-200.

Ekman, P., & Keltner, D. (1997). Universal facial expressions of emotion. Segerstrale U, P. Molnar P, eds. *Nonverbal communication: Where nature meets culture*, 27-46.

E-Prime (Version 2.0.8.22) [Computer software]. Pittsburgh, PA: Psychology Software Tools, Inc.

Federmeier, K. D. (2007). Thinking ahead: The role and roots of prediction in language comprehension. *Psychophysiology*, *44*(4), 491-505.

Federmeier, K. D., & Kutas, M. (1999). A rose by any other name: Long-term memory structure and sentence processing. *Journal of memory and Language*, *41*(4), 469-495.

Friedmann, N. & Gvion, A. (2008). Frigvi – A battery for testing phonological working memory. *Brain and Language,* 7(9), 161-181.

Huettig, F. (2015). Four central questions about prediction in language processing. *Brain research*, *1626*, 118-135.

IBM Corp, 2016. *IBM SPSS Statistics for Windows*, Version 24.0 [Computer software]. Armonk, NY: IBM Corp.

Jackson, C. N., & Roberts, L. (2010). Animacy affects the processing of subject–object ambiguities in the second language: Evidence from self-paced reading with German second language learners of Dutch. *Applied Psycholinguistics*, *31*(4), 671-691.

Jegerski, J. (2013). Self-paced reading. In *Research methods in second language psycholinguistics*. Routledge, 36-65.

Just, M. A., Carpenter, P. A., & Woolley, J. D. (1982). Paradigms and processes in reading comprehension. *Journal of experimental psychology: General*, *111*(2), 228.

Kuperberg, G. R., & Jaeger, T. F. (2016). What do we mean by prediction in language comprehension?. *Language, cognition and neuroscience*, *31*(1), 32-59.

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: finding meaning in the N400 component of the event-related brain potential (ERP). *Annual review of psychology*, *62*, 621-647.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, *207*(4427), 203-205.

Kutas, M., & Hillyard, S. A. (1984). Brain potentials during reading reflect word expectancy and semantic association. *Nature*, *307*(5947), 161-163.

McDonald, S. A., & Shillcock, R. C. (2003). Eye movements reveal the on-line computation of lexical probabilities during reading. *Psychological science*, *14*(6), 648-652.

Nieuwland, M. S., & Kuperberg, G. R. (2008). When the truth is not too hard to handle: An event-related potential study on the pragmatics of negation. *Psychological Science*, *19*(12), 1213-1218.

Nieuwland, M. S., & Martin, A. E. (2012). If the real world were irrelevant, so to speak: The role of propositional truth-value in counterfactual sentence comprehension. *Cognition*, *122*(1), 102-109.

Nieuwland, M. S., Ditman, T., & Kuperberg, G. R. (2010). On the incrementality of pragmatic processing: An ERP investigation of informativeness and pragmatic abilities. *Journal of memory and language*, *63*(3), 324-346.

Peterson, T. (2013). Rethinking mirativity: The expression and implication of surprise. *Ms., University of Toronto.*

Rasenberg, M., Rommers, J., & Van Bergen, G. (2019). Anticipating predictability: an ERP investigation of expectation-managing discourse markers in dialogue comprehension. *Language, Cognition and Neuroscience*, 1-16.

Rayner, K., & Well, A. D. (1996). Effects of contextual constraint on eye movements in reading: A further examination. *Psychonomic Bulletin & Review*, *3*(4), 504-509.

Rett, J. (2012). Miratives across constructions and languages. Handout, *CUSP (California University's Semantics and Pragmatics Conference) 5*.

Roland, D., Yun, H., Koenig, J. P., & Mauner, G. (2012). Semantic similarity, predictability, and models of sentence processing. *Cognition*, *122*(3), 267-279.

Shatil, E. (1997). One-minute test for words and pseudowords. *Unpublished Test. University of Haifa: Haifa.*

Simeonova, V. (2015). On the semantics of mirativity. In *Proceedings of the 2015 Annual Conference of the Canadian Linguistic Association.*

Smith, N. J., & Levy, R. (2013). The effect of word predictability on reading time is logarithmic. *Cognition*, *128*(3), 302-319.

Swets, B., Desmet, T., Clifton, C., & Ferreira, F. (2008). Underspecification of syntactic ambiguities: Evidence from self-paced reading. *Memory & Cognition*, *36*(1), 201-216.

Traxler, M. J., Long, D. L., Tooley, K. M., Johns, C. L., Zirnstein, M., & Jonathan, E. (2012). Individual differences in eye-movements during reading: Working memory and speed-of-processing effects. *Journal of eye movement research*, *5*(1), 1-16.

Wlotko, E. W., & Federmeier, K. D. (2015). Time for prediction? The effect of presentation rate on predictive sentence comprehension during word-by-word reading. *Cortex, 68*, 20-32.

Xiang, M., & Kuperberg, G. (2015). Reversing expectations during discourse comprehension. *Language, cognition and neuroscience, 30*(6), 648-672.

Appendix A – **examples of sentence quadruples, fillers and comprehension questions from SPR experiment**

Sentences:

הופתעתי שהרופא בדק את החולה באמצעות סטטוסקופ בחדר הטיפולים.

ראיתי שהרופא בדק את החולה באמצעות סטטוסקופ בחדר הטיפולים.

הופתעתי שהרופא בדק את החולה באמצעות מברשת אתמול בערב.

ראיתי שהרופא בדק את החולה באמצעות מברשת אתמול בערב.

הופתעתי שהגנן השקה את הצמחים בגינה עם מים פעם בשבוע.

ראיתי שהגנן השקה את הצמחים בגינה עם מים פעם בשבוע.

הופתעתי שהגנן השקה את הצמחים בגינה עם יין במשך חודש.

ראיתי שהגנן השקה את הצמחים בגינה עם יין במשך חודש.

Fillers:

מיכל הכירה את בן זוגה בצרפת.

לכבוד סוף שנת הלימודים, יעקב קיבל במתנה שני אוגרים.

הדיאטנית אמרה לאיש לשתות יותר מים.

המשחק נותן הזדמנות נחמדה לכל המשפחה להיפגש באווירה נעימה ומקרבת.

Comprehension Questions:

איפה הכירה מיכל את בן זוגה? בפריז / בצרפת.

מי קיבל במתנה אוגרים? יוסי / יעקב.

Appendix B – **stimuli for additional tasks**

1. Text Reading and Comprehension Questions

חיים ללא מזון בשרי נראים בלתי אפשריים עבור אנשים מסוימים. למרות זאת, ממצאים ארכיאולוגיים מתקופת האדם הקדמון תומכים ברעיון שהאדם הוא צמחוני במהותו.

מתברר שבשלבים המוקדמים של התפתחות המין האנושי האדם ניזון בעיקר מצמחים ולכן הוא היה בעל שיניים גדולות ולסתות מגושמות. מאוחר יותר התחולל מעבר מתפריט צמחי ברובו לתפריט בשרי ברובו. נראה שהוספת הבשר לתפריט התאפשרה בעקבות שיפור בכושר התחרות של האדם בטורפים אחרים על מקורות המזון, שיפור שהושג הודות לפיתוח מגוון כלים ובהם כלי ציד. המעבר מתפריט צמחי לאכילת בשר הביא לידי הפחתה בעומס הלעיסה שהיה מוטל על מערכת השיניים. להפחתת עומס הלעיסה תרמו גם תהליכים אחרים, ובהם פיתוחם של כלי חיתוך וכתישה, שהקלו על ריכוכו של המזון, וכן השליטה באש ובישול המזון, שהתאפשרו מאוחר יותר.

בימינו, בשר הוא חלק מהתפריט היומי של רב אוכלוסיות העולם. יחד עם זאת, המודעות לזכויות בעלי החיים הולכת וגוברת, וכך גם המודעות למען חיים צמחונים.

(143 מילים)

1. על פי הקטע, איזה מן הקבוצות הבאות התאפיינה בשיניים ובלסתות הגדולות ביותר?
   - א. בני אדם שניזונו מבשר.
   - ב. בני אדם שניזונו מצמחים.
   - ג. בני אדם בעלי תיאבון בריא.
   - ד. בני אדם של ימינו.

2. הקטע עוסק בעיקרו
   - א. בהתפתחות ההיסטורית של כלי הציד.
   - ב. בהתפתחות ההיסטורית של תזונת האדם.
   - ג. בעובדה שאין בזמננו אנשים הניזונים מצמחים.
   - ד. בעובדה שיותר בריא להיות צמחוניים.

3. ממצאים ארכיאולוגיים תומכים ברעיון שהאדם הקדמון
   - א. היה מודע לזכויות בעלי החיים.
   - ב. היה בעל שיניים ולסתות קטנות.
   - ג. היה צמחוני במהותו.
   - ד. היה מצויד בכלים מתקדמים מזה שאכל בשר.

4. הממצאים הארכיאולוגיים מתקופת האדם הקדמון
   - א. הם תמיכה לפעילות למען זכויות בעלי החיים.
   - ב. הם תמיכה לכך שאז התזונה של האדם הייתה בריאה יותר.
   - ג. הם תמיכה לכך שהמזון של האדם הפך מצמחי לבשרי בעיקרו.
   - ד. הם תמיכה לכך שהתזונה של האדם לא השתנתה.

2. Speeded Word Reading (taken from Shatil, 1997)

גדול	אליהו	חפצים	ישנים	גבורות	חצר	נאבק
הכיתה	מרשרש	חמורים	עמוקים	ספור	חג	טיילת
רוקד	אבודים	מדרכות	לפעמים	צלעות	מגרש	בשורה
רדיו	שביתה	שטרות	שמח	גולשת	השתולל	תמונה
כסא	צרכים	צמודים	לדון	כוכב	פגשו	יפרנס
נגע	תקוות	מכשול	עצובים	מבריקים	צהוב	בוקר
נהג	אדון	לערוך	מכווץ	שטיפה	תכלת	לומדים
אשכולית	ביקשה	משפיעה	התפלאו	בחורות	חזרה	מרגלית
ללמוד	ארון	מפיות	בנאי	שבטים	שוקלים	מכחול
גורע	שותלים	מסכנה	נגדם	קניות	תשרתו	מוריד
צורף	קושרת	כבשים	אפודה	שייכת	ניחשתי	לובשת
אמסור	מוריק	נפשנו	כורת	מכוניות	ספסלים	גודל
פיתגם	שבע	רחל	מודיע	מפריעים	תוספת	באתם
פורחת	למשול	מספר	עייפים	מקווה	מוסתרים	גשר
לשחות	צבוע	רם	קורים	נושאת	יתפורר	בשר
משוררת	מחליפה	יורדים	שטפון	עיקרי	חדשה	קיפודים
בחירה	חשבון	צמיד	כבד	קו	צמרת	מקפצות
רוכסן	לובשת	שוטרים	כבודו	מכולת	חכמים	צואר
מוכנים	חרסינה	ארבעה	גומר	דביק	בשורה	הקשבנו
מסכנים	מערבית	חצאית	סירות	צמרת	קפלים	משחקים
לבדוק	מתנשפים	טפלתי	שילמתי	ויתור	אשנב	משכנע
מדרכות	רכים	לוקחים	מרפסות	נאמר	אחריו	כתובים
גבאי	רחב	שביעי	הדביק	קפלים	החלה	נעריכם
עכשיו	אומנת	מצוירים	תודה	מחילות	סובלים	חטופים

3. Verbal Word Span (taken from Friedmann and Gvion, 2008)

2 מילים:

שעון, בית

דרך, קפה

פרה, מצח

מרפק, תיש

שלום, דקל

3 מילים:

פצע, שיער, כמות

ריח, ספה, אורן

ביצה, מגהץ, לילה

גדר, תורה, חמור

חלב, יונה, רדיו

4 מילים:

מלון, נוער, שדה, תקרה

תואר, שבט, פנס, מקור

מגב, שליט, סקר, חלום

דוור, שמיכה, נבל, פנים

משחה, ארמון, צמיד, כדור

5 מילים:

כרית, נצח, מקום, שפם, תיבה

שופט, ערסל, נורה, מדף, עלה

מוצה, לחם, שומר, סדין, מקדש

חמאה, סולם, נפש, אגס, שוקו

בניין, פיצה, גשום, כיסא, תנור

6 מילים:

זקן, ארגז, ריבה, סדר, מחבת, דואר

קצר, ספה, אוזן, חולצה, גלגל, דלת

צמיג, שידה, רגל, פרח, בוקר, שמלה

רגיל, שולחן, ברז, עין, פרפר, וילון

חתול, מזלג, ורד, נעל, כובע, עיגול

7 מילים:

יתוש, סכין, נרקיס, גרב, מעיל, מסור, שזיף

קיפוד, סמרטוט, עגיל, לחי, ברך, כינור, משחק

כחול, בובה, ציפור, מוחק, תפר, פטיש, תירס

זברה, כפית, כתף, מברג, חליל, לימון, ילד

תפוז, מתח, תינוק, כפתור, ספל, צוואר, דרש