The Influence of Reading-Writing Direction on Visual Perception of Timeline Direction in Non-textual Images

The paper was submitted as the thesis for M.A. degree by Yulia Goldenberg
The study was carried out under the supervision of Professor Galit Yovel

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יד ושם

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ABSTRACT

Modern technology enables communication between people from drastically different cultures - by means of visual mediums. Questions about the impact of different spoken languages on visual perception and communication remain unanswered. Are the mechanisms of visual perception identical for all people, regardless of the language spoken by each communicator and therefore it is possible to use similar stimuli for visual information transmitting? Or does speaking a different language create disparities in the way visual messages are perceived and it is necessary to take this into account in designing visual messages?

In recent years, a large number of studies have been devoted to understanding the influence of reading-writing direction (as one of the basic aspects of language) on visual perception of timeline direction (as an important element in visual communication) by different categories of language speakers. Despite a number of studies devoted to this problem, nevertheless, there are some insufficiently studied questions. In our opinion, addressing them can help better understanding the issue.

For example, in most studies of timeline direction, the only stimuli that are used are those with clearly defined temporal order. This may make it impossible to understand the perceptual bias, and the actual influence of the reading-writing direction (RWD) on the construction of the order of events. In addition, few studies involve bilinguals with languages in diametrically opposite reading-writing direction, though, in our opinion, this could help create a more comprehensive understanding of the influence of scanning habit on the perception of temporal event sequence.

Studying the influence of scanning habits (based on RWD) on constructing a temporal sequence of events upon viewing images has hardly been studied in eye-tracking research. Such research can indicate whether a person is guided solely by her scanning habit based on RWD, or whether she utilizes other cognitive mechanisms in the process of creating a sequence of events.
To focus on the aforementioned issues, in our work we developed a new diagnostic stimuli-material kit using a set of images with ambiguous logical sequences. Using this kit, we ran a between-group eye-tracking study on speakers of languages with left-to-right, right-to-left RWD and bilingual speakers of the languages with different RWD. Under this setup, we were able to learn the order of visual perception and plot analysis of non-textual images, allowing interpretation in ambiguous temporal order.

We found that reading-writing direction affects the order of visual perception and plot analysis. Participants of language with left-to-right RWD generally analyzed the sequence of images in accordance with left-to-right direction: in the picture that had two scenes, after an initial fixation on the center participants initially gazed at the left side of the image. In most cases, this group of participants analyzed and built a story plot about what they saw in the pictures in accordance with the principle that the left part is the preceding and the right is following.

Right-to-left participants perceived images and built the temporal plot mostly in the right-to-left direction, with more heterogeneous answers, while bilingual participants perceived images and built a plot in both directions with a spatial bias to the left side.

Our results and the developed stimuli-kit have practical applications in various spheres related to the planning and development of visual material for psychological diagnostics, education, marketing, and interface design.
תקציר

בעולם המודרני, הטכנולוגיה מאפשרת,arr תקשורת ביניהם של האנשים בתרבויות שונות. עם זאת, שאלות רבות באמצעות השפות המדוברות השונות על התפיסה והתקשורת החזותית נותרו פנויות. האם המנגנונים של התפיסה ויזואלית הינם אחידים בין כל אנשים, ללא קשר לשפה בה שולט כל צד בתקשורת, כאשר יש דרך לשיפור התפיסה ויזואלית? או שמא דיבור בשפות שונות יוצר פערים בדרך בה המסר הויזואלי נתפס, כך שהכרחי להתאים לכך בחירת המסר?

בשנים האחרונות, מספר רב של מחקרים הוקדש לחקר ההשפעה של כיוון הקריאה והכתיבה (כאחד מהמאפיינים הבסיסיים של השפה) על התפיסה ויזואלית מקו-זמן (כמרכיב בEnumerable תקשורת החוזה). בכדי לדון ב Astrophysics, שולח או*Kinetics (郾) אסימטרית של השם או קולין קסימי-הכifty של השם, così נกระเปבע את התפיסה ויזואלית של כיוון הקריאה והכתיבה, ולפיalez, ישנה עדות של בתי השפה של התפיסה ויזואלית, כדי להתאים את התפיסה ויזואלית לנשים של חומרים ויזואלים לצרכים אבחוניים, חינוך, שיווק ועיצוב משקי עבודה.

בCreatedBy ציוד או קולין קסימי-הכifty של השם, così נกระเปבע את התפיסה ויזואלית של כיוון הקריאה והكتابة, דרך קולין קסימי-הכifty של השם, così נ coppia את התפיסה ויזואלית, כדי להתאים את התפיסה ויזואלית לנשים של חומרים ויזואלים לצרכים אבחוניים, חינוך, שיווק ועיצוב משקי עבודה.

לדגמת, קומבינט withholding התוכן ביכורים שלзи חיות, כיוון שהוזה של שמי כול בול וاعتمדת את אינפראום של קולינו בתפיסה ויזואלית המובילה את התפיסה האימונית של כיוון הקריאה והكتابة על ביטוי של פיצ'ר או-אוריוס ביוגרף-הכifty של השם או קולין קסימי-הכifty של השם, così נ coppia את התפיסה ויזואלית של כיוון הקריאה והكتابة, דרך קולין קסימי-הכifty של השם, così נ coppia את התפיסה ויזואלית, כדי להתאים את התפיסה ויזואלית לנשים של חומרים ויזואלים לצרכים אבחוניים, חינוך, שיווק ועיצוב משקי עבודה.

לאונט, נמצאו של כל הקוראיםを持つ התוכן או כיון שהוזה של שמי כול בול וاعتمדת את אינפראום של קולינו בתפיסה ויזואלית המובילה את התפיסה האימונית של כיוון הקריאה והكتابة, דרך קולין קסימי-הכifty של השם, così נ coppia את התפיסה ויזואלית, כדי להתאים את התפיסה ויזואלית לנשים של חומרים ויזואלים לצרכים אבחוניים, חינוך, שיווק ועיצוב משקי עבודה.
INTRODUCTION

Language and Perception

In the beginning of 20th century, American linguists Edward Sapir and Benjamin Lee Whorf proposed that the language one speaks plays a major role in the construction of worldview, and in the perception of information. Learning another language - its structure, rules, spelling and orthography, involves studying a new perspective of reality, constructing a special logic, and generating rules of interaction with the surrounding world and the way it is perceived (Slobin, D.I., 1996; Tversky et al, 1991). For a long time, there was no empirical evidence for the Sapir-Whorf hypothesis. In the past several decades, however, there has been an increase in the number of experimental studies on this issue. Their results demonstrate the influence of language on a variety of cognitive processes, and now the Sapir-Whorf theory is widely used in education, science and technology (Boroditsky, 2011). My work will focus on one aspect of language – reading-writing direction, and its impact on the visual perception of timeline direction in non-textual images performed by different types of language speakers.

Reading–Writing Direction (RWD)

Writing systems are the traditional way of visually representing a language’s speech information, and are one of the means of human communication that is always associated with a specific language (The Online Encyclopedia of Writing Systems and Languages). One of the characteristics of the writing system is its direction - the order of the text that is used for data transmission. Reading, as a cognitive process, aims to decode the information contained in text, and, in turn, is directly related to the language into which the information is transferred (Crowder & Wagner, 1992).

As language skills develop throughout the human lifespan, there is a gradual formation of the reading-writing model (based on text direction) that allows us to quickly receive and send required information. This model, in turn, forms a certain habit in the performance of perceptual and motor actions, realized in the process of identifying, collecting, and transmitting visual information (Bergen & Chan Lau, 2012; Chan & Bergen, 2005).

The presence of native habits has been demonstrated by Nazir et al (2004) in an eye-tracking study in which the authors found differences between English and Hebrew speakers in saccade
side preference in visual field. The authors note an important fact: that the saccade side preference in the visual field was not directly related to a target location. According to the authors, these saccades seemed to be programmed before information about the target letter was available.

Related eye-tracking research has been devoted to studying scanning habits related to reading–writing direction. For example, in their eye tracking study, Friedrich T.E. and Elias L.J. examined the influence of native speaker text direction on pseudo-neglect during the greyscales task in left-to-right and right-to-left reading-writing direction. The researchers demonstrated the existence of scanning habit and its influence on initial fixation (especially in LTR RWD speakers) and location of attention (Friedrich & Elias, 2014). The existence of initial saccades directed to the left side of an image during the beginning of visual exploration was also demonstrated in other eye-tracking studies that used participants whose native language was left-to-right (Dickinson & Intraub, 2009; Foulsham et al., 2013; Ossando´n et al., 2014).

Recent studies demonstrated the correlation of habitual reading-writing direction with visual exploration (Chokron & Imbert, 1993; Kugelmass & Lieblich, 1970), aesthetic preferences (Chahboun et al., 2015; Nachson et al., 1999; Chokron & De Agostini, 2000; Ishii et al., 2011; Perez Gonzalez, 2012; Friedrich & Elias, 2016), pseudo-neglect (Friedrich & Elias, 2014; Smith et al., 2015), line bisection (Chokron & De Agostini, 1995), number magnitude (Bachtold, Baumuller, & Brugger, 1998; Dehaene et al., 1993; Zebian, 2005), visuospatial processing (Rinaldi et al., 2014, Chokron et al., 2009), spatial preferences (Chan & Berger, 2005; Roman et al., 2013, Roman et al., 2015) and timeline representation (Fuhrman & Boroditsky, 2010; Ouellet, Santiago, Israeli, & Gabay, 2010; Tversky et al., 1991). Below, we consider in detail the relationship between RWD and timeline perception.

**Reading–Writing Direction and Timeline Representation**

Among the important features of the human mind is the ability to project and spatially map events across a timeline of past versus future (Arzy et al., 2009). Using this timeline, people build a chronological order of events and can track the logical relationships between them. According to some researchers, however, mental timeline varies based on culture, and is associated with reading-writing direction of the language that is used by the speaker (Fuhrman
It is observed among left-to-right (LTR) RWD speakers that there is a specific relationship between the temporal past and left directionality, and between temporal future and right directionality. Usually, LTR RWD participants construct a temporary order of events on horizontal line in the direction corresponding to the RWD in their own language – placing the earlier events on the left and the later events on the right (Bergen & Chan Lau, 2012; Boroditsky, 2011; Casasanto and Bottini, 2013; Flumini & Santiago, 2013; Tversky et al 1991).

In tasks that require classifying temporal events by pressing computer keys, LTR RWD participants react quickly by using the left button for the events that took place earlier in time, and the right button for the events that took place later in time (Casasanto & Bottini, 2014; Fuhrman & Boroditsky, 2010; Ulrich & Maienborn, 2010; Weger & Pratt, 2008).

English speakers use the horizontal left-to-right axis even when they are not limited by a two-dimensional surface, such as while using gestures during storytelling - gesturing to the left when referring to the past, and to the right when talking about the future (Casasanto & Lozano, 2006).

In the task with sets of pictures that depicted temporal progressions, English speakers arrange the cards from left-to-right, assigning past events to the left and future events to the right (Bergen & Chan Lau, 2012; Fuhrman & Boroditsky, 2009, 2010; Boroditsky, 2011).

In turn, the speakers with right-to-left (RTL) reading–writing direction (Arabic or Hebrew speakers) show the reverse order in allocating temporal events, mapping earlier events toward the right, and later events toward the left (Tversky et al 1991; Boroditsky, 2011; Fuhrman & Boroditsky, 2010; Ouellet et al. 2010; Román et al, 2013).

Despite the fact that our reading-writing directional habits play an important role in the representation of the timeline, researchers believe that mapping time to directionality can be established even after a very short practice time (Casasanto and Bottini's, 2014, Roman et al, 2015). In their study with LTR RWD speakers Roman et al (2015) showed that after a brief reading of an inverse (right-to-left) script, the participants started perform a drawing task in a right-to-left direction. However, we want to note that the researches demonstrated only the
influence of short-term training on changes in the perception of temporal sequence immediately after the training, but not demonstrated long-term changes in perception of temporal order.

In our view, a category of participants that truly allows one to monitor the flexibility of reading-writing directional habits in timeline perception, may be bidirectional bilinguals. Below we review the possibilities this opened up for researching RWD habits in timeline perception with the participation of this category of participants.

**Bidirectional Bilinguals and Timeline Representation**

The question of the flexibility of lateral biases induced by participant’s RWD has been addressed in several studies carried out using bidirectional bilingual participants. Most of these studies, however, are not associated with the perception of a timeline. Some studies indicate that the bilingual’s first language influences spatial attention (Chokron & Imbert, 1993; Fagard & Dahmen, 2003, Rinaldi et al, 2014). For example, Rinaldi et al (2014) had Italian monolingual left-to-right readers, Israeli monolingual right-to-left readers, and Israeli bilinguals use an adaptation of the star cancellation task and a line bisection task. They found that monolingual participants with LTR RWD had more omissions on the cancellation task on the right side than on the left, and made more right side omissions than Hebrew speakers (who are monolinguals with RTL RWD). Bidirectional bilinguals (who spoke both Hebrew and English) showed no difference in omissions, while monolingual right-to-left speakers made more leftward omissions, but less significantly.

Noteworthy, too, is the between-group spatial biases study of Román et al (2013) including Spanish speakers (left-to-right RWD), Moroccan participants (right-to-left RWD) and a group of highly Spanish-acculturated Arabs (bidirectional bilinguals). During the study, the participants listened to a sentence describing the positions of objects in relation to each other (e.g. “The table is between the lamp and the TV”) and were asked to draw the described situation. The Spanish and Arabs-in-Spain groups conducted the task in Spanish, and the Moroccan group was tested in Darija. The authors found spatial preference in object deployment: Spanish subjects preferred to draw objects from left-to-right, whereas Moroccan participants drew in reverse order – from right-to-left. A group of highly Spanish-acculturated Arabs showed a pattern very similar to Spanish, but milder. The researchers concluded that RWD influences the
comprehension of static descriptions, and that these spatial habits are flexible and can change upon learning another language.

Among the research conducted with bidirectional bilinguals, several eye tracking studies indicate differences in the direction of eye movements between monolinguals and bilinguals while viewing visual stimuli (Abed, 1991; Afsari et al, 2016; Smith & Elias, 2013, Smith et al, 2015).

However, despite the diversity of studies with bidirectional bilinguals, only a small amount of research focuses on timeline perception, and the majority of studies were performed with bilinguals who both speak Chinese or Mandarin (RWD from top-to bottom) and English – RWD from left-to-right (Boroditsky, 2001, Fuhrman et al, 2011, Lai & Boroditsky, 2011, Miles et al, 2011, Tse & Altarriba, 2008 ). Among these studies, I would like to highlight the work of Fuhrman et al (2011), in which the authors found a correlation between degree of language proficiency and time representation; Mandarin-English bilinguals who were more proficient in Mandarin were more likely to arrange time on vertical axis. Furthermore, researchers found differences in time representation based on the language of the study - bilinguals were more likely to arrange time vertically when they were tested in Mandarin than when they were tested in English. Despite the significant contribution made by this and other research to the understanding of timeline perception of bidirectional bilinguals, in our view the question of how different categories of bidirectional bilinguals use their reading-writing experience in time representation is still poorly understood.
Open Questions

Most studies that explore the effects of reading-writing direction on the perception of the sequence of events and their display in a mental timeline were conducted using stimuli (images, text or audio tasks) that display a specific temporal sequence of events that explicitly indicate what happened before and what happened later (Bergen & Chan Lau, 2012; Fuhrman & Boroditsky, 2007, Fuhrman & Boroditsky, 2010), or using specific facts that took place during a certain time period (Casasanto & Bottini, 2014, Ouellet, et al, 2010). However, to the best of my knowledge, stimulus material with deliberately ambiguous logical sequence of events have not been used. This technique allows subjects to analyze the proposed stimulus both in terms of temporal sequence from right-to-left and left-to-right and to build alternative scenarios. Using this technique has the potential to expand our understanding of the role of RWD in building a time sequence by recognizing the inherent bias of individual speakers of different languages.

In most studies of timeline perception conducted with bidirectional bilinguals, the participant group consisted mainly of language speakers with different axis directions (left-to-right horizontal and vertical top-to-bottom directions). However, studying participants whose languages have diametrically opposed RWD (for example left-to-right and right-to-left) can help foster a better understanding of how scanning habit influences the perception of the sequence of temporal events.
STUDY

Hypothesis and Experimental Goals

The goal of this study was to examine the effects of reading-writing direction on the temporal order of visual perception of non-textual images. In particular, I tested speakers of languages with left-to-right reading-writing direction, right-to-left reading-writing direction, and bilingual speakers of languages with both reading-writing directions.

The hypothesis of the study is the following: reading-writing direction affects the order of visual perception and plot analysis of non-textual images, allowing building different temporal scene order. In our view, the visual perception process based on the effects of RWD will influence not only which object we perceive first, but also the whole scene analysis, the interpretation of the image plot, and an understanding of its causality and consequences.

Thus, left-to-right RWD language speakers will analyze the image in accordance with this (LTR) direction, for images that contain ambiguous temporal patterns. In the picture that has two scenes, the left part will be perceived by them as preceding, and the right as following. In contradiction to this, speakers of languages with right-to-left RWD, will show the opposite effect. Bilingual speakers will process image scenes in both, mixed directions.

We hypothesize that with adult Hebrew-speaking participants, though they are right-to-left RWD language speakers, we will obtain results similar to those obtained in the group of bilinguals (Kugelmass & Lieblich, 1979; Nazir et al, 2004). This assumption is based on the finding that most Hebrew speakers engage in left-to-right reading and writing of numeric series on a daily basis (Vaid & Singh 1989).

In our work, we are interested in identifying a participant's initial automatic reaction during the scene analysis as the natural expression of perception, based on a personal sustainable model of information processing.
GENERAL METHODS

Participants

A total of 107 participants took part in the study, of which 40 subjects participated in the pilot study: 40 male, 67 female, 18 to 35 years old (mean age 25.07 ± 3.7) and 67 subjects participated in the eye-tracking study: 45 female, 22 male, aged from 18 to 32 years (25.0 mean ±3.4). Six subjects were excluded from the eye-tracking study analysis due to various reasons (see reasons description in the chapter “Eye Tracking Study”, section “Results”). All participants were right-handers and had normal or corrected-to-normal vision. They gave their informed consent to participate in the study by signing the appropriate consent form that was approved by the Tel Aviv University Ethics Committee.

Stimuli

For stimuli, we used non-textual images that allow building an ambiguous temporal order. These stimuli were developed specially for this study. For example, picture №7 (see description of images below) could be interpreted to be both of the following:

A) The girl brushed her teeth and then went to sleep.

B) The girl woke up and then went to brush her teeth.

In order to improve the understanding of the task and to help subjects construct a plot, we used a single main character in all images - a girl named Maya. The name Maya (pronounced [maya]) is common in Israel (Central Bureau of Statistics of Israel, 2014), in Russia (Petrovskii, 2000) and in the U.S. (The United States Social Security Administration). In addition to the Maya character, we also used other supporting characters in the images: people of varying ages and genders, and animals.

All pictures were black-in-white, and all characters were represented from a front-facing view. The distance between the scenes in a given image varied depending on the scene depicted, and averaged 320 mm on an A4 page scale.
PILOT EXPERIMENT

The pilot study was conducted on a group of left-to-right RWD participants. These participants were used with the expectation to obtain homogeneous results. The goals of the pilot study were as follows:

- Proving the ambiguousness of the plot presented in the images with respect to chronological order of the scenes displayed.
- Testing and improving the research procedure and identifying parts that require adjustments, as well as verification of the study hypothesis on the group of LTR RWD subjects.

Participants

Forty (40) participants took part in the pilot study: 22 female, 18 male, aged 18 to 35 (mean 25.2 ± 4.4), of which 30 subjects were Russian speakers, and 10 were English speakers. All subjects had no experience learning or communicating in Hebrew, Arabic or other RTL RWD languages. The study with 15 Russian speakers was conducted in the Southern Experts Center in Volgograd, Russia. The study with other group of Russian speakers as with English speakers was conducted in Tel-Aviv University.

Stimuli

For the pilot study we have developed 12 non-textual images that allow building an ambiguous temporal plot order. In order to verify the absence of an individual plot direction due to single chronological interpretation, each image obtained a reversed version (see example on Figures 1a, 1b).

![Figure 1a. Initial image version](image1)

![Figure 1b. Reversed image version](image2)
Each image was made in accordance with the characteristics described in the previous section. All stimuli were displayed on a white background. Below we provide a text description of the images (initial version) that were used in our pilot experiment.

1. **Example task**

*Images used for task explanation:* an image of the girl, hereinafter referred to as Maya; an image with a fixation cross.

*Picture for example task:* Maya with a flower in the left hand - Maya with balloon in the left hand.

2. **The main task** (note - the image numbers are used only as the name of the image, all stimuli in the main task were shown in a random order).

1. Maya holds a closed umbrella - Maya in the rain with an open umbrella;
2. Maya with a bowl of food, near her a cat – Maya and a cat;
3. Maya and an adult woman who embraces her, standing next to a suitcase - Maya with a suitcase, there is a plane in the background;
4. Maya with a ball - Maya and a boy play ball;
5. Maya floats in water - Maya on a lounger holding a glass;
6. Maya half-dressed in warm clothes, next to a dog with a leash, the door in the background - Maya dressed in warm clothes keeps the dog on the leash outdoors;
7. Maya lifts a barbell - Maya eats pizza;
8. Maya travels by car - Maya near the shop with purchases;
9. Maya sleeping on the bed - Maya brushing her teeth;
10. Maya and a boy plant a tree - Maya holds a bucket in her hand next to the boy, who speaks on the phone;
11. Maya watches a dancing girl on the TV - Maya dances;
12. Maya and girl near an open tent - Maya and the girl are hiking.

**Apparatus and Procedure**

The study was conducted using a Dell Latitude E5520 computer (display parameters: 15.6” HD, 1366x768 pixels, Anti-Glare LED) located in front of the participants, who were seated at a comfortable distance.
During the study the stimuli were shown in a random order using MATLAB code (version R2012a). A random function was used both for the order of images and for their scene direction version (initial or reversed). Each test consisted of one example trial and then 12 test trials; each image (the initial or the reversed) was presented once. During the main task in the pilot study each participant saw 12 images.

The task instruction was provided orally in the participant’s language (see Appendix 1). The participants were asked to look at the picture and tell a short story (2-3 sentences) about Maya - what happened to her at first, and what happened afterwards, based on the depicted scenes. The display time of each image was limited to 5 seconds. Between each image a fixation cross appeared for 2 seconds. After the explanation, participants were encouraged to ask if anything was unclear to them.

For the purpose of the possibility of further analysis, the responses were recorded (with written participant consent) using a recording app on a cell phone Samsung Galaxy S4. Answer direction from left-to-right (LTR) was coded as -1, right-to-left (RTL) as 1, and no answer (or not clear answer direction) as 0. A numeric code was used instead of the name of the subject.

Results

In our study we analyzed the subjects’ answers (left-to-right = -1, no answer = 0, right-to-left =1) received in the main task from each presented image (both in initial and reversed versions).

We examined the effect of inversing the image direction on subject’s answer direction, in order to prove the independence between subjects’ answer direction and image version.

We performed a paired t-test of mean answer direction between the initial and reversed image versions, across 12 image pairs. The test had shown that there was no significant effect of image direction (initial or reversed version) on subjects’ answer: \( t(11) = 0.025, p=0.98. \)

However, since the classification of the image as ‘initial’ or ‘reversed’ was performed arbitrary, the division of the 12 image pairs into the two examined groups might have led to false statistical results. Therefore we analyzed the all possible 4096 \( (2^{12}) \) permutations of division into version groups, and found that the probability of the division to lead to a significant
difference between the version groups (p<0.05) is 0.041, which confirms the significance of the result.

There was a significant bias (mean answer is -0.906) to left-to-right direction during the plot building (it was observed in all participants and in all image versions): t (479) =-52.396, p<10^-200.

The distribution of subjects’ answer direction across pictures and scene order (initial or reversed version) is presented in Figure 2. LTR answer direction is coded as -1, RTL as +1, red dots represents answers to initial image version, and blue dots represents the answers to reversed image version.

Figure 2. Distribution of subjects’ answer direction across pictures and scene order (initial or reversed) in the pilot study

With using an outlier detection technique we found that the mean answer of image 11 (-0.7) is located outside the 95% confidence interval of the overall mean answer [-1, 0.75]. We found that when analyzing image number 11 (wherein Maya looks at a girl dancing on TV - Maya dances) 25% of participants experienced difficulty in constructing the plot, and did not complete the task in the allowed response time.

In addition we observed that subjects needed additional trials in the training task in order to estimate the time required to answer and better understand the task: after the training task, a
large part of the subjects (40%) asked questions about whether they completed the task correctly, said that they did not have sufficient time to get oriented with the task.

Discussion

The purpose of the pilot study was to validate the chronological plot ambiguity presented in the images, irrespective of the order in which the scenes were displayed. There was no significant effect of scenes order (initial or reversed version) on the perceived direction of the story plot (subject’s answers).

Another goal of the pilot study was to verify the hypothesis regarding LTR RWD subjects. The existence of significant consistent bias towards direction from left-to-right during the plot building in all observations strengthens our hypothesis regarding speakers of language with left-to-right RWD: for images with ambiguous temporal pattern they created a plot in accordance with LTR direction (the left part will be perceived by LTR speakers as preceding, and the right as following).

Testing the research procedure and the stimulus showed the presence of elements requiring adjustment: difficulty among numerous participants in analyzing and constructing the plot for image number 11, lack of the trials (aiming for helping better understanding of the main task) in the training task.

In order to provide a better understanding of the task for the subjects, it was decided to increase the number of images in the training part of the experiment (from 1 to 3). We decided to change the instructions for participants, and resolved to perform the training task using a different character in the presented scenes. We considered removing the image, causing difficulty in the analysis (№11) from the set of stimuli (see an image on Figure 3).
EYE TRACKING STUDY

The goal of the eye-tracking study was to test the main hypothesis of the experiment and to learn the features of visual perception of non-textual images that allow building an ambiguous temporal order, amongst speakers of languages with left-to-right reading-writing direction and right-to-left reading-writing direction, as well as amongst bilingual speakers with both reading-writing directions.

Participants

67 participants took part in the study: 45 female, 22 male, aged from 18 to 32 years (25.0 mean ±3.4). 24 subjects were speakers of languages with left-to-right RWD (20 Russian speakers, 4 English speakers), without experience in learning or communicating in Hebrew, Arabic or any other RTL RWD languages. 22 subjects were right-to-left Speakers (18 Hebrew speakers, 4 Arabic speakers). 21 were bilinguals (14 speakers both on Hebrew and Russian, 6 speakers both on Hebrew and English, 1 speaker both on Hebrew and Amharic). For all of the subjects in this group, Hebrew was L2 language (average age of learning Hebrew was 12.23 years old).

The study was conducted in the Laboratory of Visual Cognitive Neuroscience, School of Psychology, Tel Aviv University.

Prior the beginning of the study, participants’ level of language knowledge was tested using the Language Experience and Proficiency Questionnaire (LEAP-Q). For Russian-speaking participants, a Russian questionnaire version was used (translated by M. Belkina, K. Borodkin,
O. Lukalo and M. Goral, Lehman College, City University of New York, adapted by Marilyn Hall, Northwestern University). For bilingual and Hebrew subjects, a Hebrew version was used (translated by A. Prior, University of Haifa).

In the bilingual group, we included participants who were not only fluent in both two languages (scored more than 9 in both languages by LEAP-Q), but also used both languages in reading, writing and conversation on a daily basis.

**Stimuli**

Non-textual images that allow building an ambiguous temporal order were used as stimuli in eye–tracking study (see Appendix 2). The characteristics of the images were similar to those described in the General Methods Section. The Background tone of images was changed in accordance with the background used in eye tracking program during calibration (RGB 125, 125, 125).

Based on the results of the pilot study, we resolved to extend the example task by adding more images. Moreover, it was decided to use a new, different main character during the example task – a boy named David. Similarly to the name Maya, the name David is widely common among Russian (Petrovskii, 2000), English (The United States Social Security Administration) and Hebrew Languages (Central Bureau of Statistics of Israel, 2014). Among the scenes we used in the example task, we chose to use scenes that passed an initial test during the pilot experiment, with a slight change of the main character presented in them – the girl Maya was substituted with a boy David.

Below we provide a description of the images used in the eye-tracking study.

1. **Example task**

*Images used for task explanation*: the images similar to those that were used in the pilot study (2 in total).

*Picture for example task*: 3 images in total, the character of all scenes was a boy named David (the image numbers are used only as the name of the image, all stimuli were shown in a random order):

1. David lifts a barbell - David eats pizza;
2. David travels by car - David stands near a shop with groceries;
3. David with a flower in the left hand - David with a balloon in the left hand.

2. **Main task**: we used images (in initial and reversed versions) similar to images 1-6, 9, 10, 12 (9 in total), which were used in the pilot study.

**Apparatus and Procedure**

Participants were seated in a dimly-lit room with their heads supported by a chin and forehead rest at a viewing distance of 1m from a 24 inch LCD monitor (ASUS VG248QE) with 120 Hz refresh rate, and a resolution of 1920*1080, covering 30° of the observers’ visual field. The experimental procedure was programmed in Matlab (Mathworks Inc.) using the Psychtoolbox (Brainard, 1997; Pelli, 1997) and data was analyzed using Matlab and Python 2.7.

Binocular eye movements were monitored using infrared video-oculographic system (Eyelink 1000 Plus, SR Research), with a spatial resolution smaller than 0.01° and average accuracy of 0.25°-0.5° when using a head-rest (as reported by the manufacturer), sampled at 1000 Hz. Raw gaze positions were converted into degrees of visual angle, based on a 9-point calibration that was performed at the beginning of the session (on mid-gray background) and was repeated when necessary.

Before the beginning of the study, the features of the eye-tracking procedure were briefly explained to the subjects and they were invited to sit comfortably on a chair specifically geared to the experimental setup. After a brief explanation for each participant individually, eye-tracking settings were validated and calibrated, and task instructions were presented. The task instructions were presented orally for monolingual participants in their language (see Appendix 3) and for bilinguals in Hebrew (Appendix 3). Participants were encouraged to ask if anything was unclear to them.

The subjects were shown black-and-white images, presented on the monitor in a random order and in a random scene direction version (initial or reversed). Each test consisted of 3 example trials and then 9 main test trials; each image (the initial or the reversed version) was presented once. During the main task in the eye-tracking study each participant saw 9 images.
The character used in the example task of the experiment was a boy named David, and the character used in the main part of the experiment was a girl named Maya. After being presented with an image, the participants were requested to describe what happened to the character at first, and what happened afterwards. The image of a fixation cross in the center was presented for 2 seconds in between each image. The answer time per each image was limited to 5 seconds, followed by a new fixation cross. After finishing an example task, the participants had the opportunity to ask additional questions in order to clarify the task in the main part, and to receive feedback from the examination based on their performance in the example task. At the end of the experiment, the hypothesis of the study was explained to the participants who were interested in the subject of study.

Results

We analyzed the direction of the first big saccade, and subjects’ answers received in the main task (the task with a girl Maya) from each presented image. Eye movements were recorded during the entire task, and we analyzed the direction of the first saccade of each trial that is larger than 2° in amplitude that was exhibited after the cross appeared.

LTR participant #17 was removed from analysis due to the fact that she understood the purpose of the experiment before performing the task.

Due to the lack of eye movement results, we removed from eye-tracking analysis: 1 LTR speaker (#6), 1RTL speaker (#310) and 1 Bilingual speaker (#204).

LTR participants #2 and #10 were removed from eye-tracking analysis after discovering in a post-experiment conversation that their dominant hand was originally left, and that they were taught to use their right hand as dominant during their childhood.

Thus, for statistical analysis we used the results of 20 LTR participants, 20 bilinguals and 21 RTL participants.

Eye Movement Analysis

We conducted a Kruskal-Wallis H test to examine the difference between subjects’ groups (left-to-right speakers, right-to-left speakers and bilinguals) in subjects’ mean first saccade direction (left-to-right = -1, right-to-left =1). There was a significant effect of participant’s group on the
average first saccade direction, $\chi^2 = 33.236$, p $< 10^{-7}$, with a mean rank pain score of 14.65 for left-to-right speakers, 46.31 for right-to-left speakers and 31.28 for bilinguals.

The average first saccade direction among subjects in left-to-right group was -0.85 (SD = 0.15), ranged from -1 to -0.55; in right-to-left group 0.27 (SD = 0.47) ranged from -0.55 to 1; in bilinguals -0.31 (SD = 0.65), ranged from -1 to 1.

The distribution of mean participants’ first saccade direction is presented in Figure 4, where each point represents the average first saccade direction of each subject. Left-to-right direction is coded as -1, right-to-left as +1.

Figure 4. Mean 1st saccade direction across groups (per subject)

Subject’s Answers Analysis

We conducted a Kruskal-Wallis H test to examine the difference between subjects’ groups (left-to-right speakers, right-to-left speakers and bilinguals) in subjects’ mean answer direction (left-to-right = -1, right-to-left =1). There was a significant effect of participant’s group on the average answer direction, $\chi^2 = 30.164$, p $< 10^{-6}$, with a mean rank pain score of 14.68 for left-to-right speakers, 44.43 for right-to-left speakers and 33.23 for bilinguals.
The average answer direction among subjects in left-to-right group was -0.85 (SD = 0.26), ranged from -1 to -0.11; in right-to-left group it was 0.21 (SD = 0.54), ranged from -1 to 1; in bilinguals -0.23 (SD = 0.55), ranged from -1 to 1.

The distribution of average participants’ answer direction is presented in Figure 5, where each point represents the average answer direction of each participant. LTR direction is coded as -1, RTL as +1.

**Figure 5. Mean answer direction across groups (per subject)**

![Graph showing answer direction across groups](image)

**Correlation between Eye Movements and Subject’s Answers**

Using phi correlation coefficient we analyzed the correlation between the mean 1st saccade direction and the mean subject’s answer direction among all participants.

We found a significant correlation between mean 1st saccade direction and mean answer direction among participants R=0.71, p < 10^-10. Figure 6 presents the joint and the marginal distributions of these factors.
However, while the mean representative value among all participants correlates well between 1st saccade and answer directions, in different groups we have observed various misalignment ratios between 1st saccade and answer direction of particular trials.

With using Pearson product-moment correlation was not found linear correlation between saccade direction and answer direction in LTR speakers group $R=0.09$, $p = 0.251$. There was no linear correlation between saccade direction and answer direction in RTL speakers group $R=0.11$, $p = 0.124$. Only for bilingual group was found linear correlation between saccade direction and answer direction $R=0.38$, $p < 10^{-6}$. 
For a more complete display of this phenomenon, we created a group cross counts table (Table 1), which captures the number of matching and mismatching answers in each group.

Table 1. Group Cross Counts

<table>
<thead>
<tr>
<th>Group</th>
<th>1st Saccade</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>LTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answer Direction</td>
<td>LTR</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td>RTL</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>13</td>
</tr>
<tr>
<td>Bilinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answer Direction</td>
<td>LTR</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>RTL</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>61</td>
</tr>
<tr>
<td>RTL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answer Direction</td>
<td>LTR</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>RTL</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>118</td>
</tr>
</tbody>
</table>

Hamming Similarity between Eye Movement and Subject’s Answers

Using Hamming Similarity measure (Number of agreements/Total number of trials) we analyzed the proportion of direction agreements between the 1st saccade direction and subject’s response at the same trials in different participants’ groups.

LTR group exhibited a 0.87 proportion of agreement, bilinguals’ groups exhibited a 0.71 proportion of agreement, and RTL group exhibited only a 0.58 proportion of agreement. Meaning that in 42% of their trials, RTL subjects’ first saccades and responses disagreed in their direction.

Figure 7 (“First Saccade Direction and Answer Direction across Groups”) presents the distribution of the 1st saccade direction and answers across groups. The dot’s location represents the 1st saccade direction, and the distance from the center represents the ordered number of the trial. Blue dots represent LTR answer, and green dots represent RTL answer.
direction. As indicated in the figure, the LTR group tends to look to the left and provides mostly LTR answer. The RTL group has mixed saccade direction with a small tendency to RTL saccades and answers, while bilinguals have a balanced distribution between 1st saccade direction and answers.

Figure 7. First Saccade Direction and Answer Direction across Groups

Picture Bias Analysis

To test the independence of the participants’ responses (left-to-right or right-to-left) from the displayed picture (n=18), we conducted a One-Way ANOVA, which revealed no significant effect of the image identity on subjects’ answer: F (17, 520) = 1.13, p= 0.32.

The results of conducting a One-Way ANOVA (1st Saccade Direction ~ Number of Picture) yielded no significant effect of image identity on 1st saccade direction: F (17, 520) = 1.48, p= 0.097.

Figure 8 (“Saccade Distribution in Stimulus”) presents the 1st saccade distributions on each stimuli image. Each row presents a pair of inverted images and the distribution of the 1st saccades per trial. The dot’s location represents the 1st saccade direction, while the distance from the center represents the number of the trial at which the specific image was presented to the participant. Blue dots represents LTR answer, while green – RTL answer direction.
Figure 8. 1st Saccade distribution in stimulus

<table>
<thead>
<tr>
<th>Saccade Distribution Graph</th>
<th>Initial Picture Version</th>
<th>Saccade Distribution Graph</th>
<th>Reversed Picture Version</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Graph 1" /></td>
<td><img src="image2" alt="Initial Picture 1" /></td>
<td><img src="image3" alt="Graph 2" /></td>
<td><img src="image4" alt="Reversed Picture 1" /></td>
</tr>
<tr>
<td><img src="image5" alt="Graph 2" /></td>
<td><img src="image6" alt="Initial Picture 2" /></td>
<td><img src="image7" alt="Graph 3" /></td>
<td><img src="image8" alt="Reversed Picture 2" /></td>
</tr>
</tbody>
</table>
Discussion

The current eye-tracking study examined the main hypothesis of the experiment: reading-writing direction affects the spatial-temporal order of visual perception and plot analysis of non-textual images, allowing constructing different temporal scene order. We found a significant effect of participant’s group on the average first saccade direction and on answer direction in plot analysis of non-textual images and a strong correlation between the two measures across the groups.

Participants of language with left-to-right RWD generally analyzed the image in accordance with LTR direction: in the picture that had 2 scenes, after an initial fixation on the center, the participants gazed at the left side of the image at first. LTR participants in most cases analyzed and built a story plot about what they saw in the picture in accordance with the principle that the left part precedes, and the right part follows. Among LTR speakers we found spatial bias to the left side in the 1st saccade and in the answer direction (93% of cases for both parameters). Our findings on 1st saccade direction are similar to results obtained in previous eye-tracking studies (Dickinson & Intraub 2009; Foulsham et al. 2013; Ossando´n et al. 2014).

RTL and bilingual participants perceived images and built a plot in both, mixed directions, with spatial bias to the right side among right-to-left RWD speakers (64% of 1st their saccade and 61% of the plot construction was started from right) and spatial bias to the left side among bilingual participants (65% of 1st saccade direction and 61% of answer direction).

The results obtained for RTL group coincide with our initial forecast based on the vast usage of left-to-right reading and writing by Hebrew speakers in numeric series on a daily basis (Vaid & Singh, 1989).

We found a strong correlation between 1st saccade direction and answer direction across all the groups and within the bilingual group. Among three groups of participants, a significant correlation ($R=0.378, p<10^{-6}$) of these parameters was found only in bilinguals’ group, while the two other groups did not demonstrate significant effects. However, we want to emphasize that the correlation in LTR group was not detected due to their vast bias of answers and saccades to the LTR direction. As for the group of right-to-left RWD speakers, we assume that the basis of their entire scene analysis, the interpretation of the image plot, and understanding of its causality and
consequences is not only the result of visual perception based on reading-writing habit, but a more complex cognitive mechanism that requires additional investigation.

**GENERAL DISCUSSION OF STUDY**

In our study we examined the features of visual perception of non-textual images that generate an ambiguous temporal order by speakers of languages with left-to-right reading-writing direction and right-to-left reading-writing direction, as well as by bilingual speakers on the languages with both reading-writing directions.

Our contribution to research fields include developing a new diagnostic stimuli-material kit, using a set of images with ambiguous chronological sequences. Another key contribution included the study of the differences in timeline perception among participants whose languages have diametrically opposed RWD. Moreover, the inclusion of an eye-tracking study expands the understanding of the nature of time-line direction perception by demonstrating the differences both at the visual-gazing level and the final plot-direction answers analysis.

We have expanded the understanding of the phenomenon of perception of timeline direction by LTR, RTL speakers and bidirectional bilinguals. We have demonstrated the influence of scanning habits (based on RWD) on 1st saccade direction and on building a temporal sequence of events depicted on the image. The results of building temporary order of events by the LTR group (placing the earlier events on the left and the later events to the right) are similar to the findings in the previous studies of timeline perception by LTR RWD participants (see Bergen & Chan Lau, 2012; Boroditsky, 2011; Casasanto and Bottini, 2013; Flumini & Santiago, 2013; Tversky et al 1991).

We found that the RTL speakers are not guided only by their scanning habit based on RWD, but by other mechanisms in the process of creating a sequence of events. Our results of timeline perception and building temporal order by RTL participants supplement previous results found in studies that used similar groups of participants (see Tversky et al 1991; Boroditsky, 2011; Fuhrman & Boroditsky, 2010; Ouellet et al. 2010; Román et al, 2013).

The results of bidirectional bilinguals (visual perception of non-textual images that allow building an ambiguous temporal order and plot construction in both, mixed directions, with spatial bias to
the left side) contribute to an understanding of the relationship between native language and the 2nd language, and their influence on construction of worldview and perception of information.

In our study, we have developed and tested a unique research procedure that use stimuli of non-textual images with ambiguous chronological sequences, and allow the subjects to analyze them both in terms of temporal sequence from right-to-left and left-to-right, and to build alternative scenarios. We proved the independence of the subjects' responses and of 1st saccade direction from the displayed image. The stimulus material developed by us can be used in future psychological and linguistic studies with LTR and RTL speakers as an instrument to help foster a better understanding of the role of RWD in constructing time sequences.

In conclusion, our study contributes to understanding the cognitive mechanisms of timeline perception by LTR, RTL speakers and bidirectional bilinguals and can be used as a basis for further research on this issue.

Our results can be used in practical applications in various spheres related to the planning and development of visual material (e.g. interface design, data visualization, marketing etc.) where the direction of image plot processing can play a crucial role in understanding or misunderstanding the message presented by the publisher. This result can also play a helpful role in designing psychological diagnostic and education visual materials for LTR, RTL speakers and bidirectional bilinguals.
ACKNOWLEDGMENTS

Special thanks to my advisor, Professor Galit Yovel, for the support in overcoming the research and academic challenges, and for her belief in the potential of my research; to PHD student Dekel Abeles who assisted in stimuli preparation and results’ analysis; to Dr. Shlomit Yuval-Greenberg and PhD student Rinat Hilo for the opportunity to use the resources of the laboratory of visual cognitive neuroscience; to Professor Orna Peleg for consultations about the world of psycholinguistics and the assistance in the selection of references; to Rachel Zviran for helping with organizational matters.

I would like to thank my undergraduate studies teachers: PhD Alexander Kritskiy and PhD. Larisa Bondareva - my undergraduate studies advisor, for their encouragement to start graduate studies in Cognitive Psychology.

Last but not least, I would also like to thank my all my family and specially: my husband Dmitri Goldenberg for unlimited support during the study implementation, my sister Milena Tsinker, from Southern Experts Center (Volgograd, Russia), for her help with conducting the pilot study on Russian speakers and my mom PhD Zoya Grebneva, for developing me as a researcher.
REFERENCES


APPENDIX

Appendix 1

Instruction for Subjects in a Pilot Study

Version for English Speakers
You will see images, on which a sequence of scenes will be shown. The hero of all scenes will be a
girl named Maya (Maya's image appears on the screen). When you will see an image, you will tell
us, on the basis of the depicted scenes, a short story of 2-3 sentences about Maya – what she did
at first, and what she did after. The displaying time for each image is limited to 5 seconds. The
image of a cross will appear after each picture (the image of fixation cross appears on the screen),
and then the following picture will be shown. All clear? Let's try to perform the task with an
example picture, if something is not clear, you can ask the questions. Are you ready? Let’s begin.

Version for Russian Speakers
Сейчас вы увидите картинки, на которых будет изображена последовательность сюжетов.
Действующий герой всех сюжетов девочка по имени Майя (на экране перед испытуемым
появляется изображение Майи). Как только вы увидите картинку, вам будет необходимо на
основании изображенных сюжетов рассказать короткую историю 2-3 предложения про
Майю - что она делала сначала и что потом. Время на показ каждой картинки ограничено
5ю секундами. После каждой картинки будет появляться крест (на экране появляется
изображение фиксационного креста), а после него следующая картинка. Все понятно?
Давайте попробуем выполнить задание с картинкой для примера, после этого если что-то
будет непонятно вы сможете задать вопросы! Готовы? Начинаем.
### Appendix 2

**Pictures Set for Eye Tracking Study** *(initial version)*

#### Example Task

<table>
<thead>
<tr>
<th>Image used for task explanation “Maya”</th>
<th>Image used for task explanation «Fixation Cross»</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image 01" /></td>
<td><img src="image2.png" alt="Image 02" /></td>
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</table>

#### Images for Example Task

<table>
<thead>
<tr>
<th>Image 01.</th>
<th>Image 02.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Image 03" /></td>
<td><img src="image4.png" alt="Image 04" /></td>
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<table>
<thead>
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<th>Image 03.</th>
<th>Image 04.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Image 05" /></td>
<td><img src="image6.png" alt="Image 06" /></td>
</tr>
<tr>
<td>Image 1.</td>
<td>Image 2.</td>
</tr>
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<td>---</td>
<td>---</td>
</tr>
<tr>
<td><img src="image1.png" alt="Image 1" /></td>
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<table>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Image 5" /></td>
<td><img src="image6.png" alt="Image 6" /></td>
</tr>
</tbody>
</table>
Appendix 3

Instruction for Subjects in Eye Tracking Study

Version for English Speakers
You will see images, on which a sequence of scenes will be shown. The hero of all scenes will be a girl named Maya (*Maya's image appears on the screen*). When you will see an image, you will tell us, on the basis of the depicted scenes, a short story of 2-3 sentences about Maya – what she did at first, and what she did after. The displaying time for each image is limited to 5 seconds. The image of a cross will appear after each picture (*the image of fixation cross appears on the screen*), and then the following picture with Maya will be shown.

At the initial stage for training, I will show you 3 pictures with another hero, it will be a boy named David and you will need to tell, on the basis of the depicted scenes, a short story of 2-3 sentences about David – what he did at first, and what after it. As in a task with Maya the time for each picture is limited to 5 seconds. The image of a cross will appear after each picture, and then the following picture with David will be shown. Let's try to perform the task, then, if something is not clear, you can ask any question. Are you ready? Let’s begin (*the example task*).

Is it clear how to perform a task? Do you have a questions? Ok, now we will continue our experiment, with the girl Maya as a hero. You will need to tell what she did at first, and what after it. Are you ready? Let's start! (*The main task*).

Version for Russian Speakers
Сейчас вы увидите картинки, на которых будет изображена последовательность сюжетов. Действующий герой сюжетов девочка по имени Майя (*на экране появляется изображение Майи*). Как только вы увидите картинку, вам будет необходимо на основании сюжетов рассказать короткую историю 2-3 предложения про Майю - что она делала сначала и что потом. Время на показ каждой картинки ограничено 5ю секундами. После каждой картинки будет появляться крест по центру листа (*изображение фиксационного креста*) и вам нужно будет помотреть на него, а после него следующая картинка.
На начальном этапе для тренировки я покажу вам 3 картинки с другим действующим лицом – мальчиком Давидом и вам нужно будет, на основании увиденного, составить короткий рассказ о том, что происходило с Давидом сначала и что - потом. Время на показ каждой картинки ограничено 5ю секундами. После каждой картинки будет появляться крест по центру листа (изображение фиксационного креста), а после него следующая картинка. Все ли понятно, что нужно делать? Отлично, начинаем (ориентационная часть).

Все ли вам понятно? Есть ли у вас какие –то вопросы? Отлично, теперь мы продолжим наш эксперимент, с девочкой Майей в качестве главного героя и вам нужно будет рассказать историю о том, что она делала вначале, а что потом. Готовы? Начнем!

Version for Hebrew Speakers and Bilinguals (version for male participants, version for female participants was the similar, with the corresponding change in pronouns and verb forms).

של כל הסצנה תהיה ילדהAMEDA. בזמן שתראה עכשיו אתה תראה תמונות, שבהן יהיו כמה סצנות. הגיבורה ואת התמונה אתה צריך לספר סיפור של 2-3 משפטים על מאיה: מה היא עשתה בחתחולה وما אחר-כך lakh הסצנות המוארות בתמונות. גימור התמונה מונביל ל 5 שניות. עבור כל התמונה יינו עלב ביצואים המסוים ואותרים התמונה הובאה ואתה מתייחס עלייה.

בשלב השעון, כדי להתרגל, את התמונה של דמות אחרת – סיפור קצר לספר אתה תצטרך ד. דויד בשם MEYI עליה – מה הוא עשתה בחתחולה وما אחר-כך lakh מה היא עשתהMEYI. גימור התמונה מונביל ל 5 שניות. עבור כל התמונה יינו עלב ביצואים המסוים ואותרים התמונה הובאה. אם בהר כומעتلفת על יפו, נוחל.

האם הכל ברור? האם יש לי שאלות? אם כן, אני מצפה את השאלות. אם לא, אני ייע愆 להתחילה עם מהCOMEカラך. אם אתהが多く! נוחל!