Does statistical learning, as a cognitive tool, determines the effectiveness of grapheme learning? evidence from typical and poor readers

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What is statistical Learning?

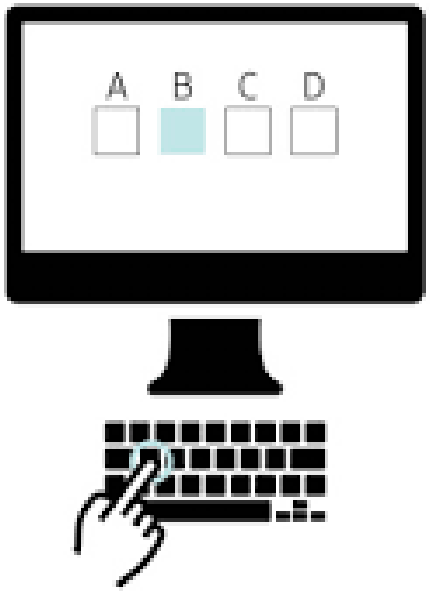
- Statistical learning is defined as a cognitive process by which the individual learns about the frequencies of the occurrence and re-occurrence of events

- An implicit process while there is no necessary for further explicit understanding why the event is expected to occur in certain circumstances

- The main factor which can affect the learning about the occurrence of an event is the familiarity with its past occurrence and probabilities

(Romberg & Saffran, 2010; Saffran, Newport, & Aslin, 1996)

Serial Reaction Time Task-SRT



A sample sequence:

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D
11. A B C D

Statistical Learning and Learning to Read

- Children start to learn about the statistics of the letter shapes before they know how or that these shapes represent language.

- It was found that young children are generally better at copying and writing from memory shapes such as <b> and <F>, which have the typical arrangement with the coda on the right, than those such as <d> and <J>, which do not.

(Treiman & Kessler, 2011)

- Children were more likely to reverse letter forms that face left, such as <d> and <J>, than forms that face right, such as <b> and <C>. This asymmetry reflects statistical learning because children implicitly learn that the right-facing pattern is more typical of Latin letters.

(Treiman et. al., 2014)

- Children learn implicitly that words in English usually do not start with consonant doublets, BBIL →BILL

(Deacon, Conrad, & Pacton, 2008; Wright & Ehri, 2007)

- children at early ages of reading acquisition (grade 1), were sensitive to the orthographic regularities in French and preferred to choose non-words which matched the orthographic regularities in French. These findings were explained as a direct result of statistical learning mechanism.

(Pacton, Perruchet, Fayol, & Cleeremans, 2001)

- Different from Latin orthographies, other orthographic systems have their own unique features which may affect the orthographic learning among the readers of those orthographies

(Share & Daniels, 2015; Seymour, Aro, & Erskine, 2003).

Orthographic connectivity

ن= نـ ـنـ ـن

س= سـ ـسـ ـس

ر= ـر

و= ـو

As a result, different types of written words can be produced:

i) fully connected (Cw): (عَسَل =Honey)

ii) partially connected (PCw): (نُور = Light)

iii) non-connected words (NCw): (دَرْس=Lesson). -

Taha, Ibrahim & Khateb
Brain Topography,2013

Stimuli: A total of 180 words : 1) 60 NC words 2) 60 PCw 3) 60 CW, together with 360 pseudo-words (PWs)

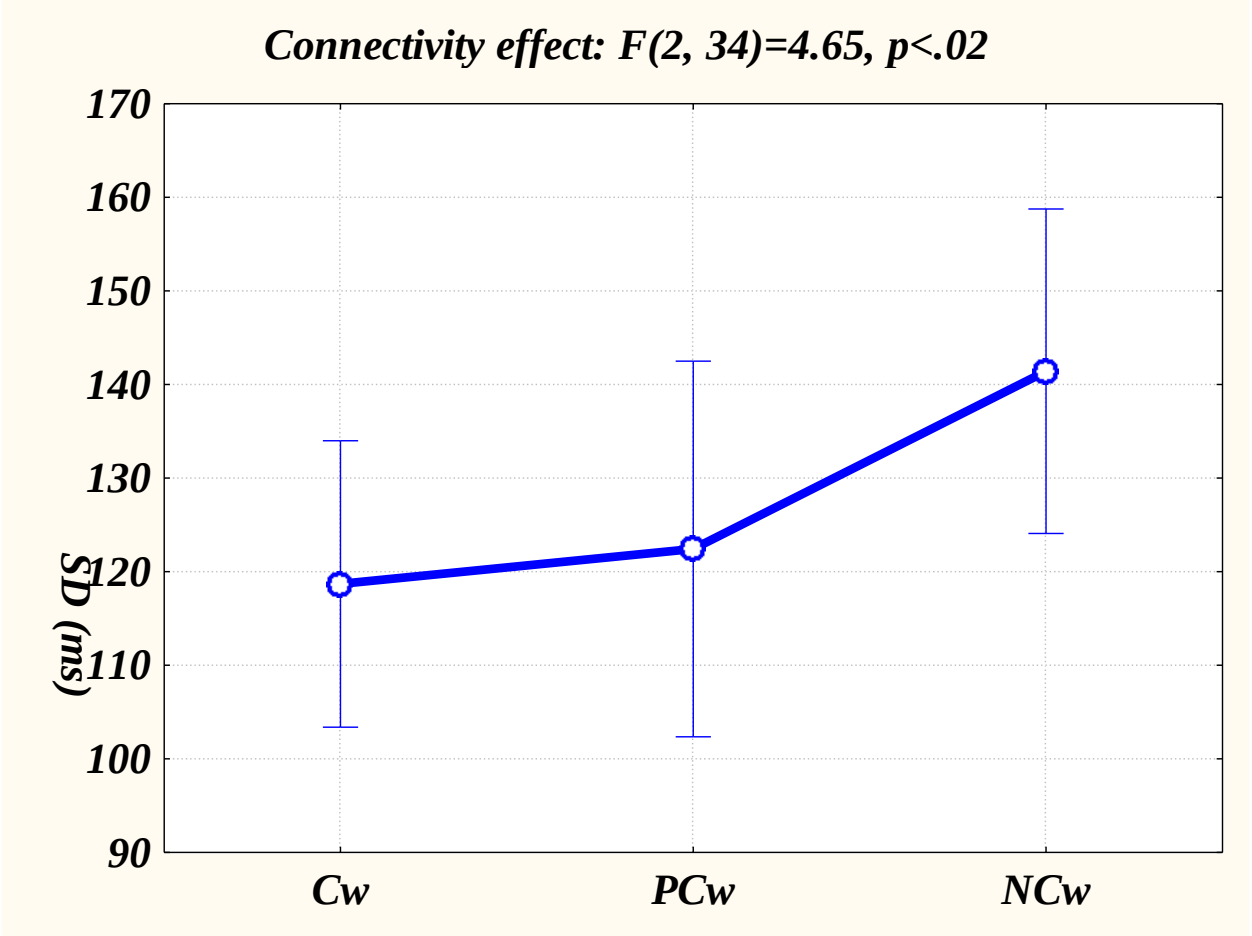
EEG recordings and analysis: the ERPs were collected from 64 channels, waves were analyzed during the time window of the N170.

Methods-bis

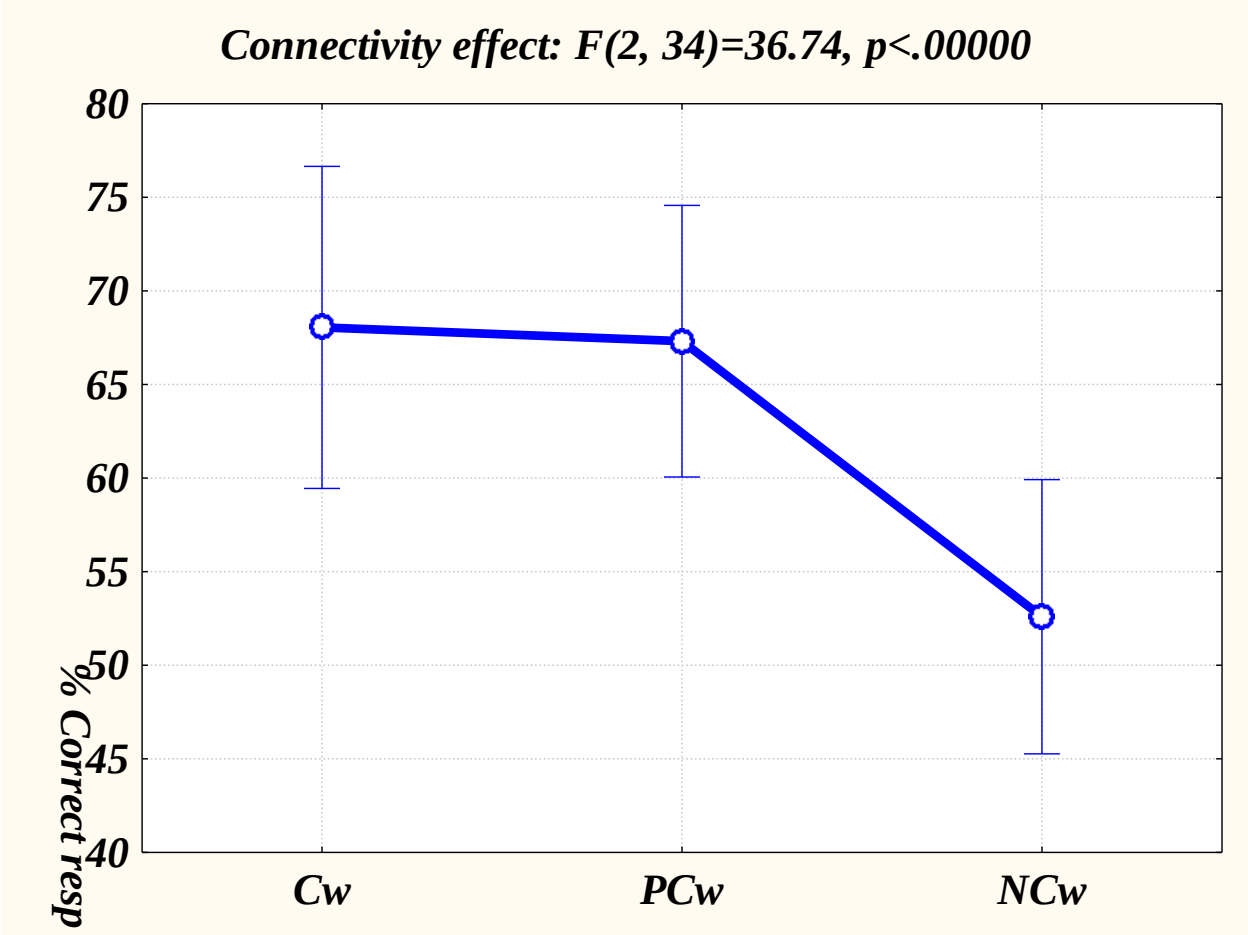
Procedure: Each stimulus was presented for 150ms centrally. The response window= 1550ms. Subjects, at 90cm distance and performed a speeded lexical decision task (LDT): they were asked to decide as quickly and accurately as possible if the presented stimulus was a real word or a pseudoword.

This study was published as: Taha, H., Ibrahim, R., Khateb, A. How does Arabic orthographic connectivity modulate brain activity during visual word recognition: an ERP study, *Brain Topogr.* (2013) 26:292-302.

Taha, Ibrahim & Khateb,2013



Accuracy



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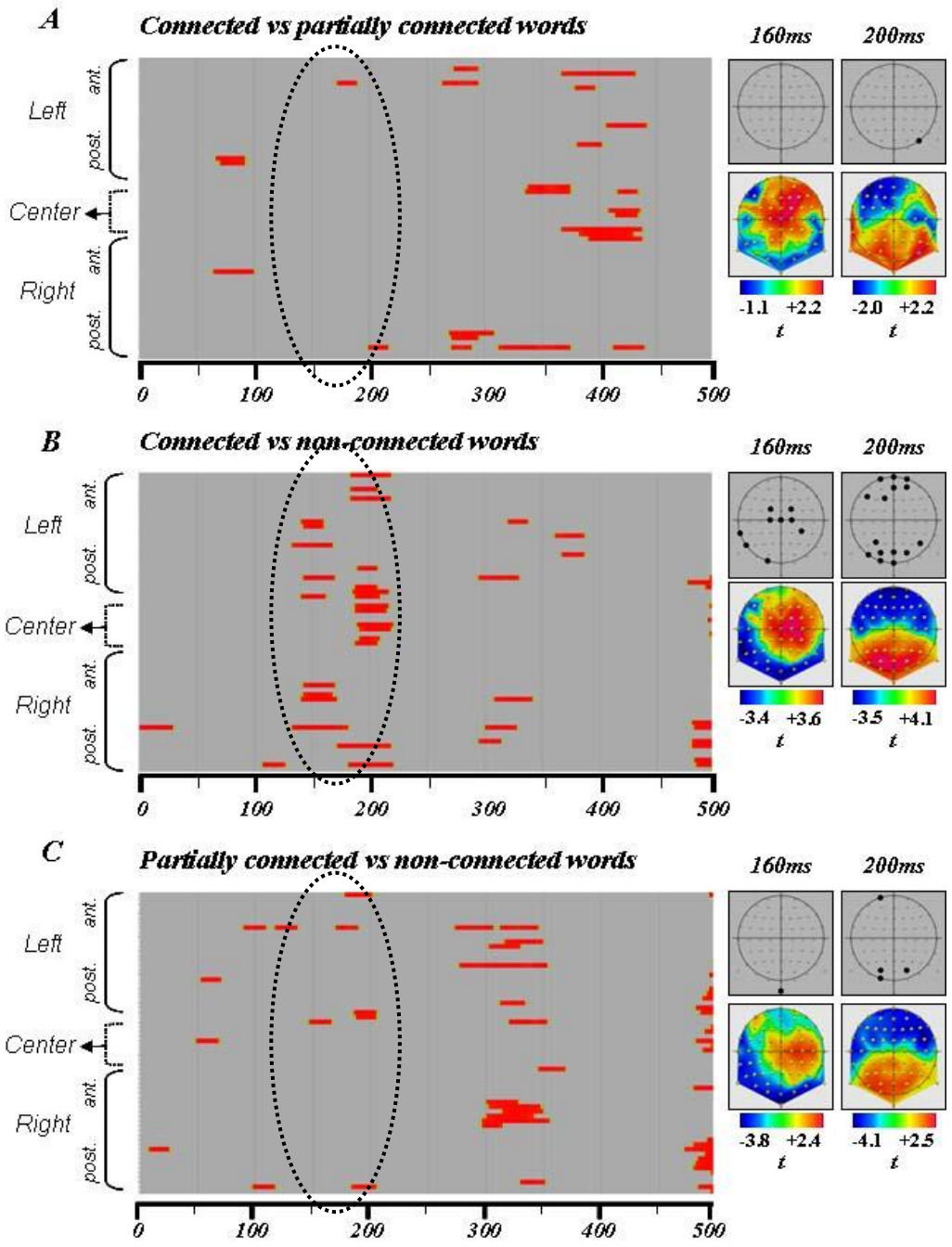
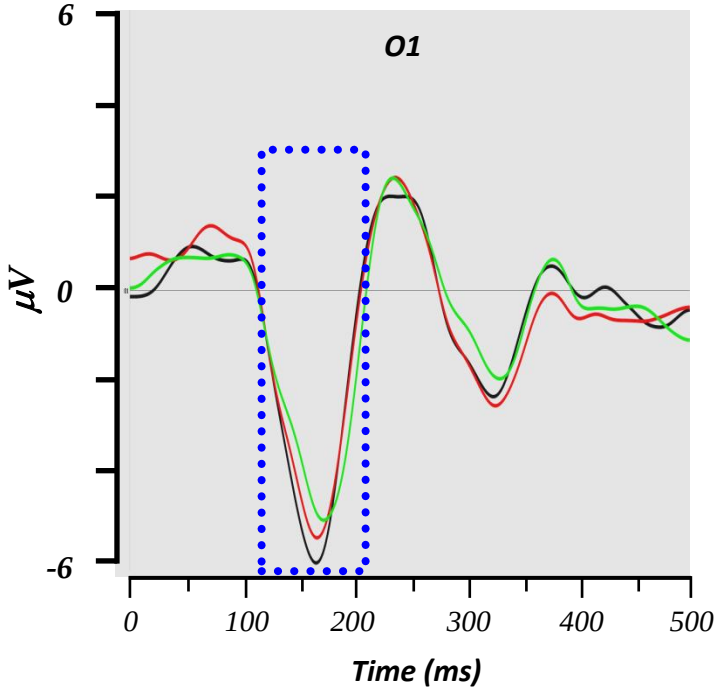
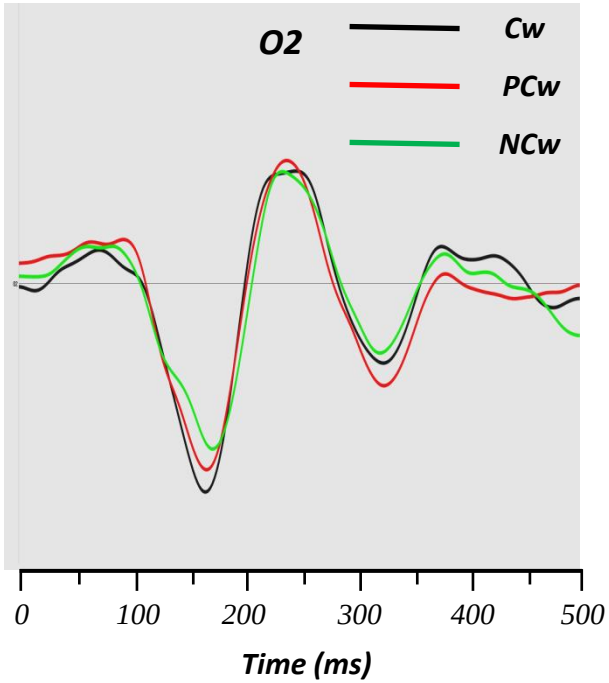


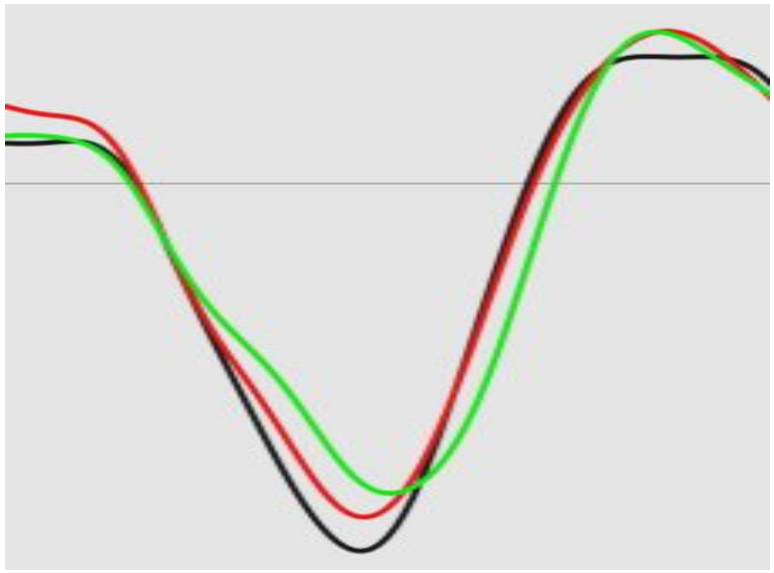
ERP analysis:

We first computed point-wise t-tests on all time point and all electrodes

Statistical analysis then focused on the posterior electrodes for the N170







Not only there appear difference in the amplitude of the response of the N170, but also in its time latency, let's see that

These results indicate that skilled readers of Arabic read more efficiently Cw than NCw and this is reflected already in the very early stages of information processing (in the N170 amplitude and latency)

Statistical Learning and Orthographic Preferences among young Arab native children

- In light of the fact that frequencies of the Arabic orthographic regularities were found to affect the orthographic sensitivity among Arab readers (Khateb, Taha, Elias, & Ibrahim, 2014; Khateb, Khateb-Abdelgani, Taha, & Ibrahim, 2014; Taha, Ibrahim & Khateb, 2013), it will be interesting to explore if Arab children, in early stages of reading and writing acquisition, develop specific orthographic sensitivities as a result of an implicit exposure to print.

Statistical Learning and Orthographic Preferences among Kindergarten and First Native Arab Graders

Taha & Khateeb (Writing Systems Research, 2018)

- It was assumed that children in pre-systematic learning stages of reading (like kindergarten) might develop orthographic preferences toward familiar letters strings than arbitrary symbol strings which are not-real words (for example: written patterns that been composed from letters and non-letters symbols).

- in Arabic orthography, the frequency of the FC and the PC patterns could be higher than the NC patterns, it can be assumed that orthographic preferences toward FC and PC words could be higher than NC words and the arbitrary non-words patterns as well (i.e. Non-words letter-symbols strings).

Participants

In the current study 40 first grade (age= 6.6±.36) students and 40 kindergarteners (age= 5.89±.39) were recruited from different schools in the north of Israel. The first graders group consists from 22 girls and 18 boys while the kindergarten group consists from 22 girls and 18 boys.

- Each participant was tested with an orthographic decision task. In this task the participant was presented with written pattern in the middle of computer power-point slides for 7 seconds.

- Two sets of written patterns were developed for the purposes of the current study: 90 real words patterns and 90 pseudo-orthographic patterns (the non-words, which were composed from non-alpha symbols and real letters, don't match the orthographic regularities in Arabic), hereafter PO.

- The real words' group itself consisted from three types of written words: a) 30 Full connected words > كَلْبdog> (Hereafter: FC) b) 30 partially connected words < سور wall> (Hereafter: PC) and, c) 30 Non-connected words <رأس head> (Hereafter: NC).

- The PO patterns were composed by using a random combination of non-alphabetic symbols (such like # $ % & @ * ¤ ¿) and real letters of the Arabic script). Accordingly, three groups of PO patterns were composed: a) 30 Full connected PO patterns تـ#ـل hereafter: FCp. b) 30 partially connected PO patterns مـ@خ hereafter: PCp and, c) 30 Non-connected PO patterns ط $ر hereafter: NCp.

Real Words Condition

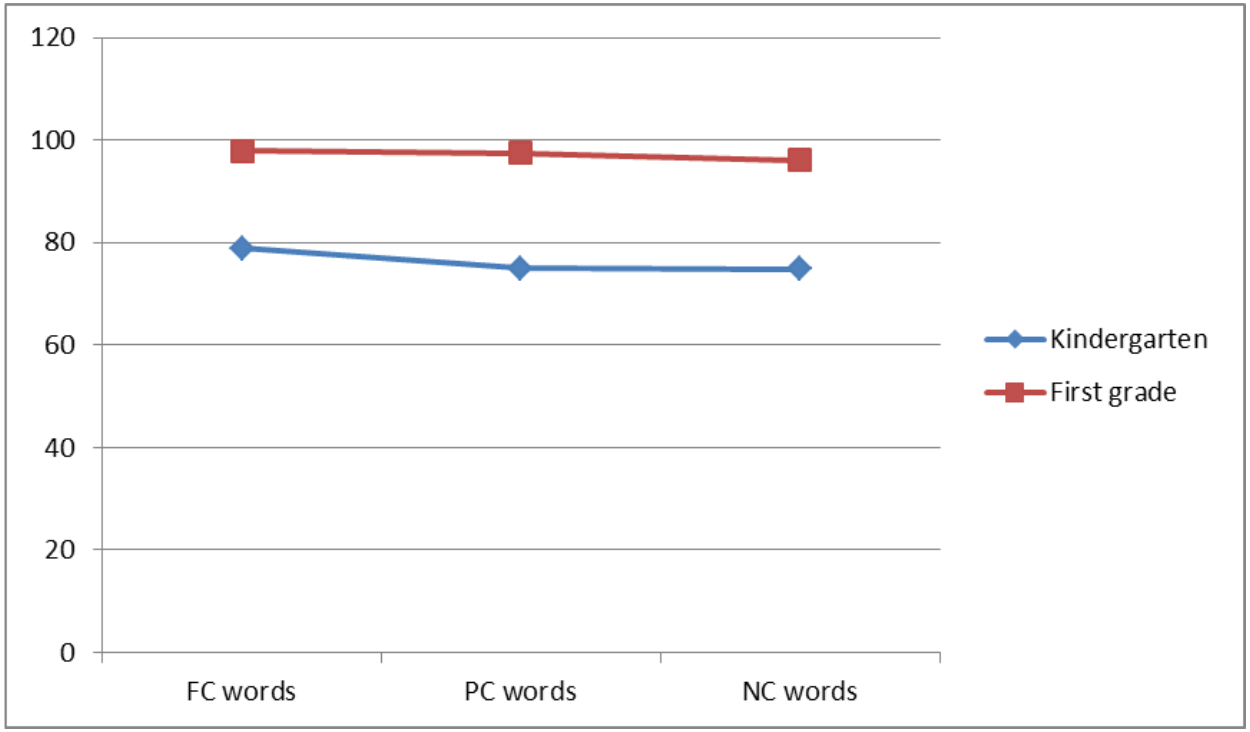


Figure 2: accuracy levels for the performance on the orthographic choice task among the different groups within the real words condition (Abbreviations: FC= full connected, PC= partially connected, NC= non-connected).

1st grade: FC> NC

Kindergarten: non-significant differences

Rejection Accuracy of PO!!

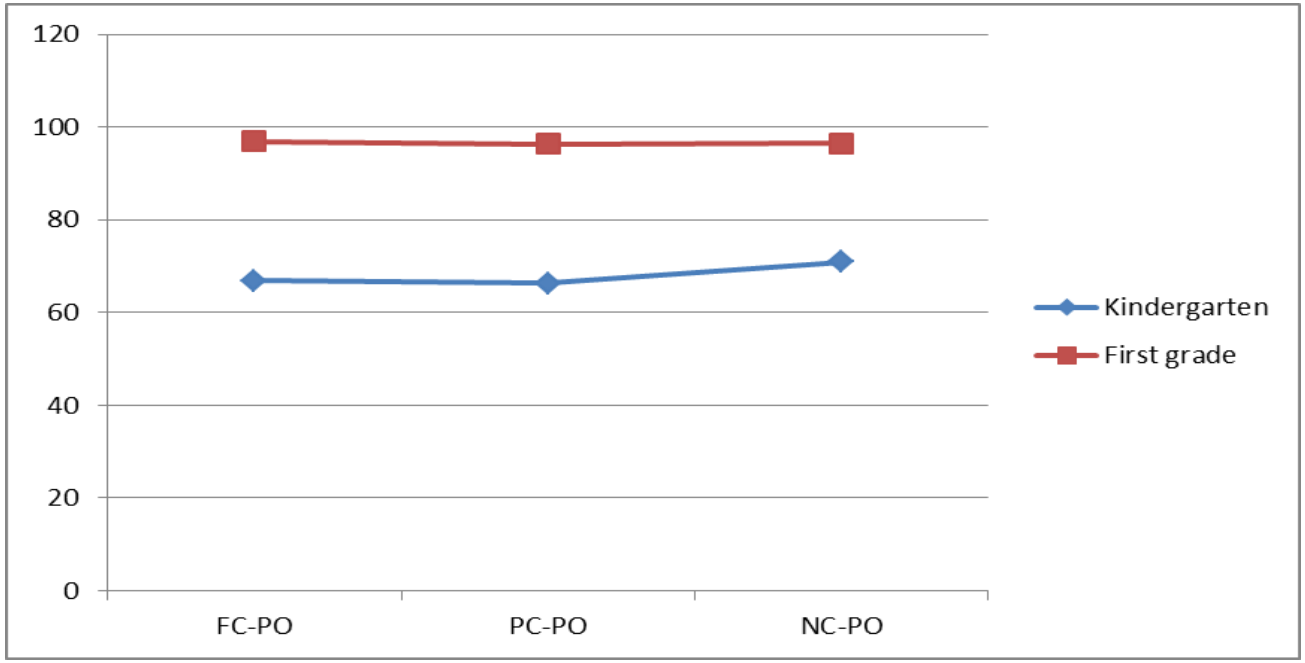


Figure 3: accuracy levels for the performance on the orthographic choice task among the different groups within the pseudo-orthographic condition (Abbreviations: FC-PO= full connected pseudo-orthographic, PC-PO= partially connected pseudo-orthographic, NC-PO= non-connected pseudo-orthographic).

1st grade: No significant Differences

Kindergarten: NC-PO > FC-PO and NC-PO > PC-PO (Rejection Accuracy !!!)

Conclusions-bis

- The kindergarten group was able to accept real patterns as real words with high levels of accuracy and to reject the PO patterns with high levels of accuracy as well. This finding indicated that even without explicit process of learning, the pre-school children can develop an implicit statistical learning about the acceptable orthographic patterns in their own orthography.

- kindergarten children prefer more connected patterns as acceptable to consider as a real orthographic words than non-connected patterns. This resulted in high tendency to reject the non-connected PO patterns as real words than the PCp and even the FCp. The frequency of connected and partially connected patterns is higher than the frequency of the non-connected patterns due to the fact that there are more letters which can connect with former and subsequent letters in the written words than letters that can connect just with former letters only.

Does statistical learning, as a cognitive tool, that enables the detecting visual regularities differ between typical and poor readers?

- Recently, different researchers assume that struggled readers fail in acquiring reading and spelling skills as it is expected according to their age levels because of their inefficient skills in detecting orthographic, alphabetic and phonological statistical regularities (Arciuli, 2018; Vandermosten, Wouters, Ghesquière, & Golestani, 2019).

- Others postulate that struggled readers exhibit poor performances in detecting visual regularities, which can explain their difficulties in detecting orthographic regularities (See for example: Gabay, Thiessen, & Holt, 2015; von Koss Torkildsen, Arciuli, & Wie, 2019.

Detecting visual regularities: Comparison between typical and poor readers

- The current study aims to investigate the performances of poor readers as compared to typical readers in SL task which designed to investigate the capacity in detecting visual regularities.

- If poor reading skills poor are associated with poor SL capacities, then it can be expected that the performances of poor readers in such learning tasks of detecting visual regularities will be significantly below the expected from typical readers.

Method

- *Participants.* Twenty typical (age 11.1 ±.32), and twenty poor readers (age 11.03 ±.28), were selected to participate in the current study

Detecting Visual Regularities Task Taha, In preparation

- Participants were passively presented with four shapes: squares, triangles, circles, and rhombuses. Each shape had stable features which present the regularities of the shape.

- Therefore, circles shapes consistently appeared with two bars from the left and right, tringle shapes appeared with one bar from right only, square shapes appeared always with one bar from left while rhombuses shapes were presented without any unique and stable features.

- Except for the stable features of each shape, which differed between the four shapes, all shapes included variable features that appeared randomally inside the basic shape.

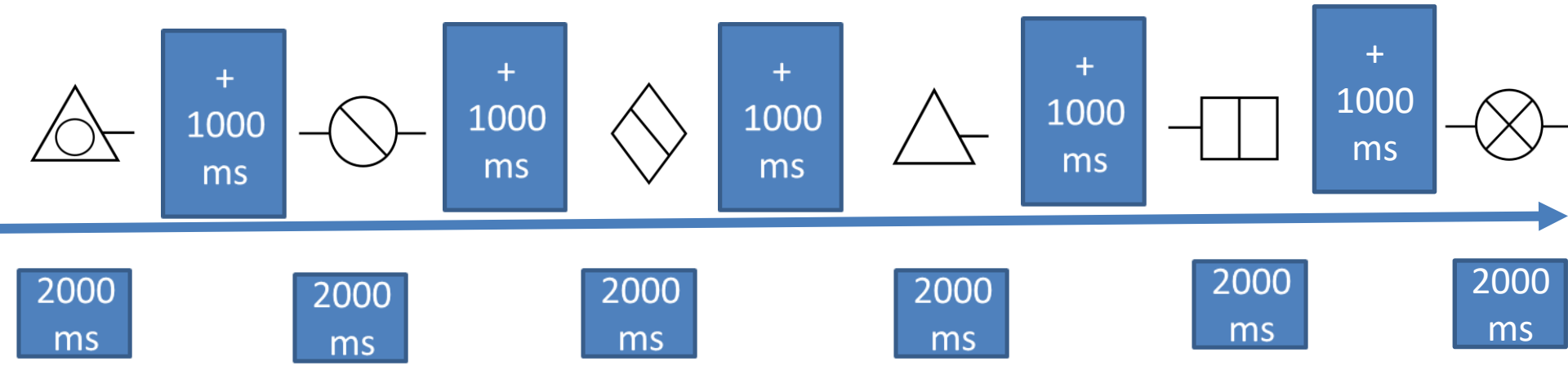
The implicit learning stage

- All shapes were presented in the same size of 0.59 inches for high and 1.04 inches of width. During this stage, each participant was seated about 70 cm in front of 21” screen, and passively was presented with the different shape.

- Each shape was presented randomly **twenty** times in the center of the screen for 2000 ms followed by cross sign which was presented for 1000 ms before presenting the following stimulus.

- The passive learning stage was repeated three times over three consecutive days for each participant, one presentation for each day.

The implicit learning stage



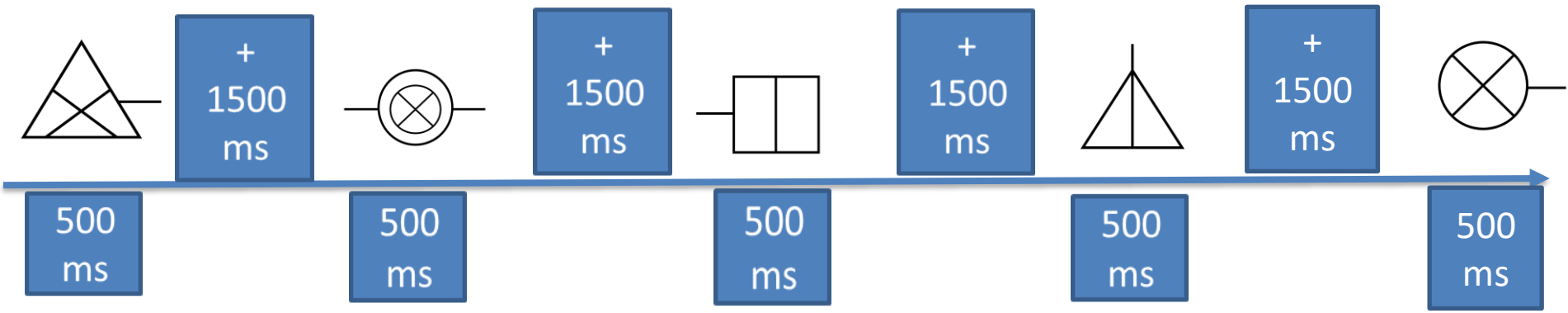
The Decision Task

- **Was implemented immediately after the third passive presentation, the participants were presented with shapes decision task.**
- **In such task the participants were asked to make an acceptance or rejection of presented shapes based on their preferences.**
- **Each participant was presented with 160 shapes.**
- **Eighty shapes were compatible with the shapes regularities as was presented during the passive learning stage, while the other shapes were not matched such regularities.**
- **The presentation of the different shapes was balanced; therefore, each shape was presented twenty times in compatible manner with the basic shape regularities and other twenty time as non-compatible with the regularities.**
- **Accordingly, Half of the presented shapes in the decision task were compatible with the shapes regularities which were presented in the first stage and the other were not.**

The Decision Task-bis

- Each stimulus was randomly presented in the center of the 21” screen for 500 ms, followed by cross sign for 1500 ms.
- Followed with the signal detection theory, responses were measured and encoded for four categories:
- A) **True positives**: when the response of the participant was “yes” for presented items which are compatible with the visual regularities.
- B) **True Negatives**: when the response of the participant was “No” for presented items which are not compatible with the visual regularities.
- C) **False positives**: when the response of the participant was “yes” for presented items which are not compatible with the visual regularities.
- D) **False Negatives**: when the response of the participant was “no” for presented items which are compatible with the visual regularities.

The Decision Task



Results

ACC

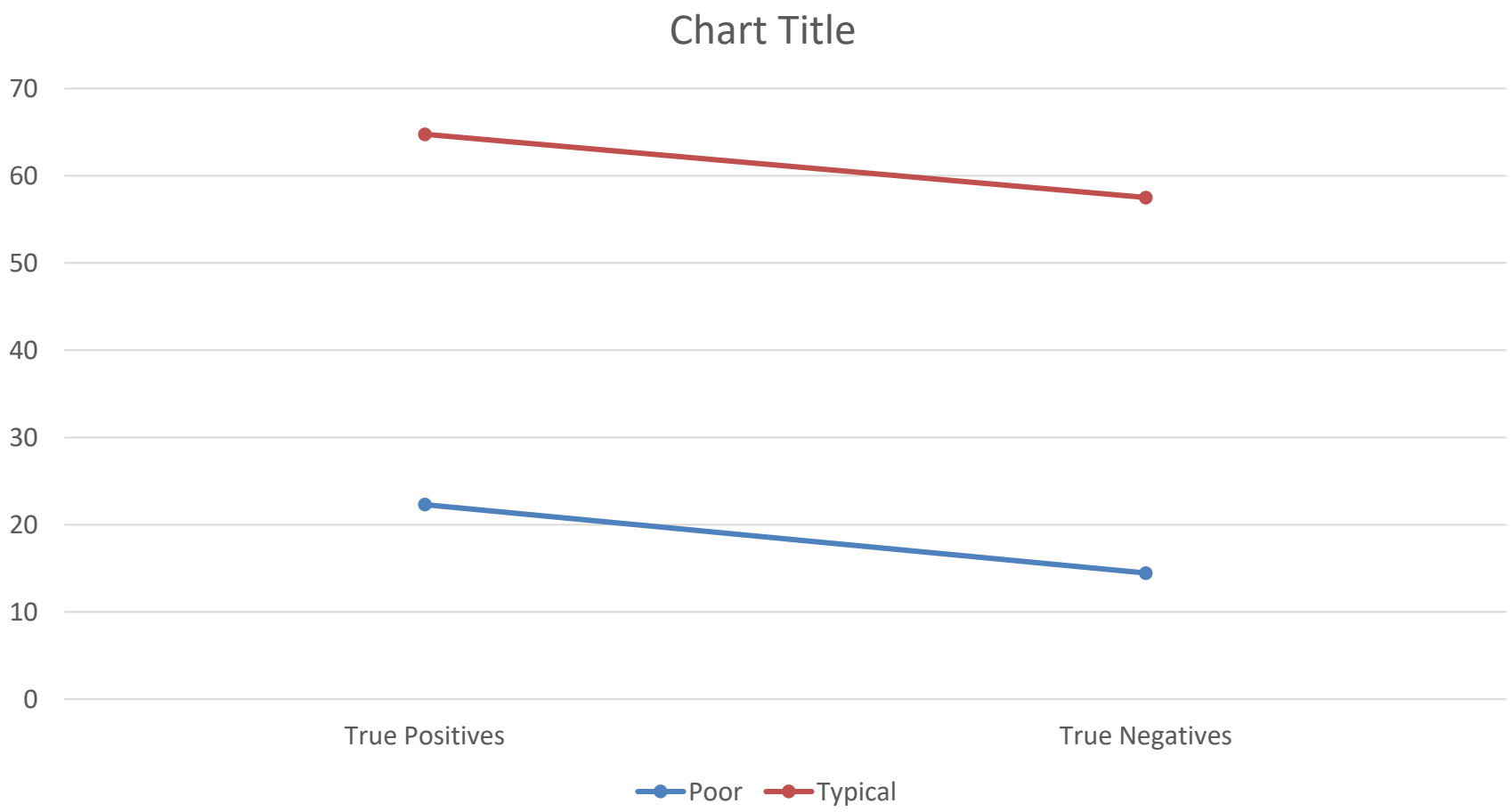


Chart Title
70
60
50
40
30
20
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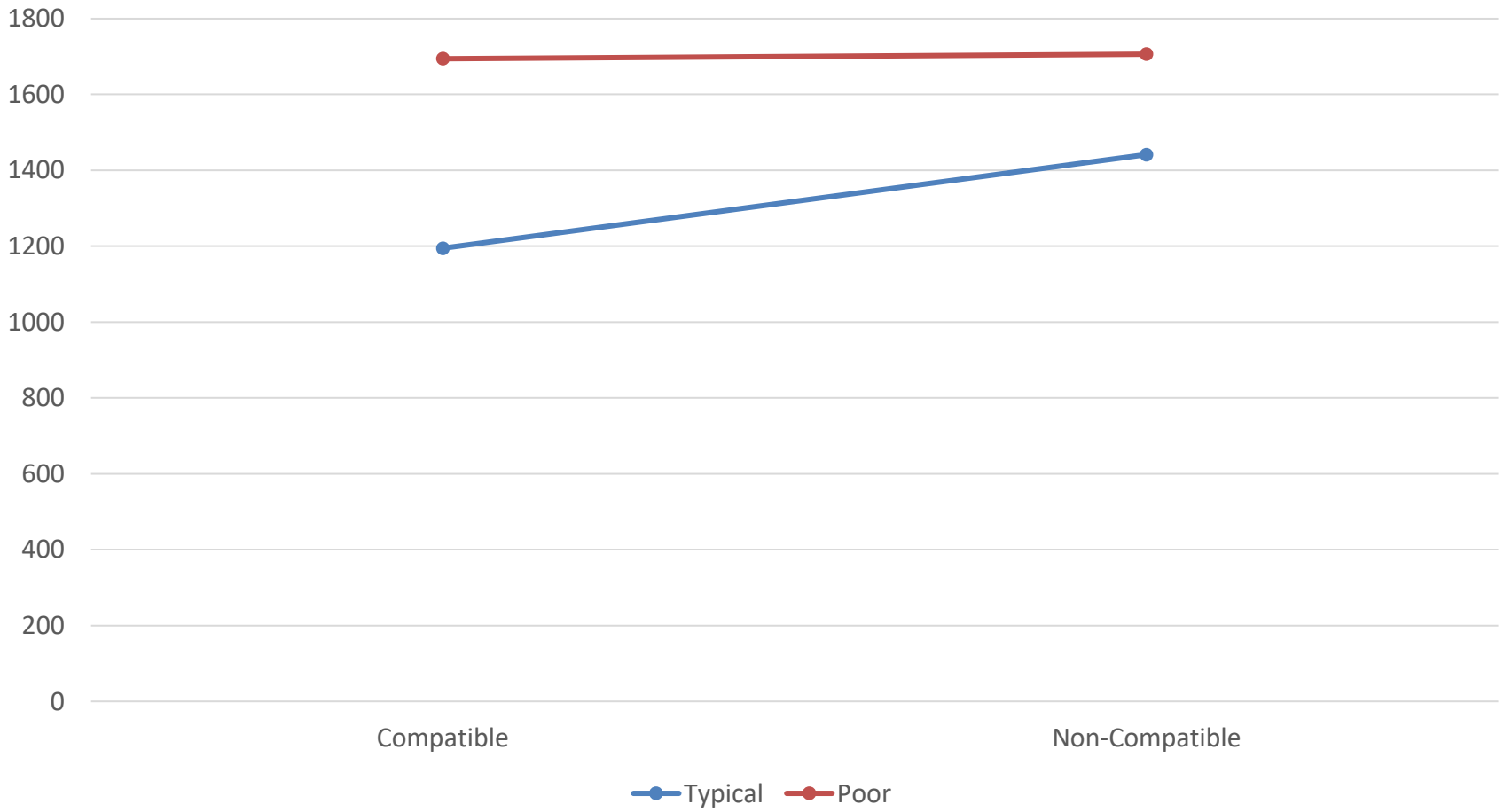
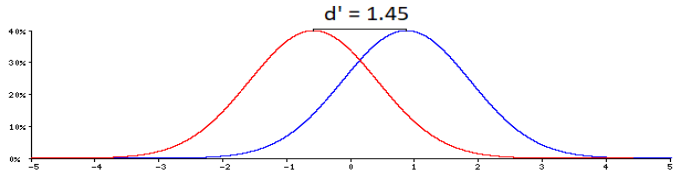
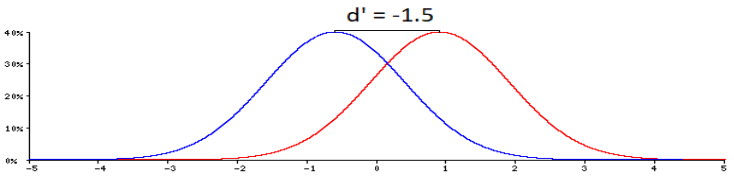
0
True Positives
True Negatives
Poor
Typical

RTs (milliseconds)





d’ typical readers



d’ poor readers

Conclusions

- The findings of the present study showed that the performances of poor readers in the decision task was lower than the performance of typical readers.

- While the implemented exposure sessions were sufficient for the typical readers to consolidate implicit knowledge about the visual regularities of the stimuli, it seems that for poor readers more repetitions are still needed in order to enable such implicit knowledge about the visual regularities.

- The findings indicate that the delay in learning orthographic regularity among poor readers may result on the lack of effectiveness of the implicit learning processes.

Thank you for your attention!

شُكْرًا لِإِصْغائِكُم