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Global representations of occluded objects hinder priming effects of local interpolations in a complex matching prime paradigm.

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Abstract

In this study, we explore the type of representations that observers have about surfaces that are partially occluded. When a surface is partially occluded, we can have a theoretically infinite number of representations for that surface. Most prominent are local (based on local good continuation of the intersecting edges) and global (based on the Pragnanz principle and stimulus symmetry) representations and both have been shown to exist in our cognitive system.

We employed a priming matching paradigm (van Lier, van der Helm & Leeuwenberg, 1995) but added more objects to the series of surfaces used in the trials. Observers had to respond quickly to a pair of stimuli (same/different response) that followed a brief presentation of a prime stimulus of several types (local, global, etc.).

Our data show that there was no priming effect for either category of primes unlike the original study, but that the global category of stimuli was processed faster than the other categories. We take these results to suggest that in complex stimulus environments, "primes" may not be good facilitators, and that the visual system completes the task at hand based on core global representations.

Keywords: visual recognition, occlusion, completion, priming

1. A brief account of amodal completion history

One of the most commonly occurring-and often without us being consciously aware of it-perceptual phenomenon is the so-called amodal completion. The world around us

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consists of objects, the contours and surfaces of which overlap on our retina resulting in a "fragmented" reality. Several surfaces are unavoidably hidden by others in our field of view, yet our perceptual system is able to fill these visual gaps and represent the *occluded* segment and the shape or object as whole. Amodal completion, therefore, is the perceptual process through which our brain is able to mentally represent parts of objects of which we receive no sensory input (thus the term *a*-modal), as a complete perceptual entity.

The term *amodal* completion was first coined by Michotte paired with its twin perceptual process *modal* completion (as mentioned in Wagemans et.al, 2006). According to Michotte, modal completion refers to the perception of a form within an array of shapes of a complex stimulus due to the emergence of illusory contours (Breckon & Fischer, 2005), such as illustrated in picture 1. In this example, we perceive a white square which actually is not modally present, due to the alignment of the contours protruded from the background black circles. The complimentary process is that of amodal completion which is demonstrated in picture 2. Here, modal and amodal completion co-exist in one of the most famous completion displays: the Kanizsa triangle.

As far as modal completion is concerned, the arrangement of the three background "pacman-shaped" black circles allows the illusory white triangle to arise in the foreground and overlap the bordered one beneath it. At the same time, the function of amodal completion enables us to keep perceiving the "pacmen" shapes as complete circles, even attempting to unify these distant components of the stimulus. Moreover, Gerbino and Salmaso suggest that modal and amodal

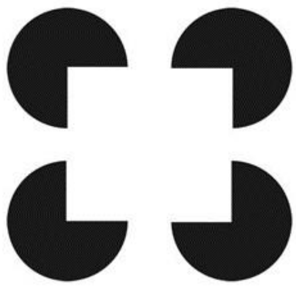


Figure 1. An example of a modally completed stimulus.

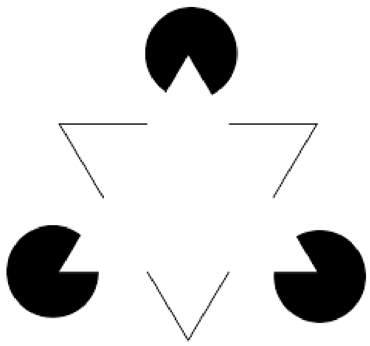


Figure 2. *The Kanizsa triangle, a typical example of the amodal completion phenomenon*

completion share some "common fate" regarding the causal relationship between them, with modal resulting from amodal and the existence within common geometrical boundaries.

Wagemans et al., 2006 also discuss Michotte's point according to which amodal completion is a hardwired, rapid and largely automated *visual* process. Even though the deduction considering the completion of the shape in question appears to be a decision verbally expressed, Michotte claims it is fundamentally the output of the visual system. A similar train of thought is presented by Kanizsa (1985) according to whom amodal completion is a visual task not governed by the axioms and categories of logical processes. The hidden surface is not *always* completed according to its context following regularities or *knowledge* but rather is subject to the organization principles that hold the surface together. The last point is rigorously debated in completion research and we urge the reader to bear it in mind as we proceed to the discussion of occlusion phenomena and specifically of the role of intrinsic shape regularities in object completion.

2. Visual Occlusion

Amodal completion is studied within a spectrum of frameworks such as motion or conception, however most extensively documented is the study of the completion of 2D (mostly but also 3D) linear object drawings. As the present study takes on methods from this line of research, we will next inspect the theoretical framework and experimental designs that have been utilized in completion research.

2.1 Local vs global theories of completion

The first major theoretical dichotomy we encounter when reviewing object completion literature is the one between local and global theories. The explanatory power of local theories stems from conjoining the Gestalt simplicity principle and the Gestalt good continuation principle. Local theories suggest that in order to predict and determine the completion of an occluded object our perceptual system examines the discontinuities in the contours comprising the background shape at the points of occlusion.

This principle was first phrased by Kellman and Shipley (1991) as the relatability criterion, which predicts that if the imagined extensions of the occluded object's junctions converge behind the occluder (foreground shape) then we will perceive the shape in a complete manner (van Lier, 1999), (see figure 3). Otherwise the occluded shape will be perceived as a mosaic one. The relatability criterion can be applied in any number of given junctions within a stimulus as long as they are harmonically joined. In addition, it functions towards the minimum possible number of contours to complete the shape and towards the most common point of convergence between them. This model therefore limits the influence of intrinsic shape regularities in shape completion.

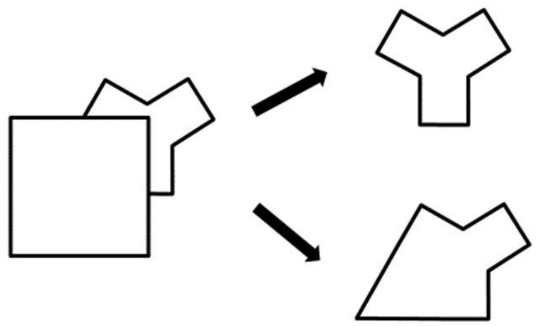


Figure 3. *An example of two possible completions for an occluded stimulus according to global predictions (top) and local predictions (bottom).*

An alternative good continuation model was brought forward by Wouterlood and Boselie (1992). Their criticism on the findings of the existing good continuation models is based on the fact that most of them where conducted utilizing stimuli with a high degree of regularity influences. In their study, they used irregular patterns resulting in a functional model that predicts completion when specific types of junction continuation are joined within a stimulus (van Lier, van der Helm & Leeuwenberg, 1994). This model, however, is restricted to the domain of irregular patterns.

We now shift our attention to global theories which, to a wide extent trace their origin to the Gestalt principle of Pragnanz. The latter states that our perception organizes perceived patterns in the most simple and regular way considering the symmetrical elements (such as axis of symmetry) of the occluded surface in order to predict the perceptual output. This principle has been translated in the global minimum principle and combined with elements of coding theory has been used in an attempt to predict the outcome of the completion process in terms of "the simplest code" (Leeuwenberg, 1971).

Such attempts have been partially successful albeit studies and stimuli have emerged in which the simplest interpretation isn't always preferred (van Lier et al., 1995). These authors have also proposed a model which attempts to unify elements of local and global theory by considering the degree of overlap between occluding and occluded shapes in a given stimulus and also by taking into account the total amount of regularities in the structure. The simplest "sum" of the above-mentioned factors is predicted to be the most probable selection. SIT (structural information theory) however does not claim to reflect an internal process that actually takes place within the function of our perceptual system but rather attempts to describe how the possible number of interpretations could be constrained.

Local and global approaches in the literature nevertheless haven't always been integrated van Lier & Gerbino (2015). On the contrary, empirical findings have led researchers to consider these interpretations as being opposed, or suppressing one another (Sekuler and Palmer 1994; van Lier, van der Helm and Leeuwenberg, 1995). Also in other studies, such as de Wit and van Lier (2002), global influences have been found to dominate completion processes a fact which leads us to the final point of the present section.

Both local and global theoretical predictions, despite their differences, attempt to outline the factors that may potentially dominate the outcome of our inherent visual processes regarding completion of occluded surfaces. They attempt we could say to define the architectural rules by which our brain begins to represent the world around us. However, we need not consider completion to be neither a static nor a fully insulated operation. On the contrary, various experimental paradigms have suggested that a number of variables such as the time course of completion, the spatial context and the complexity of form Plomp and van Leuwen (2006) could alter the way probable completions are computed as well the outcome of the process per se.

3. Evidence from primed matching and other paradigms in completion research

3.1 Implementation of primed matching: global dominance and the two-staged model of completion processing

Over the last 25 years a wide spectrum of experimental paradigms has been utilized in the attempt to decipher the underlying mechanisms of visual completion of occluded surfaces. The case, however, has not always been as such: Earlier paradigms such as continuity judgements by Kellman and Shipley (1991) or drawing tasks and simultaneous matching by Gerbino and Salmaso (1987) tested completion hypotheses in a less strict manner (although not less important with regard to their findings), so a more rigorous method of hypotheses testing was required.

This need was recognized by Sekuler and Palmer (1992) who were the first to introduce the primed matching paradigm to determine whether our interpretation of occluded stimuli leaned more towards global or mosaic interpretations. Sekuler and Palmer characteristically indicate that previous paradigms such as the aforementioned or the adaptation task by Weinstein 1972 (as reported in Sekuler and Palmer, 1992), did not quite probe completion mechanisms under 1 second but primarily their products. They set out to examine the "microgenesis of completion effects".

In primed matching the higher the similarity between prime and target the higher the facilitation is expected to be (van Lier et al., 1995). Specifically, if an occluded prime triggers a same response time as a complete (global prime), then the preferred internal representation is that of a complete shape and, if an occluded prime triggers a response time similar to the mosaic primes, then the preferred internal representation is that of a puzzle like percept.

Initial testing of their paradigm took place within a temporal context of 740 ms and provided a successful function of primed matching. Congruence between prime and target resulted in faster reaction times both for complete and mosaic pairs. Occluded primes which make the decisive difference in terms of perceptual processes yielded a pattern of results very similar to that of complete pairs. What is even more interesting, however, is the results obtained in their second experiment where primed matching for complete and mosaic prime was tested within a temporal context of 50, 100, 200 and 400 ms. In this case a very important interaction appeared in the data: performance of mosaic primes resembled occluded more in short SOA compared to complete primes, while as time progressed (approximately at 200 ms) occluded primes yielded reaction times very similar, if not identical, to that of complete primes.

This finding was one of the first indications in the literature for the existence of a staged model process in shape completion. Sekuler and Palmer introduced the notion that occluded shapes may be first represented retinotopically in a 2D manner, whilst obtaining a more complete 3D representation as completion information progressed through the visual stream. According to them, completion has run its course within 200 ms with global influences gradually discarding mosaic influences. Later studies (Murray, Sekuler, & Bennett, 2001) place the average completion time even lower, at 75 ms, although as the researchers note it may vary depending on the given task and viewing conditions.

More recent evidence from MRI studies (Weigelt, Singer, & Muckli, 2007) suggests that the proposed two-staged model may be valid. Weigelt et al. (2007) presented observers with mosaic and complete versions of shapes (circles and pacmen) for various presentation times while monitoring fMRI activation. Physical (mosaic) induced activation in early V1 areas of the brain and complete shapes induced activation in LOC.

In another study (Sekuler, Palmer, & Flynn, 1994) mosaic primes and targets were not included in the experimental design. Yet this decision did not at all hinder the very important findings in this study. Sekuler et al. (1994) tested local and global predictions utilizing local, global and occluded primes in different temporal context and stimuli (transparent-filled). Local predictions mean that local primes and occluded primes will not differ at all when examining the pattern of reaction times and the same stands for global predictions: global and occluded reactions times will be quite close. Results were dramatically in favor of global predictions even in very short (150 ms) SOA and retained their lead as SOA increased (300, 1000 ms). Global completions dominated when filled figures where used in the design.

These findings led Sekuler and Palmer (1992) to propose a model in which global and local elements are relevant in early stages of completion but global influences quickly take over resulting in faster RT's as the completion process has reached its peak (150 ms) and is concluded (1000 ms). The pattern of priming effects also complements this model since the larger facilitation is obtained at 300 ms when completion reaches its developmental ceiling.

Global completions have been found to dominate visual occlusion outside the range of regular stimuli. De Wit and van Lier (2002) tested the valence of possible completion interpretations (global, local anomalous) in quasi regular shapes. They tested the prediction of local theories that the shape will be completed at the linear continuation at the points of occlusion versus the prediction of global theories that intrinsic shapes regularities will determine the outcome of completion. Both local and global cues where abundant in the presented stimuli. Results were dramatically in favor of a global preference in irregular shape completions in terms of facilitation with an absence of the effect for local and anomalous completions. The same pattern was also observed when multiple versions of the same stimulus (in various degrees of completions) were used as primes: The versions of the stimulus that primed most were the ones closer to the global pattern. Another conclusion drawn from the above results is that perception can discern between multiple possible completions for a stimulus limiting their range however in terms of cognitive efficiency and plausibility.

Similar results have been found by the study of van Lier, Leeuwenberg, & Helm (1994). The focus of the study was not to test directly local versus global theoretical predictions but rather explored the possible generations of completions beyond the local and global ones: anomalous completions. We believe that based in Sekuler and Palmer’s (1992) findings they did not include mosaic interpretations of their occlusion stimuli. Yet in their study a very clean pattern of data emerged: global completions produced both faster reaction times and larger facilitation effects followed by local and anomalous completions. In addition, a control experiment was conducted testing multiple completion versions of one test pair revealing both facilitation and better RT performance for global completions followed by local and anomalous. We shall return to the original study immediately after presenting an alternative to the two-staged model discussed earlier.

3.2 An alternative view to sequential processing: the parallel processing model

Primed matching has appeared in several variations, one of which was the addition of binocular parallax condition by Bruno, Bertamini and Domini (1997). Bruno et al. (1997) examined primed matching using binocular parallax because, according to their rational, it simulates a more realistic setting, thus providing greater ecological validity. Their findings suggest the following: Firstly, the pattern of results replicates those of Sekuler and Palmer (1992) in every experiment for the pictorial condition only. In the parallax condition, on other hand, occlusion primes reached reaction times similar to those of complete primes at 100 ms, which is the half of the crucial temporal point suggested by Sekuler and Palmer. Even more important is the fact that, when a monocular control experiment was conducted, results became very close to those of pictorial condition.

Bruno et al. (1997) claimed that mosaic completions were discarded in the parallax condition because of their complexity and their contradiction with depth cues. It requires a trained observer to view a mosaic completion in a parallax situation. If the observer is not trained, then the complete interpretation is quickly preferred. Bruno et al. brought forward an alternative model to the two-staged model, in order to interpret their findings: Mosaic and complete interpretations are both available when completion process sets off but it requires "attentional effort" in order for one of them to suppress the other. More importantly, they suggest that available visual cues, such as depth information, dramatically change the outcome of the completion process.

Primed matching has been expanded beyond the traditional two-frame version by Plomp and van Leuween (2006). Plomp and van Leuween included an extra priming frame in their design which was either a congruent component of the priming stimulus or an incongruent one in 50 and 500 ms conditions. A supper additive effect was evident in all SOA conditions as well as possible sequences between the two priming components with some exceptions. The single figure elicited facilitation generally in all conditions while occlusion stimuli sped up responses when presented immediately before the test pair. Even more global completions were consistently faster, followed by local and mosaic ones. At the same time, however, single figures were able to prime both complete and mosaic completion interpretations, suggesting that both of them may be available early on.

Another significant component in Plomp and van Leuween's study is the fact that there was a clear presence of priming for an SOA of 500 ms. The finding is important because it means that researchers aiming to examine the valence of various possible completions may use it as a baseline to asses them. It has also been suggested elsewhere in completion research (Plomp, Liu, van Leeuwen & Ioannides, 2006) that global and local completions may have more in common compared to (complex) mosaic ones and even global ones may be hindered if presented in a way that increases their processing needs.

Advocates of a parallel processing in amodal completion are found also outside the domain of priming research. Rauschenberg and Yantis (2004) tested the effects of context on visual search of occluded and complete targets, which were surrounded by notched (mosaic + occlusion square) non-targets. The task was to recognize as fast as possible the occluded target in the display. Non-target mosaic stimuli had a profound effect on the search for occluded targets since, contrary to the two-staged model prediction (that a mosaic completion initially dominates under 200 ms), search was delayed at the 100 ms condition. Also in the 250 ms condition the search for occluded targets was not sufficient again against two-staged model predictions. These results suggest that the completion process can be biased at a critical point where possible interpretations are processed in parallel.

3.3 Scope of the present study

Several facts regarding completion research are unequivocal in the literature. Firstly, within the quite strict context of primed matching (in terms of temporal context and stimuli elements control) global influences have clearly dominated. Global completions, be it because of the regularities or the simplest and symmetric interpretation they often provide, have been found both to elicit faster reaction times and greater facilitation in visual occlusion research. Such is the case in the study of van Lier et al. (1994). We hypothesize that if global completions hold sway over completion processes and local completions follow them, then the same pattern of clear results is expected in our study both in terms of reaction times and facilitation.

Secondly, there is an issue concerning the architecture of the primed matching itself. Prime matching tasks have functioned successfully in all the studies we have discussed in the previous sections. Most of these studies (the original one included), however, had up to three conditions of test pairs, since making the paradigm operate within a context that limited the possibility of obtaining results that could mask priming effects. In all truth, it has surprised us that none of the aforementioned studies has encountered this issue before. Our aim was to test priming matching within a more complex environment

Thirdly, there is the issue of mosaic interpretations, which has been settled only partially. Evidence supports both a two staged and a parallel model of processing for mosaic shapes in various viewing conditions (in terms of context and presentation) but both of them agree that as the completion course moves forward mosaic interpretations' power weakens and they concede their place to either local or global ones. Yet, we believe that including a mosaic condition in our priming study may provide some insight over the temporal point that they are completely neutralized. Furthermore, we aim to test our visual system's competence at discerning between discarded (mosaic) and less probable (anomalous) completions. We hypothesize that mosaic and anomalous completions will yield the slowest reaction times but if they are ruled out because of the complexity then their pattern of results will be quite similar.

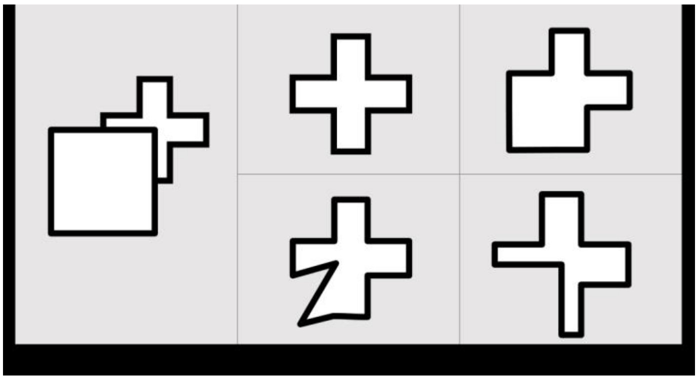


Figure 4. *Example completions for a composite-occluded stimulus in the present study: top-left global, top right local, bottom-left anomalous, bottom right mosaic. Note that shapes in the table do not represent to actual stimuli size.*

Methods

Participants

30 under-graduate students of the Department of Psychology of University of Crete participated in the study (N=30, 26 female και 4 male) age (19-25). All participants received course credit for a cognitive psychology course as compensation for participating ct. All participants had normal or corrected 20-20 vision and were naïve as to the experimental hypotheses of the study.

Materials

Stimuli. All stimuli used in the study are a replication of the ones used by van Lier, Leeuwenberg & van der Helm (1995) with the addition of one more stimulus type. Six patterns of visual occlusion were utilized followed by four possible completions (global, local, anomalous, mosaic). The latter was not included in the original study and is an addition of the present one. For each of the 6 shape patterns there were 11 different targets as compared to the 6 targets of the original study.

Each experimental trial in our study consisted of a prime-target combination. Each of the 6 subsets consisted of 55 stimulus combinations yielding 330 in total (55 x 6 subsets) and 330 experimental trials. One more note must be made regarding the stimuli combinations: A prime followed by a test pair with the same shape is considered congruent, whilst a prime followed by a test pair with a different shape is considered incongruent. This distinction holds only for the prime within each subset where the completion is at the foreground.

Equipment. All experimental trials were presented on a LG flatiron 23" diagonal screen and all observations were collected via a simple Logitech keyboard. Participants made their observations sitting at a distance of about 70 cm from the center of the screen. During the course of all experimental sessions constant natural lighting conditions were maintained. Stimuli presentation was controlled by the experimental presentation software SuperLab4.5.

Procedure. Each experimental trial consisted of three frames. Firstly, a fixation cross was presented on the screen for 500 ms followed by a blank screen for 50 ms. Immediately after appeared on the screen either a stimulus consisting of two shapes (in the priming condition) either two dots (in the no prime condition). Afterwards the screen remained blank for another 17 ms followed by the test pairs, for which the subject had to decide if they were the same or not. As illustrated in figure…5 the occluding square remained on the answer screen to inhibit a weakening of the effect (Sekuler & Palmer, 1992; van Lier et al., 1994).

The test pair remained on display until a response was given by the participant. Responses were given by pressing a button (yes=same/no=different).Responses were timed to the nearest possible millisecond and in contrast with previous research (Sekuler

& Palmer, 1992; van Lier et al., 1994) participants received no feedback on their performance.

Each participant was given the same oral and written instructions (on the screen). They were instructed to focus their attention at the center of the screen near the occlusion point (they were oblivious as to what the occlusion point was) and answer if the shapes on the test pair were the same or not. In order to proceed to the main experimental session, participants had to complete a set of 4 practice trials in order to get themselves acquainted with the response method. If one practice trial was wrong, then all four were looped anew until correctly responded.

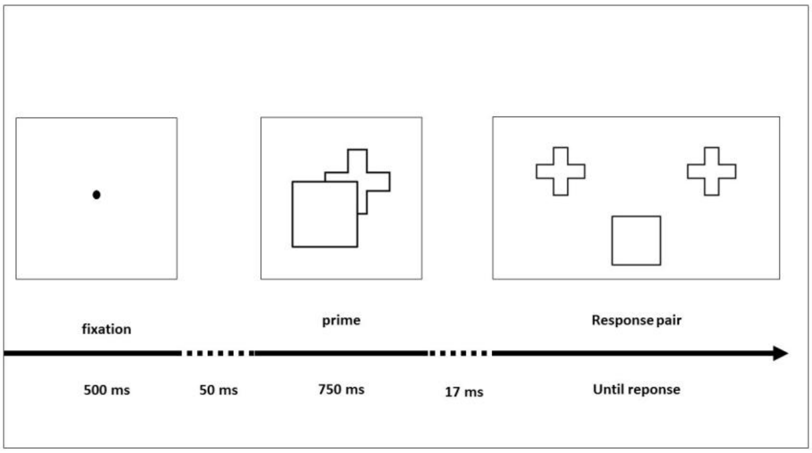


Figure 5. *An example of the temporal sequence of events and stimulus presentation in the present study*

Design and Analyses

A two factor (5x10) within subject design was implemented. The first factor comprised of *prime type* (occlusion, global, local, anomalous, no prime) and the second factor of *response pair target* (global/global, local/local, anomalous/anomalous, mosaic/ mosaic, global/local, global/anomalous, global/mosaic, local/anomalous, local/mosaic, mosaic/anomalous) (see figure 5). Response time (RT) measured in milliseconds (ms) was set as the dependent variable. Due to a coding error when matching primes and test pairs one stimulus subset out of the initial six was excluded from the analyses.

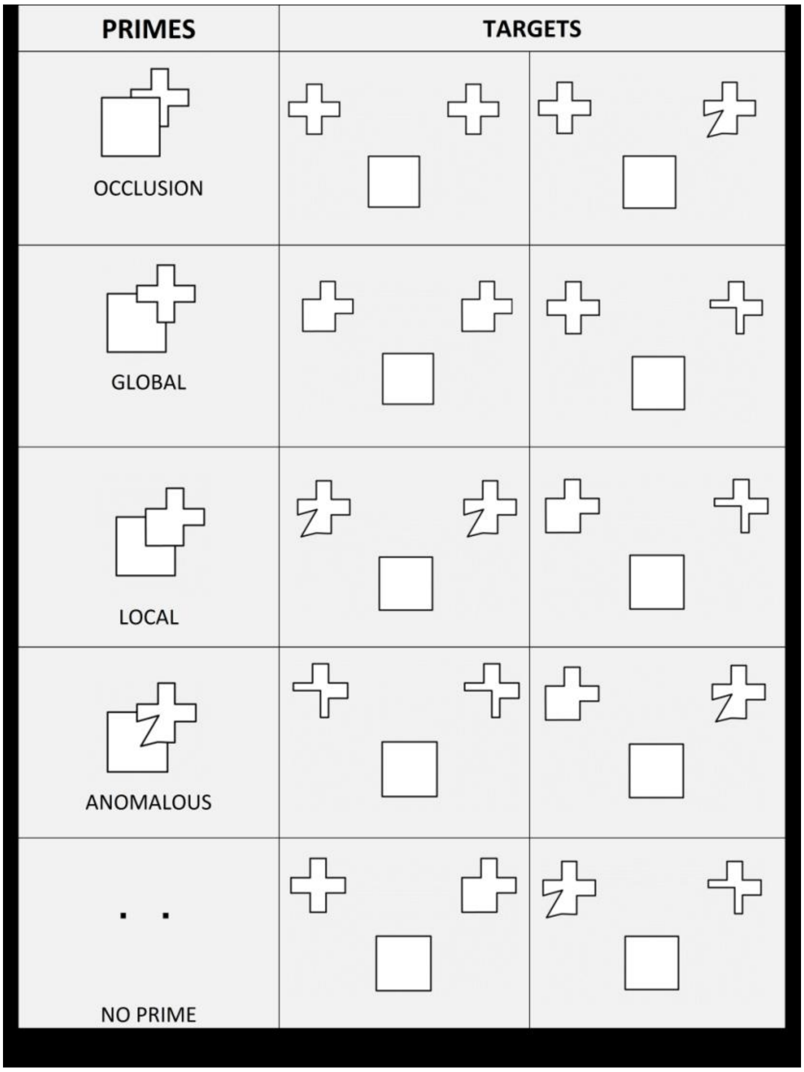


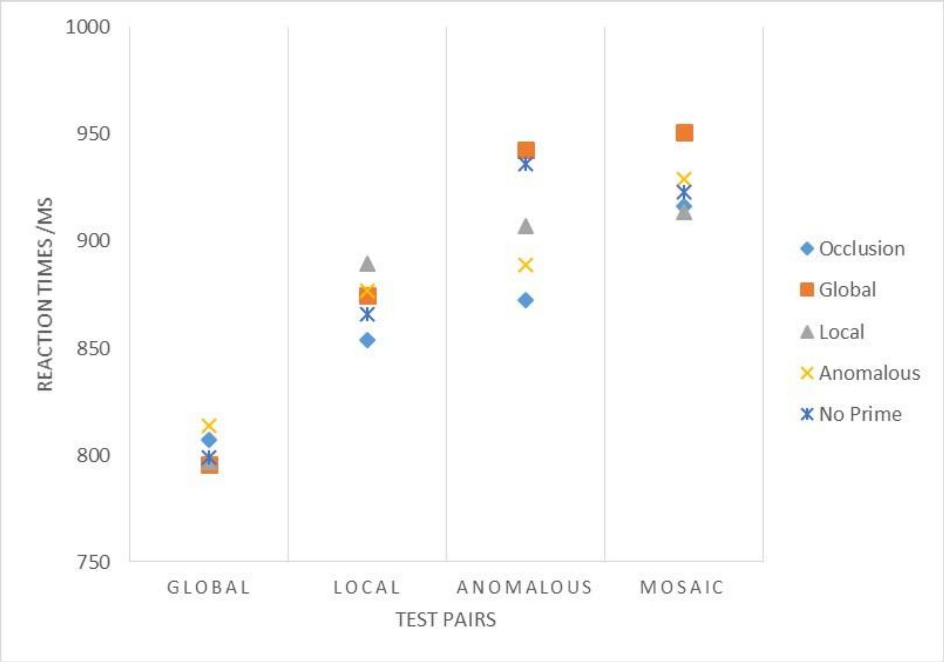
Figure 6. *Full listing of 1 out of 6 stimuli subsets included in the experimental design. Shape sizes do not correspond to actual stimuli sizes.*

Results

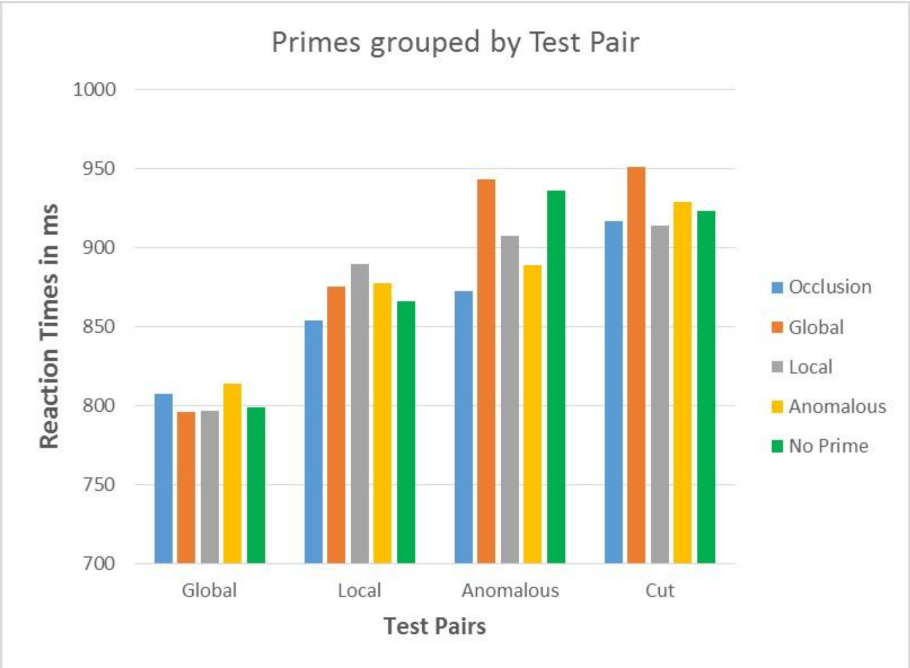
All statistical analyses were conducted using SPSS v21. Prior to the analysis, the complete dataset was examined for outliers and missing values. Only the correct ‘yes’ responses given by participants were kept for statistical analysis. Out of 30 subjects, 2 were found to have approximately 40% erroneous responses and therefore were removed from further processing. A *missing value analysis* of the rest of the cases revealed that 9.4% of our total values were missing from the dataset which is not negligible. Little's MCAR (missing completely at random) test came out not significant [Little's MCAR test: χ^2 = 728.989, (2551, N = 28) p = 1.000)] and a multiple imputation process was utilized to fill in the missing data.

This approach led to the creation of 5 new imputed datasets, in addition to our original dataset, which maintained a lower and upper cut-point of 250 and 2000 milliseconds respectively. Therefore, the total number of datasets was 6 (1 original plus 5 imputed). Next step was to compute the prime and test pair totals by averaging all of the different shapes together for each prime-test pair condition. So, for example the total occlusion-global variable would contain aggregated elements of the same condition for each of the different shapes (e.g. Angle occlusion-global + Square occlusion-global + Star occlusion global + etc...) divided by the number of different shapes. This was performed for all prime and test pair categories for a total of 20 variables (5 primes X 4 test pairs).

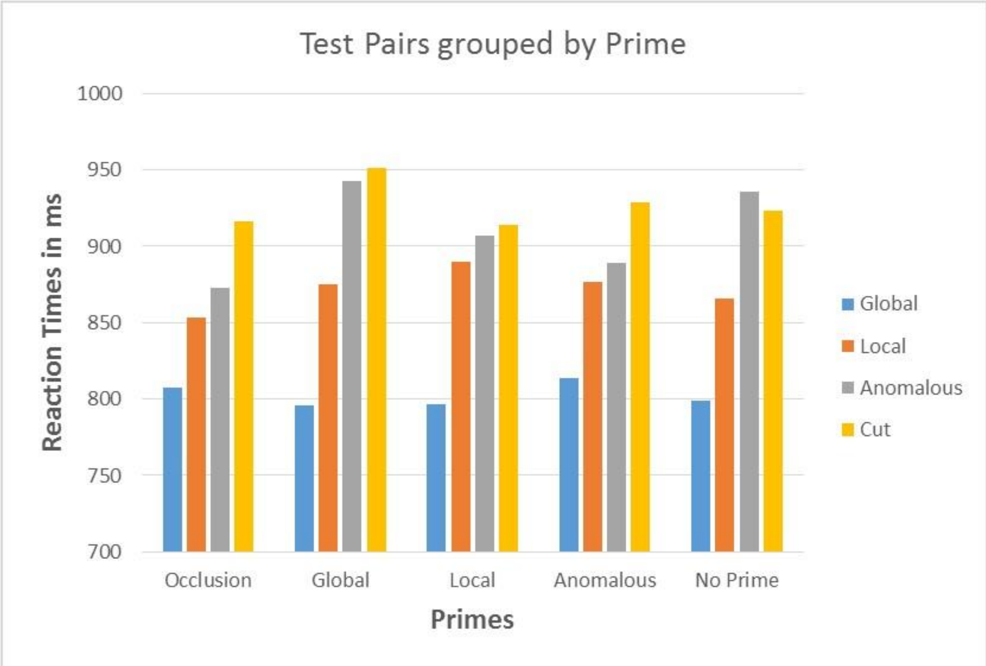
Previous research by van Lier et al. (1995) successfully predicted that a foreground prime followed by a congruent test pair (i.e. global foreground prime followed by the global test pair) would have faster reaction times compared to incongruent prime-test pairs. What is more, they predicted that the response time after the occlusion prime would be similar to the congruent foreground prime's (van Lier, 1995, p.734). Based on this assumption coming true they created a function measuring the priming effect by subtracting the occlusion prime response time for a given test pair from a mean baseline value for the congruent foreground and no prime conditions for the same test pair. Their assumption was confirmed and thus was how the priming effect (PE) of the occlusion prime calculated.



Graph 1: Calculated from pooling 5 multiply imputed datasets plus the original one



Graph 2: Calculated from pooling 5 multiply imputed datasets plus the original one



Graph 3: Calculated from pooling 5 multiply imputed datasets plus the original one

Since this assumption was not confirmed, in the present research calculating priming effects in the same way would not provide credible measurement of the occlusion priming effect. Therefore, we performed two different kinds of analysis of variance (ANOVA) using only Reaction Time data.

<u>Analysis 1</u>

As mentioned above, a multiple imputation with 5 imputed datasets was performed due to values missing in the original dataset (N=28). At this point it is important to explain how SPSS analyses multiple imputed datasets. First the software produces separate datasets (in this case 5). Then an analysis of each individual complete dataset (5 imputed and 1 original) is performed to create multiple analysis results and Then an analysis of each individual complete data set (5 imputed and 1 original) is performed to create multiple analysis results which are then combined (pooled) into one table. This is the case for a variety of different types of statistical procedures. However, this is not possible in SPSS v21 by default for repeated measures analysis of variance (ANOVA). Following the instructions by Ginkel (2014) it has been possible to conduct a mixed model repeated measures ANOVA with Reaction Time as the dependent variable including the imputed datasets and pooling the results together using SPSS syntax.

The main effect of test pair was significant [$F(3, 510.99) = 63.01$, $p < .001$], while there was no significant effect of prime [$F(4, 510.99) = 1.8$, $p = .1344$] and no significant interaction between prime and test pair [$F(12, 511) = 1.3$, $p = .21$]. Further, a priori contrast analysis between test pairs revealed that any of the primes which were followed by the global test pair elicited significantly faster responses compared to the ones that were followed by the anomalous b = 31.7, [$t(510.70) = 5.28$, $p < .001$], and the mosaic test pair b = 49.03, [$t(510.9) = 8.16$, $p < .001$].

Analysis 2

Since the aforementioned method of dataset pooling by Ginkel is relatively new and experimental and in order to have a general linear model analysis to serve as a more "conventional" yardstick for our analysis, another ANOVA was conducted utilizing the general linear model. This time a different imputation technique was utilized, namely the Expectation Maximization (EM) which is a single imputation technique.

That basically means that only the missing values of the given dataset are computed in a way that appears relevant to the already observed ones. However, in order to do that it was necessary to reduce the percentage of missing values. That has been accomplished by removing 8 more participants who had the most missing values out of our total 28 subjects. That left 20 (N=20) subjects for the analysis and 6% of total values missing. That percentage is still high but not as bad as the previous 9%. Still, the results from this analysis should be interpreted with caution. Performing the expectation maximization imputation creates a new dataset so there is no pooling problem and a common repeated measures ANOVA is very possible.

In this ANOVA the results were essentially the same as in the previous one. The main effect of test pair was significant [$F(3, 57) = 31.6$, $p < .001$] while the main effects of prime and the prime by test pair interaction was not, [$F(4, 76) = .182$, $p = .947$] and [$F(12, 228) = 1.189$, $p = .292$] respectively.

Contrasts revealed that irrespectively of the prime the global test pair elicited significantly faster responses than the local, [$F(1, 19) = 59.096$, $p < .001$], the anomalous, [$F(1, 19) = 57.127$, $p < .001$] and the mosaic test pair [$F(1, 19) = 72.894$, $p < .001$].

Discussion

In the present study, we set out to investigate the effectiveness of different types of primes to facilitate response in a complex matching prime paradigm. In addition to the original stimulus set, we also employed a mosaic condition aiming to directly compare global, local, and anomalous and mosaic completions. Of special interest also was the relationship of anomalous and mosaic targets within the same temporal context. Finally, we intended to examine possible complications that may arise due to the increase in the conditions in the primed matching paradigm. Overall, our data do suggest a distinct level of activation for the four completion types, the most prevalent being the global completion, however, the lack of significant main effects for prime types and most test pairs and also the lack of significant interactions between the two factors does not allow us to draw decisive conclusions as to the level of replication and further entangles the interpretation of our data.

It is evident from our results that priming was not observed in all our conditions. Normally same test pairs elicit faster reaction times when preceded by primes with the exact same shapes (Sekuler & Palmer, 1992; van Lier et al., 1995). Our local condition is a sound example of the dysfunction: not only local primes produced slower reaction times when targeting local test pairs, but also they were the slowest across the five prime types. In addition, when considering mosaic targets, the RT levels of all primes where roughly the same. Another important aspect of our data is the fact that the no prime condition sometimes was faster than (local test pairs) or equal (global test pairs) to other conditions. Therefore, any attempt to extract a baseline for priming calculation was unsuccessful (at least when adopting the priming effect equation of the original study)[22]. Finally, occlusion levels were similar to any other priming condition mostly for global test pairs.

The analysis of the data in terms of average RT was the next logical step. Global test pairs produced the only significant difference compared to local anomalous and

[22] For a detailed discussion of the original priming equation see van Lier et al. (1995).

mosaic. Such a result is not surprising. The vast majority of completion research shows that global completions are favored in perception especially as the process runs its course. In our study, SOA's were set at 750 ms therefore representations were tapped after receiving their final form. This explains the fact that although global test pairs were the faster, when global primes targeted anomalous and mosaic test pairs, they elicited the slowest RT's in the entire study. Although the test pair on display is that of an anomalous or mosaic test pair the representations of these completions have been largely discarded or are less strong whilst being marginally available (see also Plomp & van Leuween, 2006).

Moreover, recent visual memory research (Chen, Muller & Conci, 2016) has shown that global perceptual modes are preferred in visual working memory, however, they require more resources in order to be sustained and differentiate themselves from 2D-pictorial representations. In our case, it makes sense that asking the perceptual system to tap into discarded completions hinders even the accessibility of those readily available, therefore increasing memory load and reaction times in behavioral responses. We consider this finding an important indication of the different qualities and processing functions between global and other types of completion. We need to note, however, that these differences do not translate into an inability (of perception) to distinguish between possible completions (de Wit & van Lier, 2002) but rather into an intrinsic versatility with regard to temporal context effects and top down modulation.

We should, now, shift our attention to local primes and test pairs since the failure of local primes to facilitate responses is probably the most unexpected finding in our study. We claim however that this result is not a novelty in the research. The original study by van Lier et al. (1995) did not investigate the prevalence of specific completions but rather the degree that these completions are generated during the completion process. Still, in their study, although all types of completions were generated, only global primes elicited positive priming values. In another important study (Sekuler et al., 1994) global and local primes were tested in direct contrast (although with stimuli of somewhat different properties of the ones presently discussed). The fact remains though that local primes and completions resulted in negative priming (for 300 ms SOA) while occluded and global figures facilitated responses. We regard these findings as an indication that when global completion presence is strong in the completion processes, the rest possible completions may result in negative results in terms of response times.

We believe that the composition of our test pairs may have diluted the pattern of results at least for a portion of the data presently examined and we explain: Due to an addition of an extra test pair (mosaic) in the response targets we had to increase the number of matching test pairs in order to account for all their possible combinations, thus resulting in a rather large number of target stimuli.

At the same time the amount of time between primes increased. It is possible that the abundance of stimuli influenced negatively the distinctiveness between non-dominant completions (anomalous-local-mosaic) while at the same time boosted the global representation additively: an already preferred completion had more chances to be established within the temporal context of our experimental design. Although the typical trend in many priming completion studies was roughly retained (see introduction), the aforementioned factors resulted in a less clear priming effect. We believe, finally, that the prevalence of the no prime in several conditions adds to the previous argument: After a specific point, target stimuli may have lost their valence in terms of shape properties (dots, angles and concaves may appeared to vary less than they should have).

This is a very intuitive hypothesis. Being in a visual environment that contains stimuli which methodically predict the future stimulation should alert the system that paying attention to a preceding stimulus facilitates its future recognition task. However, when this relationship is not as systematic, the system might adopt to not pay attention to the preceding stimulus and save recourses for the main task.

A final point that requires clarification, despite being a technical one, is the increased amount of error rate in our study and the consequent need for data imputation. The typical error rate across several prime matching studies (Sekuler & Palmer, 1992; van Lier et al., 1995; Plomp & van Leeuwen, 2006; de Wit & van Lier, 2002) was around or never exceeded 10 % and rarely were imputation procedures required. Several conditions, such as the mosaic one, had substantially increased error rates, which in our case meant missing data. We consider the above mentioned factors as a possible explanation for the absence of effects at least in the mosaic condition.

Conclusion

The findings in the present study are consistent with global theory predictions in amodal completion and specifically visual occlusion: global test pairs were more readily available to observers. At the same time, anomalous completions seem to behave differently from mosaic ones as we move towards the final stages of completion, since mosaic stimuli require additional resources in order to be restored resulting either in negative or null facilitation effects. Finally, local completions appear to weaken when global completions are firmly established. The initial replication objectives of our study were not fully met since the pattern of results and the occasionally problematic data did not allow us to observe a reliable priming effect. Nevertheless, we believe that the pattern of results is complementary to the original data and a contribution as to the limits of primed matching in completion research.

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Οι Επισκοπικές Αναπαραστάσεις Μερικώς Καλυπτόμενων Αντικειμένων Εμποδίζουν την Προέγερση από τις Τοπικές Πληροφορίες σε Ένα Περίπλοκο Έργο Προέγερσης.

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Περίληψη

Στην παρούσα μελέτη διερευνούμε τους τύπους των αναπαραστάσεων που ενεργοποιούν οι παρατηρητές για ερεθίσματα οπτικής επικάλυψης. Όταν μια επιφάνεια επικαλύπτεται από μια άλλη, θεωρητικά προκύπτουν άπειρες αναπαραστάσεις για αυτή την επιφάνεια. Οι επικρατέστερες είναι οι local (με βάση την καλή συνέχεια των επιφανειών στα σημεία της επικάλυψης) και global (με βάση την αρχή Pragnanz και τη συμμετρία του σχήματος) αναπαραστάσεις, ενώ υπάρχουν ενδείξεις πως και οι δυο ενεργοποιούνται στο γνωστικό σύστημα.

Χρησιμοποιήσαμε το παράδειγμα αντιστοίχισης έπειτα από προέγερση (primed matching) (van Lier, van der Helm & Leeuwenberg, 1995), προσθέτοντας περισσότερα ερεθίσματα στο σύνολο των στόχων που υπήρχαν στις πειραματικές δοκιμές. Οι συμμετέχοντες έπρεπε να απαντούν γρήγορα σε ένα ζεύγος ερεθισμάτων (απαντώντας ίδιο/διαφορετικό) που ακολουθούσε μια σύντομη παρουσίαση ενός προεγέρτη διαφόρων τύπων (local, global, κ.τλ.).

Τα δεδομένα μας δείχνουν ότι δεν υπήρξε προέγερση για κάποιον από τους προεγέρτες, σε αντίθεση με την πρωτότυπη μελέτη, αλλά ότι οι global ολοκληρώσεις των ερεθισμάτων επιηξεργάζοντο πιο γρήγορα από τις άλλες κατηγορίες. Τα αποτελέσματα δείχνουν πως σε σύνθετα σύνολα ερεθισμάτων, οι προεγέρτες χάνουν τη δυνατότητα να διευκολύνουν τη πειραματική δοκιμασία, την οποία το αντιληπτικό σύστημα διεκπεραιώνει με βάση θεμελιώδεις global αναπαραστάσεις.

Λέξεις κλειδιά: οπτική αναγνώριση, επικάλυψη, οπτική συμπλήρωση, προέγερση

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