Steps towards a more naturalistic picture of change blindness – The Influence of Context on Change Detection

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Abstract

How we perceive distinct characteristics as multiple objects in the visual field is not completely clear. The influence of context on visual-feature and variable binding affecting change detection is investigated using the conceptual network model by de Vries (2004). This paper expected that context helps change detection through the implicit memory effect of context, an often-neglected factor guiding attention.

Two change detection tasks examined the effect of context. The in-context condition is expected to support change detection. In the first experiment, in-context is defined as the target item being in its natural position, e.g., changes to a rabbit positioned on the floor would be easier to detect compared to when placed in top location. In the second experiment, in-context, defined as the identity cue and target having the same relative angle to the observer, supposedly supports change detection compared to out-of-context, when cue and target are depicted from different perspectives. The samples consisted of fifty-three (E1) and forty-nine (E2) participants. Dependent variables were change sensitivity d' (Signal Detection Theory) and location accuracy. Independent variables are the manipulation of context (*in-context*, *out-of-context*) and the occurrence of change (*change, no change*).

For the first experiment, a repeated-measures ANOVA found no statistically significant influence of in-context positioning on change detection. For the second experiment, a repeated-measures ANOVA found a statistically significant benefit for in-context trials supporting location accuracy during change detection. This study shows that context influences change blindness. Future studies could examine the impact of other operationalisations of context on change blindness.

Keywords: conceptual network model, binding problem, change detection, visual working memory, contextual cueing

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Change Blindness (CB) is the phenomenon of failing to notice changes in the visual field due to disruption (Rensink, 2005). The effects of CB in daily life such as traffic can be detrimental. CB can help to explain when visual perception fails and how we compensate in the light of excessive visual information (Chun &Nakayama, 2000). CB delivers insights into mechanisms of attention, visual working memory (VWM) and perception and how those are influenced by cues and context (Simons & Rensink, 2005). This paper advances the understanding of context influencing perception and which conditions can help alleviate CB.

This study investigates whether contextual manipulations aid change detection, as context is a crucial factor in scene perception (Olivia & Torralba, 2007). This paper looks at CB using the conceptual network model (CNM) (de Vries, 2004). This advances the theoretical debate about the role of context for CB, strengthens the existing knowledge regarding the importance of context, and delivers additional insights about how context affects binding. First, the background of the CNM is discussed. It explains the relationship between CB, memory, attention and binding. Following this, the connection between the role of context in CB, CNM and binding is described. Lastly, the present study consisting of two experiments is explained.

Literature Review

Capacities of visual working memory

CB is a proxy to learn more about how VWM works to explain how we perceive our surroundings (Simons & Rensink, 2005). Two streams are differentiating the issue: resource-based and slot-based models (Donkin et al., 2016). According to resource-based theories, the iconic memory keeps an image of the scene, which is stored in the VWM. Then this post-change image is compared to the stored pre-change image. Resource-based models allow for flexible storage of scenes, as the number of items remembered is not limited. Opposingly, slot-based theories assume that we only remember a limited number of items which occupy slots in the VWM. The difference is that resource-based theories claim that items are flexibly stored without quantity limitations but with a quality trade-off (Zhang & Luck, 2011). Whilst slot-based theories assume no quality trade-off, the VWM only offers a limited amount of space where items are stored (Zhang & Luck, 2011). The limit is set to three to four available slots in the VWM for items and if items exceed the available slots, performance declines (Awh et al., 2007, Luck & Vogel, 2013).

This paper relies on the CNM (de Vries, 2004), a model closely related to slot-based models. In line with the CNM, there is psychophysiological evidence for a slot-based system, as shape and location are encoded in different subsystems that need to cooperate to form a complete picture (Feldmann, 2013).

Four subproblems make up the binding problem (Feldman, 2013). The two relevant for this thesis are visual feature binding and variable binding. Visual feature-binding refers to how we can perceive and match characteristics uniquely to one object and form an identity (Feldmann, 2013). Variable binding refers to the unknown neuronal explanation of how characteristics are perceived as objects in the visual field (Feldmann, 2013), the connection within identity and between identity and location (de Vries, 2020).

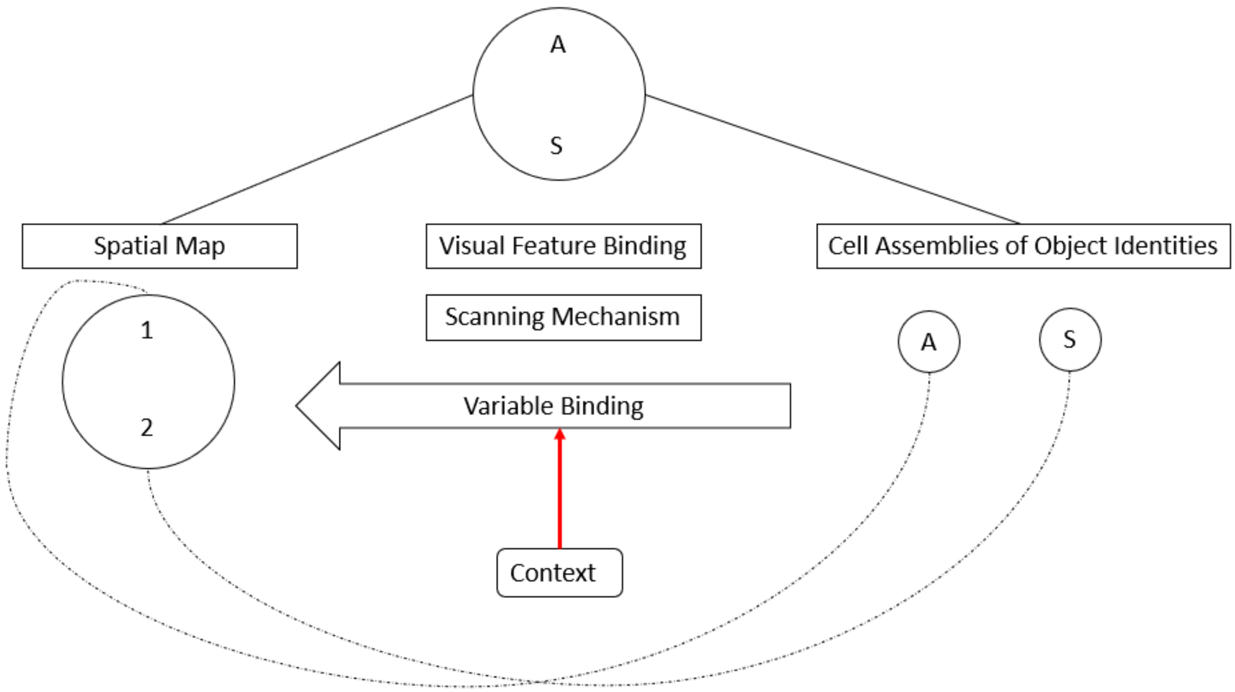
Another reason for employing slot-based theories in this experiment is the presence of noise between frames (Sperling, 1960, 1963). Resource-based theories do not apply here because participants would fail overall to report on changes as more items need storage. Furthermore, Sterling (1963) showed that regardless of how long the stimuli are presented, most participants are only limited to four items. For the resource-based model, no such limit would exist and only quality would be affected. The current thesis investigates how context facilitates binding between identity and location that bind in the CNM.

What is the CNM? How does it explain change blindness?

CB occurs when binding fails, and temporary bindings alleviate CB (Rensink, 2005). Change detection is bound to the capacity limitations of VWM (Pashler, 1988). Slot-based models such as the CNM account for those capacity limitations (Luck & Vogel, 2013). On a functional level, binding is due to the cooperation between attention and working memory capacities (de Vries, 2004). As the CNM describes binding by unifying this functional with a structural perspective of what needs to occur on a neuronal level for binding to happen, it is an excellent candidate for explaining binding (de Vries, 2004). Describing binding from multiple perspectives is necessary as the neural binding problem is usually a collective synonym for four subtypes of the binding problem (Feldmann, 2013, 2016). Figure 1 depicts the CNM by de Vries (2004), including variable and visual feature binding. It shows that, visual-feature binding refers to combining clusters of distinct identity characteristics (e.g., shape) (Feldmann, 2013), so that the identity of an object is perceived (de Vries, 2020). Variable binding refers in this project to the connection between identity and location and if its temporary connection does not reach the critical threshold, binding fails (de Vries, 2020). Within the CNM, the underlying binding by synchrony is dependent on context (de Vries, 2004).

Figure 1

CNM by de Vries (2004)



Note. *Letters* are object identities encoded in cell assemblies; *Positions 1-2:* positioning in spatial map. *Visual Feature Binding* is relevant at the stage when separating object identity and location. *Variable Binding* when perceiving parts as a unified image without losing previous perceived items. Dotted lines resemble temporary bindings between the identity slot and the location slot.

Within the CNM (de Vries, 2004), objects have an identity representation, which consists of neurons accounting for distinct characteristics of items. A cell assembly of neurons contains these representations that can flexibly represent the characteristics of objects. The features of an object determine which combinations of cell assemblies are activated and form a temporary memory trace representing the object's identity. Then attention is allocated to the object and it is stored in VWM (de Vries, 2004). Attention plays a crucial role in detecting a change, as attention must be allocated to the object (Chun & Nakayama, 2000). This idea of memory traces builds on Hebbian learning whereby neurons that are activated together form a union that expedites the activation of one another (Hebb, 1949). The Tanzi-Hebb learning rule takes this further by describing that forming this synaptic connection corresponds to learning (de Vries, 2020) and eases forming a temporary memory trace over time (Brown et al., 2021). On a structural level, external input is redundant once enough neurons are excited.

The CNM encodes location slots in a spatial map (de Vries, 2004). In this map, excitation patterns for all distinct positions in the visual field hold the spatial information which are activated and reach VWM. Object perception in space needs a temporary binding between cell assemblies representing identity and excitation patterns of location. From a functional perspective, once those temporary bindings between identity and location reach a critical threshold, the combination of identity and location will receive attention and reach VWM (de Vries, 2004). Therefore, the pre-change image will be stored to be compared to the post-change image so that people can report on the change in a CB paradigm.

Change detection can be helped with different experimental configurations. For example, the effect of double occurrence occurs when there is a second identical object whereby excitation of the first item is recycled. This aids excitation for the secondary item, through which changes are more easily detected because the identity of an item participates in multiple excitation loops (Braam, 2021; de Vries, 2004; Gerresheim, 2021; Manchev, 2021). However, the specific role of context has not been examined yet. Therefore, the present study focuses on context and how different contextual manipulations influence change detection and binding. The present study zooms into context in Figure 1 that is located between the cell assemblies of item identities and location.

The Present Study – Experiment 1

Context, in its various possible definitions like position, depth and orientation, influences visual perception (Kapadia et al., 1995). In this study, we use two context manipulations in two experiments. The first one relies on position manipulation and the second one on perspective. Experiment two is introduced after experiment one.

Matching contextual information in learning and retrieval, supports recall (Smith & Vela, 2001). Contextual factors need thorough investigation regarding their influence on visual perception as they may influence the use of slot and resource-based encoding (Donkin et al., 2016). The natural context of a scene alleviates change detection (Zimmermann et al., 2010). According to Kaiser et al. (2015) items positioned in a natural context are grouped which alleviates strains on VWM. So, the six positions in the present study would be grouped into pairs of two for each level. The CNM is heavily reliant on context. Context is the main denominator for binding as the shared context builds a network of cell assemblies temporarily connected to the object identities (de Vries, 2004). Context has a supporting role when activated at the same time for cell assemblies for two items, so when they have a shared context (de Vries, 2020).

Context guides visual cognition through the implicit memory of context (Chun & Jiang, 1998). Often attention is only seen as bottom-up and top-down control and context is often neglected (Awh et al., 2012). Implicit memory effect refers to the unintentional learning of environmental information of context affects attention, which supports the retention of visual information between disruption and previously encountered specific contexts guiding attention (Chun & Nakayama, 2000; Awh, 2012). This notion is related to statistical learning, according to which learning of patterns occurs implicitly (Fiser & Aslin, 2001), whereby participants are supposed to implicitly connect previous experiences and learn about the in- and out-of-context layout (Chun & Jiang, 1998) that then helps to see changes. This implicit learning is differentiated by psychophysiological evidence from its use and is more efficient than explicit learning (Spaak & de Lange, 2020).

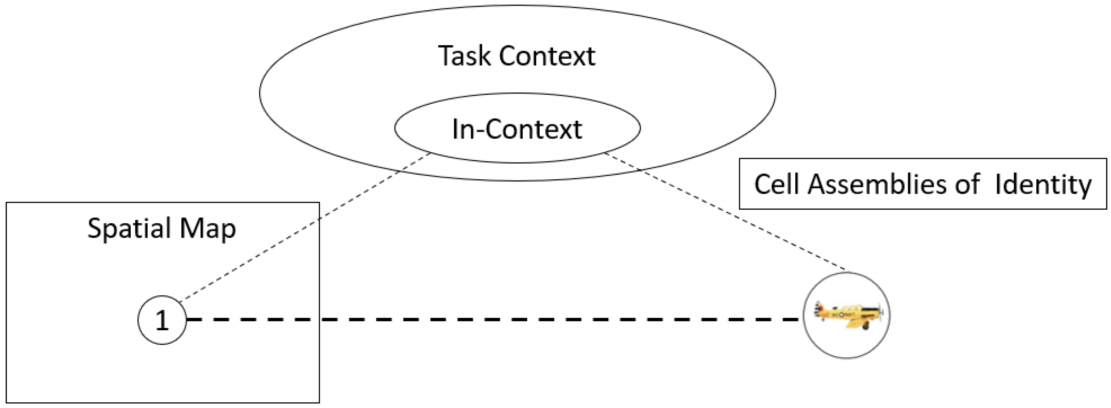
For the position manipulation of context, there are two potential explanations. On the one hand, objects that are out-of-context are attention-grabbing and may make it easier to detect changes (Bubic et al., 2008). On the other hand, according to Chun & Nakayama (2000), attention is determined by past experienced stimuli in the light of their context that formed implicit memory traces, which are reactivated by contextual cueing supporting perception in the current task. Therefore, objects in-context make it easier to detect changes as expectation and contextual cues aid object perception (LaPointe et al., 2013). Expectation and following attention interchangeably support top down and bottom-up processing which helps VWM (Gordon et al., 2019). As we remember, attention allocation to a target depends on the activation of enough neurons within an assembly. The memory for the natural position of objects is supposed to support reaching the threshold for memory , dispatching attention and helping the person to see changes in the visual field (de Vries, 2004). Binding can happen in any form of shared context but formerly encountered arrangements of objects and positioning act as determining factor (Zimmermann et al. 2010).

In this study, the matching natural context hypothesised to support binding through the implicit memory effect of context, whereby excitation happens within the shared connection for context. The memory of where the object commonly occurs is supposed to help the excitation required for binding and therefore help change detection in this paradigm. Context as part of the connection of object identities supporting the strength of formed temporary memory traces and concurrent binding for multiple objects (de Vries, 2004). They participate in several excitation loops, always have a connection to the neurons forming the context and facilitate recognition (de Vries, 2004). Figure 2 depicts the role of context within the CNM. Context, a network of cell assemblies that is part of the item identity, feeds back into the cell assembly and spatial map to reach the threshold and ease recognition (de Vries, 2004). There is still a contextual influence for out-of-context items as these are in the experimental context. However, the effect of context is supposedly greater for in-context target items due to the implicit memory of context.

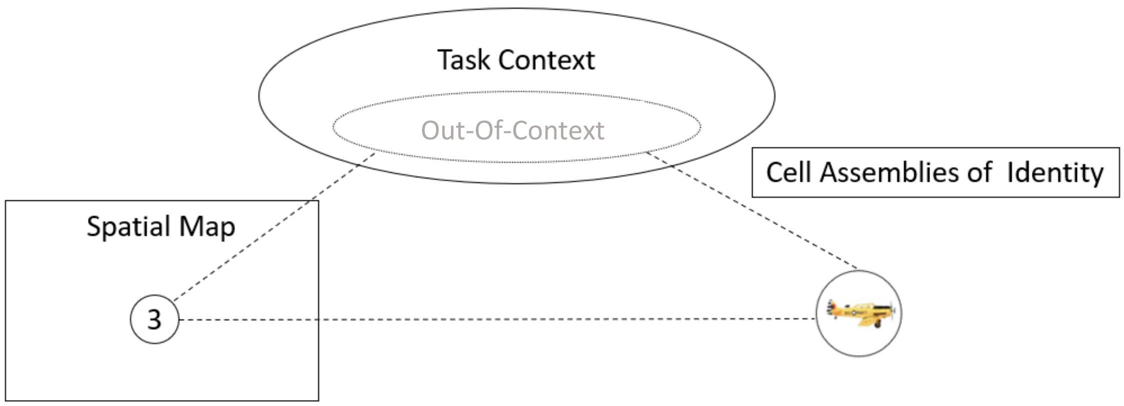
Figure 2

Role of Context within the CNM in Experiment 1 2a) in-context condition as one item located in-context (airplane in an elevated position) and 2b) out-of-context condition

2a)



2b)



Note. *1*: left-upper location, *3*: left-lower location. The change in an in-context target item is aided by memory for context, indicated by dense dashed line for binding between location and identity and therefore change detection is improved. Whereas change in an out-of-context item (2b) no memory effect is expected and therefore change detection is not helped, indicated by the standard dotted line. The object still occurs within the context of a trial, as resembled here by the dotted line around greyed-out “out-of-context”.

To summarise, the present study is the first step in examining the context within perception and visual memory by utilizing the CNM in a CB paradigm with contextual manipulations. In the first experiment, participants have better change detection (*change sensitivity d'*) and location accuracy if a target item is in its natural context. The second experiment, explained after experiment one, expects that the in-context condition, defined as the identity cue and target item depicted from the same perspective (e.g., an identity cue shown from the same angle as the target), will be detected more easily. For both experiments, changes in objects positioned in-context are easier perceived and located because of the implicit memory for context.

Method – Experiment 1

Participants

Fifty-seven participants were recruited with the local student participant pool for psychological research. Students received 0.6 credits for participation, counting towards their curriculum. Volunteers recruited from the personal circle of the author did not receive compensation. For privacy reasons and an error, age was not collected for the participants, but given that most were early university students, the mean age was probably between 18 and 29 years. Gender was collected for fifty of the fifty-seven participants. Thirty-two were female and eighteen were male. For adequate statistical power, approximately 50 participants needed to be recruited (Brysbaert et al., 2019). The Ethics Committee of the Faculty of Behavioural and Social Sciences at the University of Groningen approved this study.

Design

As dependent variables, change sensitivity d’ *(*d' prime*)* was calculated according to signal detection theory (Wickens, 2002) and location accuracy, quantifying whether the participant clicked on the correct item that changed. Change sensitivity d' has the advantage that it assumes that the components of decision-making under uncertainty, the mean of people correctly identifying the changes and wrongly perceiving a change (noise), has a normal distribution. Based on the strategy bias of the participant, either being more lenient or too strict in deciding whether they saw a change or not. The d’ prime shows the sensitivity to detecting this change and is calculated as d’ prime = z (hit rate) – z (1-false alarm rate) for in- and out-of-context. Half a trial was subtracted from extreme, perfectly correct scores (max(score) – 0.5*1/24). Half of a correct trial was added to accuracy scores of zero by applying (min(score) + 0.5*1/24). The context is whether the object is in its naturally occurring location. Context has two levels *in-context* and *out-of-context*. This experiment is a 2 (natural positioning: *in-context* versus *out-of-context*) x 2 (sameness: *change* versus *no change*) repeated measures ANOVA.

Stimuli

Stimuli for the experimental were retrieved from Konkle et al. (2010) and Konkle et al. (2012). Only stimuli showing exemplar changes were chosen as state changes are more difficult to see (Braam, 2021; Gerresheim, 2021; Manchev, 2021). Stimuli were sorted into six categories, one per location slot, with four pairs each – traffic, food, toys, animals, office and household objects. The description of categories and items within those categories are in Table 1. Table 1 shows the natural in-context condition. Natural means objects placed in a lifelike manner (Zimmermann et al., 2010), where they would be expected in the visual field (i.e., a tent positioned on the floor (lower) instead of atop (upper)). Table 2 shows the presentation times.

Table 1

Object Categories for Position

Level	*Category*: Image Pair of Objects
High	*Traffic*: Hot air balloon, Propellor Airplane, Jet, Street Sign
	Household items: Wall Clock, Horn, Wall Sconce, Ceiling Lamp
Middle	*Office*: Sharpener, Calculator, Puncher, Clipper
	Food: Grapes, Pizza, Bread, Muffin
Low	*Toys*: Ball, Backgammon, Pacifier, Toy Rake
	Animals: Rabbit, Cow, Turtle, Dog

Table 2

Presentation Times

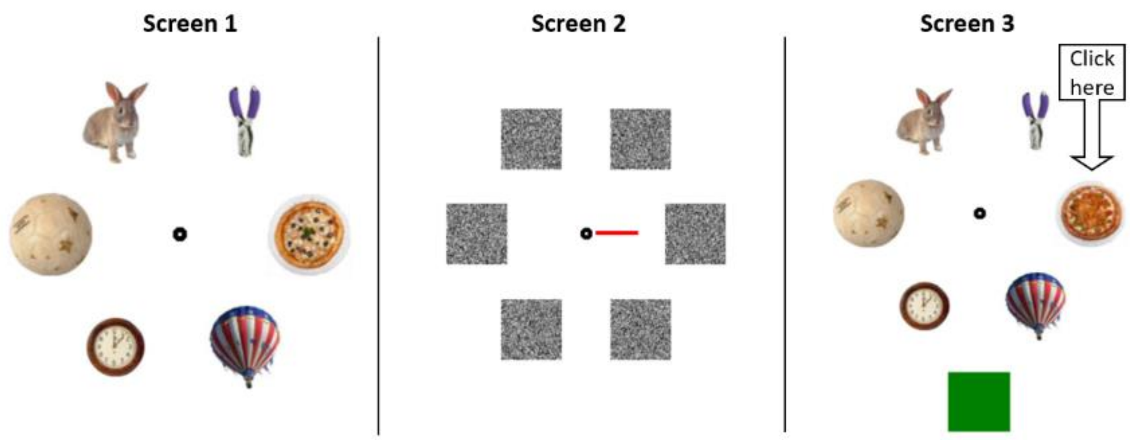
Phase	Presentation time
Blue Square	Until the participant clicks to start the trial
Pre-change image	1200ms
Mask before cue appears	50ms
Mask with cue	200ms
Mask between cue and post-image	750ms
Post Image	Until participants indicated a change or no change

Procedure

A depiction of a trial is in Figure 4. Contrary to prior studies (Braam, 2021; Gerresheim, 2021; Manchev, 2021), items were arranged in a hexagon shape so that each contextual level (high, middle, low) had two potential locations. Distance does not affect perception, as objects had the same distance to each other. For example, changes in items closer together may be easier detected. Due to the difficulty, the task included a location cue. The experimental task consisted of six items because four to five is the limit of items kept in working memory and having slightly more excludes the possibility that participants just remembered the array seen but complied with the slot-based theory used here (Luck & Vogel, 2013). A mask between trials prevents storing the seen arrangement in iconic working memory. Items that naturally occur on the floor and would occupy the two lower positions (e.g., pets like a rabbit). Objects that would naturally occur on elevated surfaces (e.g., office supplies like sharpeners) appear in the middle two positions. And objects that would be up and out of reach at the two top positions (e.g., airplane). Each position can only be occupied by one item from each category to avoid showing items with a shared visual concept. This avoids eliciting activation of the same cell assembly by accident, and experimental manipulation is reduced to contextual positioning, so that shared characteristics cannot explain results, as similar features compete for storage (Manchev, 2021). The experiment draws from constructed proto-trials that fulfil the condition that items from the same category cannot occur together with each position having the chance to be occupied equally often with an in- and out-of-context item from each category.

Figure 4

Example Trial of an in-context change



The participant completed the experiment online on their private laptop or computer. First, participants received a brief explanation of the study in Qualtrics (Qualtrics, Provo, UT, USA., https://www.qualtrics.com, 2022). Following this, Participants received an explanation for the experiment and a consent form. After giving consent, three screens guided participants through examples of the task. The explanation sheet informed the participants about the aim of understanding the underlying mechanism of VWM but did not explicitly mention the interest in how context influences VWM. Participants were asked to detect changes between the first and third screens, interrupted by a mask on the second screen. After the explanation, OSWeb launched (Mathôt et al., 2012; Mathôt & March, 2022), a website where they completed the experimental task.

First, they completed two blocks consisting of six practice trials each. During the practice trials, participants received feedback. The fixation point turned green when they correctly indicated a change and no change and red if they made a mistake. This way, participants learnt how to do the task but not explicitly about the manipulation and hypothesis. Each of the six practice trials was one of the possible combinations of experimental variables. At the end of the experiment, participants were asked whether they used a strategy to remember. The actual experiment consisted of four blocks with 24 trials each. The experiment consisted of 96 trials. Obtaining consent, reading the instructions and doing the task took approximately 20 minutes.

Analysis Plan. This experiment is a 2 (natural positioning: in-context versus out-of-context) x 2 (sameness: change versus no change) repeated measures ANOVA. Dependent variables were change sensitivity and location detection. Mean and standard deviation for accuracy measures was calculated as preliminary analysis. A repeated measures ANOVA was used to compare performance between in-context and out-of-context trials.

Analysis of the data was done in R (v4.1.3; R Core Team, 2022) using the packages psycho (V0.6.1; Makowski, 2018) psych (V2.2.5; Revelle, 2022), data.table (V1.14.2; Dowle & Srinivasan, 2021), ggplot2 (v3.3.5; Wickham, 2016), plotrix (V3.8-2; L. , 2006), afex (V1.0-1; Singmann et al., 2021), emmeans (V1.7.0; Length, 2021), ggpubr (V0.4.0; Kassambra, 2020), rstatix (V07.0; Kassambra, 2021) and ez (V4.4-0; Lawrence, 2016).

Results – Experiment 1

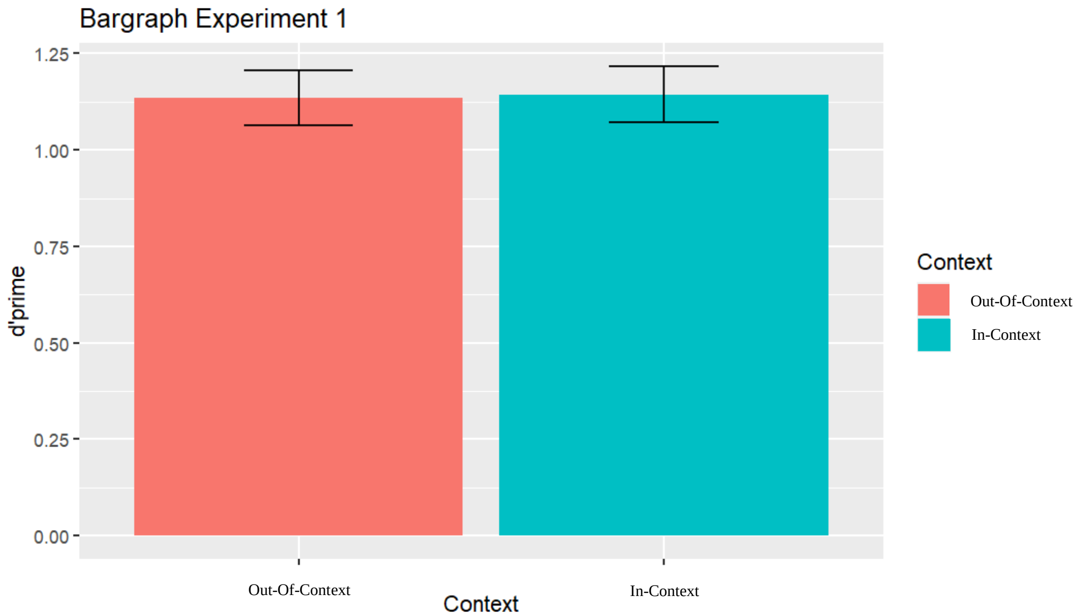
The assumption check and preliminary analysis are in Appendix A. An exploratory analysis regarding the change over time can be found in Appendix B. The assumption check did not reveal any violation. Four participants were removed for obviously low-quality responses (Appendix A). The preliminary analysis indicates a very small difference in favour of the in-context condition for change sensitivity (Δ mean d’prime = 0.02) and for out-of-context for location accuracy (Δ mean location accuracy = 0.03). The main analysis presents further investigation.

Main Analysis

Change Sensitivity. The analysis assessed whether d’primes are associated with context. Figure 7 indicates that in-context does not aid change detection compared to out-of-context for d’primes (F (1,52) = 0.04, p = .835).

Figure 7

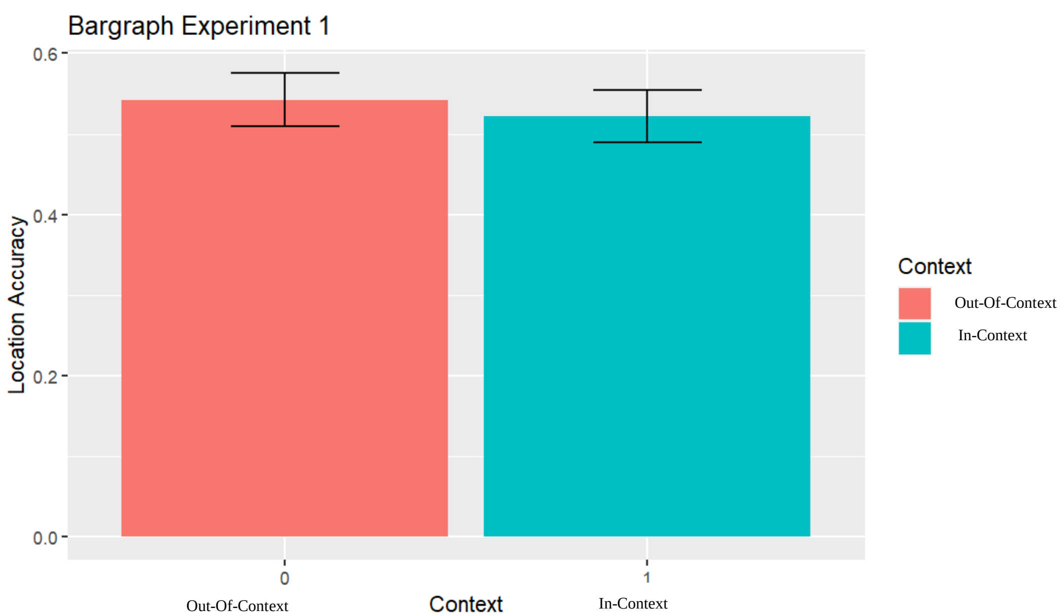
Bar graph Experiment 1 for d'prime



Location Accuracy. It was assessed whether context helps to detect the correct location of the change. Figure 8 indicates that out-of-context may aid change detection, however, error bars overlap indicating insignificance. The results were indeed insignificant for the main effect of context (F (1,52) = 2.80, p = .100). Context does not aid location accuracy in a change detection task.

Figure 8

Bar graph Experiment 1 for Location Accuracy



Strategy

The majority of 25 participants indicated that they were not using any strategy. Some participants focused on unique characteristics like colour and orientation and tried to remember if those changed. The third favoured strategy was remembering all objects or looking at the centre to divide focus evenly across all objects. Three used a mix of different strategies. An overview of strategies can be found in the Table 4 the full list of all comments is in the Appendix E.

Table 4

Overarching Strategy Themes

Strategy	Count
1. None	25
2. Paying attention to unique characteristics like colour and shape	11
3. Focus on centre and/or remembering all objects	13
4. Looking at and remembering only three-four objects	2
5. Using the red line as indicator	3
6. Mix of 3 and 4	2
7. Mix of 3 and 5	1

Preliminary Discussion - Experiment 1

The first experiment did not support the hypothesis. The natural in-context positioning of an object did not help change sensitivity or location accuracy. For location accuracy, participants performed slightly better in the out-of-context condition but not at a significant level. Contrary to LaPointe et al. (2013), in-context situations did not guide expectation of where objects should be positioned and did not improve change detection. It also contradicts Zimmermann et al. (2010) and Kaiser et al. (2015), who found that change in natural scene context is improved compared to non-natural scene context. Yet, Zimmermann et al. (2010) used reaction time, a different performance measure, as the outcome variable. And although Kaiser et al. (2015) used a similar manipulation, they employed four stimuli that formed a pair of two and the two items were semantically related (i.e., showing sink and mirror). In general, this does not necessarily mean that context does not support change detection but that the type of operationalisation in this study was not supportive. As later on discussed, there are other ways of operationalising context.

Here, although not significant, there is a tendency towards the out-of-context manipulation alleviating CB for location accuracy. According to Bubic et al. (2008), objects that are out-of-context are unexpected and attention-grabbing. An exploratory analysis investigated whether participants improved in change detection and location accuracy over time. For change detection, there was no significant difference observed. For location accuracy, participants improved over time, but not specific to one context manipulation. Participants may have learnt over time where images were to be expected, to which image an item could change, and the positioning of objects may not be influential. Several comments mentioned that participants noticed to which image a target item could change into (i.e., a black rabbit would only change to a white rabbit and vice versa). Some participants guessed that the hypotheses relate to image positioning, which may have influenced their judgement.

The Role of Context in Experiment 2

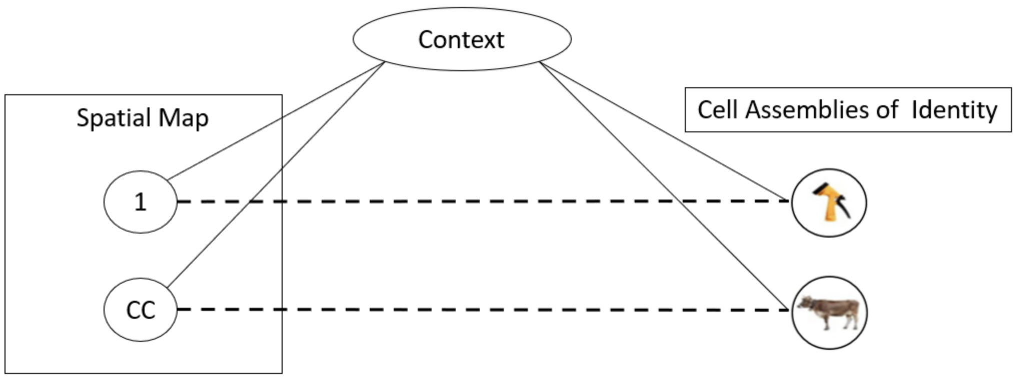
The second context manipulation is perspective, similarly to orientation (Zimmermann et al., 2010). This experiment examined whether a matching perspective would influence change detection. When we look at an object, this perspective depends on our relative position as observers which is another type of context that influences change detection. Detecting this relative position as the viewer supposedly activates a context for the memory traces of an item identities of the photographed objects. This shared contextual activation should support the binding of identity and location, which helps in remembering the pre-screen and detecting the changes (de Vries, 2004).

Experiment 2 uses a different type of cue to implicitly activate a shared context. In the in-context condition, an identity cue and target item are photographed from the same perspective. Figure 3 shows this process. This expectation is similar to Holman & Gîrbă (2019), with the difference that they examined the match in orientation between a descriptive sentence succeeded by a change trial where the described orientation matches or differs. They found that if the described orientation matches the orientation of the changing target, participants reacted faster. Given that the CNM (de Vries, 2004) also applies to word processing, it is expected that a similar effect occurs in the current experiment. An identity cue either has the same perspective as the target item or a unique one. Identity cues are equally often the object to the right and the left of the target item. The second experiment expected that when identity cue and target are in-context, so when they are shown from the same perspective, attention is directed to the object of the same perspective and aids change detection.

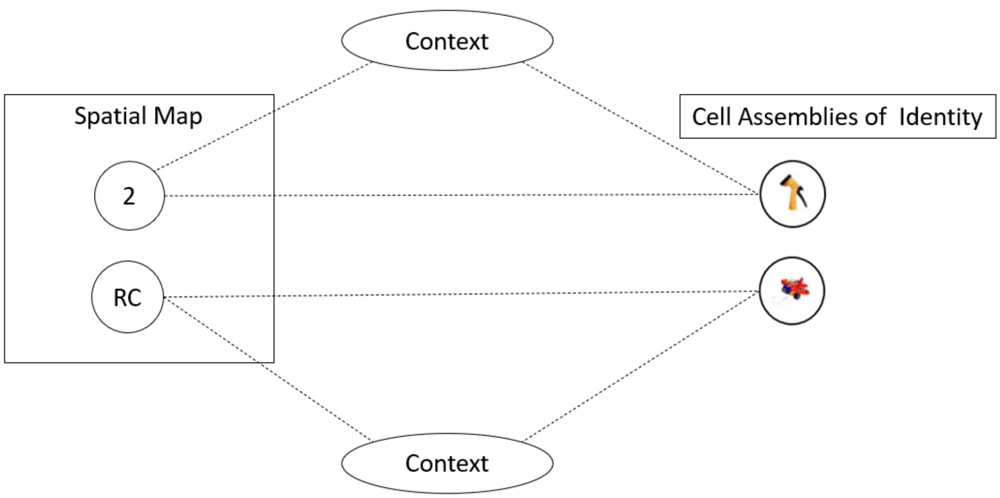
Figure 3

Role of Context within the CNM in Experiment 2 2a) in-context condition as target item and identity cue have the same perspective (both are centrally oriented) and 2b) out-of-context condition as target item and identity cue are shown from different perspectives (target from a central perspective cue from right-angled perspective

2a)



2b)



Note. *1*: position upper-middle, *2*: position upper left, *C*: centrally oriented identity cue; *RC*: right-angled identity cue. Between 2a and 2b the observer context differs as the orientation is different. Therefore, in 2a given that the perspective is the same, identities share a context and binding is eased. In 2b, the context differs as the perspectives differ and binding is not eased.

Method - Experiment 2

Participants

Fifty-two participants were recruited with Prolific (www.prolific.co, 2022). For adequate statistical power, approximately 50 participants were needed (Brysbaert et al., 2019). Participants received a compensation of 3 euros compensation. The experiment was open to people aged between 18 and 29 years to match the age group of the first experiment. Data from 26 females and 26 males was collected. The average age was 22.92 years (*SD* = 2.83). The Ethics Committee at the Faculty of Behavioural and Social Sciences at the University of Groningen approved the study.

Design

Independent variables were sameness, with two levels of whether a *change* or *no change* occurred, context, defined as whether the identity cue and target have the same perspective (*in-context*) or not (*out-of-context*) and cue, whether it was the item in the clockwise to the *left* or the *right* of the target item. Dependent variables were change sensitivity d' and location accuracy again. The correction for change sensitivity d' was adjusted to 48 trials. The experiment is a 2 (cue and target perspective align *in-context* versus do not align *out-of-context*) x 2 (sameness: *change* versus *no change*) x 2 (identity cue is the object in the *clockwise* or *anti-clockwise* direction of the target) repeated-measures ANOVA. Outcome variables were *change sensitivity* and *location detection*.

Stimuli

The stimuli were retrieved from Konkle et al. (2010) and Konkle et al. (2012). Table 3 lists all six categories and object pairs. The central objects are all unique, whereas all angled objects occurred as original and flipped from a right and left angle (e.g., a left-angled rabbit also occurs as a right-angled rabbit). Figure 5 shows the context arrangements for understanding, 5a shows which position combined with image angle is defined as in-context (e.g., images with a central perspective are in-context in the upper and lower middle position), and 5b shows the opposite for out-of-context (e.g., images with a left-angled perspective are in an out-of-context position in the middle lower and right lower position). The difference to experiment one is that the six categories are subdivided into central and angled objects.

Table 3

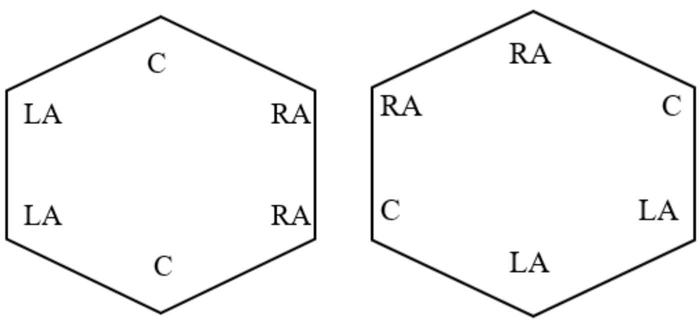
Object Categories for Perspective

Category	Perspective	Object pairs
Fauna & Flora	Central	Cow
		Sea Star
	Angled	Rabbit
		Animal Skull
Office	Central	Folder
		Bell
	Angled	Stapler
		Sharpener
Vessel	Central	Beaker
		Spray bottle
	Angled	Hourglass

		Basket
Tools	Central	Nozzle
		Brick
	Angled	Spatula
		Ladder
Transport	Central	Street cone
		Parking Meter
	Angled	Train wagon
		Locomotive
Toys	Central	Balloon
		Ball
	Angled	Model Ship
		Toy Plane

Figure 5

a) Perspectives in-context b) Perspectives out-of-context



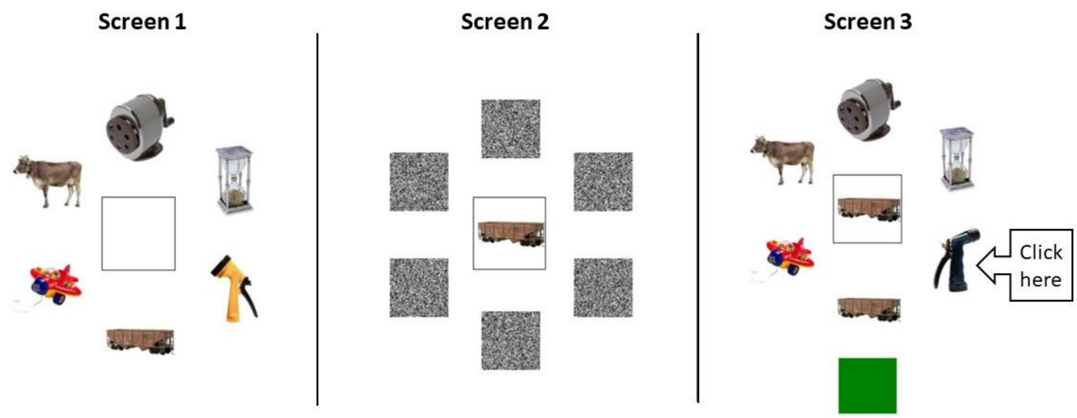
Note. *LA*, *RA*, *C*: angles of the items, i.e., central, left-angled and right-angled. A) Shows which positions are defined as in-context for each perspective. B) Shows which positions are defined as out-of-context positions.

Procedure

Similar to Experiment 1, the experiment draws from premade proto-trials for each combination. Each category appears equally often in each location as in- and out-of-context. And the identity cue is equally often to the left and right. Objects were defined as in-context when the target item changed while it appeared in its correct position and shared the perspective with the cue. Correct position here means that central objects appear in one of the two middle positions, right-angled images on the right side in one of two positions and left-angled objects on the left side (see Figure 5). There are again two positions for each contextual manipulation, here perspective. The arrangement in the second experiment coincides with previous studies (Braam, 2021; Gerresheim, 2021; Manchev, 2021), fitting the manipulation of perspective better. Figure 6 shows an example of a trial.

Figure 6

Example Trial with perspective



The second experiment was an online experiment as well. Participants received an explanation of the study that referred to examining the underlying functioning of the VWM but did not mention the role of context. Similarly, to Experiment 1, participants were shown an explanation of three trials, directed to OSWeb, guided through practice trials and the actual experiment and asked about their strategy. In contrast to Experiment 1, this experiment consisted of two blocks with 48 trials each, yielding 96 experimental trials. Participants were informed about their accuracy and the remaining blocks between blocks. Including obtaining consent, giving instructions and doing the experimental tasks, the study took approximately 20 minutes to complete.

Analysis Plan

A preliminary analysis was performed. A repeated-measures ANOVA was used to compare performance between in-context and out-of-context. Analysis of the data was done in R (v4.1.3; R Core Team, 2022) using the same packages as in Experiment 1.

Results -Experiment 2

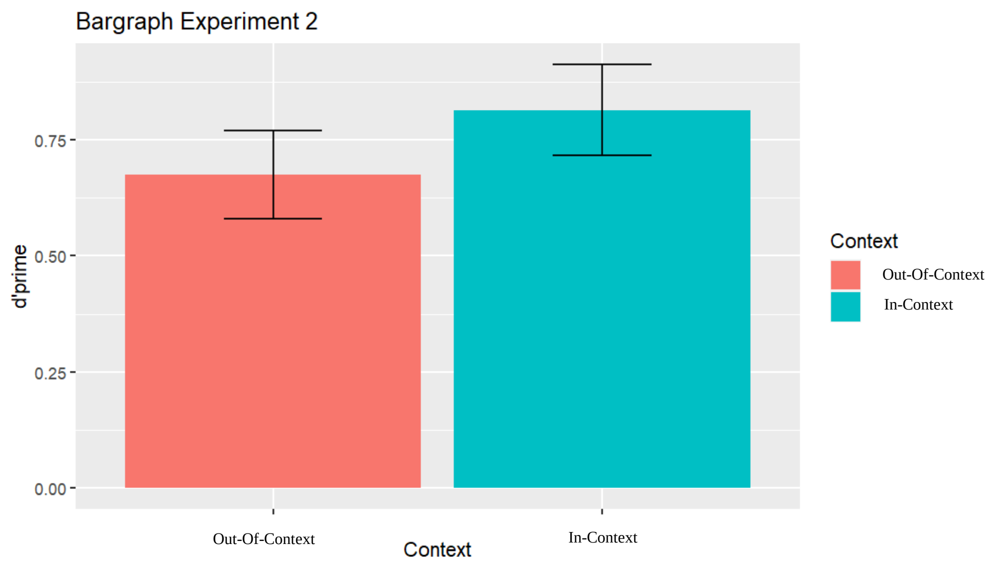
A preliminary analysis can be found in Appendix B. Three participants were removed for low quality responses. Appendix D includes an analysis of the improvement over time. No significant effects were found. Though, change sensitivity d' hints that participants improved over time for in-context but not for out-of-context. For location accuracy it shows the opposite pattern indicating that participants may have performed better in the in-context condition than in the out-of-context condition. The assumption check indicates a violation of normality. Additionally, a Wilcoxon Sign Rank test is performed.

Main Analysis

Change Detection. Figure 13 indicates that there is a better performance in the in-context condition however it does not indicate significance. There was no significant better performance for in-context compared out-of-context (F (1,48) = 2.68, p = .108). Context, here defined as coinciding cue angle does not help change detection. There was no interaction between context and cue direction (F (1,48) = .04, p = .845). As normality seemed violated, a Wilcoxon Signed Rank test was performed that was not significance (W = 764.50, p = .132).

Figure 13

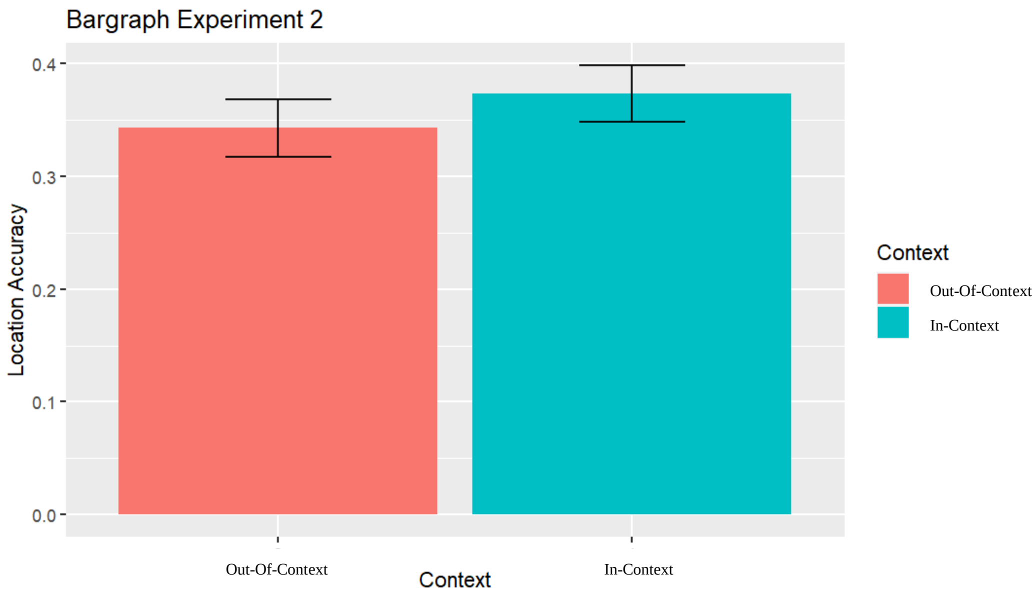
Bar graph of d'primes of experiment 2



Location Accuracy. Figure 14 indicates that there may be a better location accuracy for the in-context condition, as expected, but it does not indicate significance. Location accuracy was approaching significance (F (1,48) = 3.95, p = .053). Again, a Wilcoxon Signed Rank test was performed which is significant (W=609.5, p = .049). Context seems to aid location accuracy within this change blindness paradigm.

Figure 14

Bar graph of Location Accuracy



Strategy

Participants were asked which strategy they employed during the experiment. The majority of 17 participants did not indicate using a strategy. The majority focused on the centre and/or trying to remember all of them used by ten people. The second favoured strategy was focusing on colour and or shape and seeing if something changes there. Six people used a mix of strategies. Appendix F shows all strategies. Eleven people mentioned that they experienced the experiment as particularly challenging.

Table 5

Overarching Strategy Themes

Strategy	Count
1. None	17
2. Focus on centre and/or remembering all objects	10
3. Paying attention to unique characteristics like colour and shape	10
4. Rehearsing out loud what was seen	1
5. Only look at limited amount (3-4 items)	6
6. Focusing on objects around cued object	3
7. Used a camera	1

8. Mix of 2 and 5	2
9. Mix of 2 and 3	3
10. Mix of 3 and 5	1

Preliminary Discussion - Experiment 2

Due to violations of assumptions, results included nonparametric tests. Location accuracy showed a significantly better result for the in-context condition but change sensitivity d’ did not. In the in-context condition, the target object and identity cue were photographed from the same angle. The identity cue supports binding for location accuracy as cue and target item is in the same perspective. Here perspective similarly to orientation, which influences VWM and helped change detection (Holman & Girba, 2019). The improvement over time was examined, no overall improvement or specific to the context manipulation was seen here.

The hypothesis is supported for location accuracy as in-context supports CB. The perspective is determined by the relative position of the observer to the object. In the CNM (de Vries, 2004), this is encoded within the network for context which here supports and strengthens the binding of identity and location, needed to remember the pre-screen and detect change. Change detection is supported as the scanning mechanism is engaged from an item with the same perspective in the first screen, followed by the cue matching the perspective. This probably feeds into the excitation loop and supports binding and change detection. Comparable to Holman & Girba (2019), the in-context perspective supports binding via a top-down mechanism that sensitises the observer to relevant changes. Hence, perspective is a relevant feature indicated by the perspective of the identity cue and target item. However, the significance could be due to chance and future studies could replicate and validate results. Future experiments can examine how different operationalisations of context but also natural positioning and perspective impact change detection, which is discussed in the general discussion.

General Discussion

This study examined whether context influences change detection and location accuracy with two experiments operationalising context in two ways. The first study found no significant effect of in-context manipulations helping change detection. There may be an indication that the out-of-context manipulation supports location accuracy. The second study showed that in-context items supported the hypothesis on location accuracy but not on change detection. Though mixed results, there is support for context helping the memory trace and excitation pattern to reach the critical threshold to detect changes, allowing the participant to remember the previous screen and identify changes in the second screen coinciding with the CNM (de Vries, 2004). However, the exact direction of the effect may differ between operationalisations.

The context seems to be influencing change detection in different ways. For positioning, the explanation of items being out-of-context and thereby sticking out may be more likely (Bubic, 2007). This way, out-of-context manipulations may help to detect changes quicker because of better encoding and grabbing attention (Bubic, 2018). There may be other factors influencing contextual learning, such as identity. Object identity influences transferring the learnt to another context. Jiang and Song (2005) found that experiments with mixed identity configurations (e.g., shape and type) may hinder this transfer. The second experiment partially supports the implicit learning context by guiding top-down attention to the in-context items for location accuracy (Chun & Jiang, 1999).

The experiments examined two different operationalisations of context. The first experiment relied on a relatively weak manipulation, which may not have been strong enough to produce the expected effect to the participant. The manipulation of the second experiment was less dependent on perceiving the image as an entire scene. The second experiment may have been more successful as it was similar to orientation, and the effect of matching orientation helping change detection has been shown before (Holman & Gibra, 2018).

Strategies

In both experiments, participants favoured focusing on unique or attention-grabbing characteristics like colour or shape. Secondly, they attempted to only focus on a limited number of items. Some explicitly mentioned that participants intuitively tried to keep three to four objects in mind, similar to chunking (Kaiser et al., 2015). According to Luck and Vogel (2013), this is the maximum number of items we can keep in mind at once. Interestingly, some participants found the identity and location cues distracting when they were supposed to help. Future studies could examine the differences between those cues when seen as supporting or distracting.

Limitations & future directions

In an exploratory analysis, it was evaluated whether there were differences between high, middle and low items. Two out of the three combinations were significant. However, the difference between high and middle context items and the interaction between the position manipulation and context was not significant, indicating that the contextual manipulation was not prominent enough. Future studies could focus on finding stimuli that distinguish better between middle and high contexts or employ a background for a better scene perception. A pilot study can establish which items participants judge as occurring naturally high, middle and low position.

The first experiment may benefit from a conceptual replication by changing the trial structure. Here the target item was either in-context or out-of-context and changed or it did not. Positioning of the objects surrounding the target occurred randomly and only the occurrence of object categories and context of the target item was controlled which makes this a rather weaker manipulation. Another study could be more restrictive and, for example, define out-of-context as there being only one object out-of-context and the rest being in-context and vice versa. Future studies may benefit from operationalising context in various ways and examining the influence on change detection. In the second experiment, the angles of objects may not have been correctly perceived and may not have been distinct enough. Other studies have addressed the influence of various levels of saliency on change detection and binding contextual information (Qiu et al., 2022). Change sensitivity d’ and location accuracy complement each other as variables. Given the mixed results and low statistical significance, it is necessary to replicate the significant and insignificant results.

Additionally, this was an online cognitive experiment that required attention and memory engagement. Participants may lose engagement quicker, as they completed the experiment at home. And it is not possible to prevent camera recordings but may be made more difficult by restricting the response time. One participant admitted that they used their phone camera to record and detect differences. Due to those reasons, the results may have been different in the lab.

Lastly, there are papers indicating that exclusively slot- or resource-based models accommodate each other. Donkin et al. (2016) propose that people can switch and mix between resource and slot-based encoding strategies when the number of items that need to be remembered is unpredictable. However, there is more that influences VWM than just set size as Donkin et al. (2016) highlight accommodating context in those models. Also, Brady & Alvarez (2015) found that participants showed similar struggles with the same trials and item amount, showing that there is more that influences change detection than just the number of items and referred to the global statistics of the screen.

There are several ways to define context, for example, spatial context and temporal context (Brady & Alvarez, 2015). For example, change detection decays when objects completely disappear or reappear in a different spatial location grasping spatial context (Brady & Alvarez, 2015). Temporal context causes the similarities between objects to be stored which supports change detection since we encode items in relationship to each other (Brady & Alvarez, 2015), so the experience from, for example, previous trials influences the expectation for the current trial. Lastly, the global statistic of a screen changes can be defined as context and examined in its influence, i.e., when in a screen with more left-angled items, one changes to a different angle.

These global statistics of the interplay between position and perspective are modifiable, which when aligned with natural context, support change detection (Zimmermann et al., 2010). The present study was more focused on single context types. Manipulations in coming studies may extend the natural context and include manipulations of the background such as colouring that supports the implicit perception of the positioning. For example, when using the image of an airplane the sky could be coloured blue. On the contrary, it may be interesting to see how a non-matching background may influence. Future studies could examine how different context operationalisations combined influence change detection.

Conclusion

This thesis tested whether context aids change detection. The context was defined in two ways and investigated in two separate experiments. The first experiment examined natural context and indicated that out-of-context positioning may be better support for change perception, though insignificant. However, the second one was only significant for change detection and indicated that the identity cue photographed from the same angle and in-context manipulation helped location accuracy, but not change sensitivity. Overall, the influence of context and especially the direction of the influence depends on the operationalisation of context. In line with previous research, experiment 2 found that perspective influences change detection. In line with previous research, the influence of natural positioning is ambiguous. In conclusion, no conclusive evidence was found for the first set of manipulations of context influencing change detection in a change blindness paradigm. However, this study gained valuable insights regarding the influence of context and its various operationalisations. Future studies should build on the findings in this study and advance our understanding of the influence of context on attention and memory.

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Appendix A

Assumptions and preliminary analysis for Experiment 1

Preliminary Analysis

The no-change trials were removed from the location accuracy analysis as those are irrelevant for the research question. Furthermore, one participant was removed as they declared in the strategy section (see below in main analysis) that they did not try and their data will not be used their data. Four other participants were removed as they did not try to do the task, which is indicated by a perfect score for either change or no change trials and a score of zero for the respective opposite trials. The sample size for experiment 1 is 52.

Table A1, Figure A1 and A2 give a first sense of what the data looks like. For d'prime it indicates that there seems to be no difference between in- and out-of-context. However, change detection is slightly better for out-of-context. For location accuracy, participants are better at indicating no-change trials. Within change trials, participants identify the change location more accurately in the out-of-context condition.

Table A1

Descriptive Statistics of Experiment 1

Condition	Mean of d'primes (SD)	Mean of Location Accuracy (SD)
In-context	.90 (.65)	.51 (.50)
Out-of-context	.88 (.64)	.54 (.50)

Note. Variable *same* was integrated into the d'primes as part of the false alarms and was removed for the analysis of Location Accuracy as there is only possible correct location in which we are not interested.

Figure A1

Histogram of d'primes

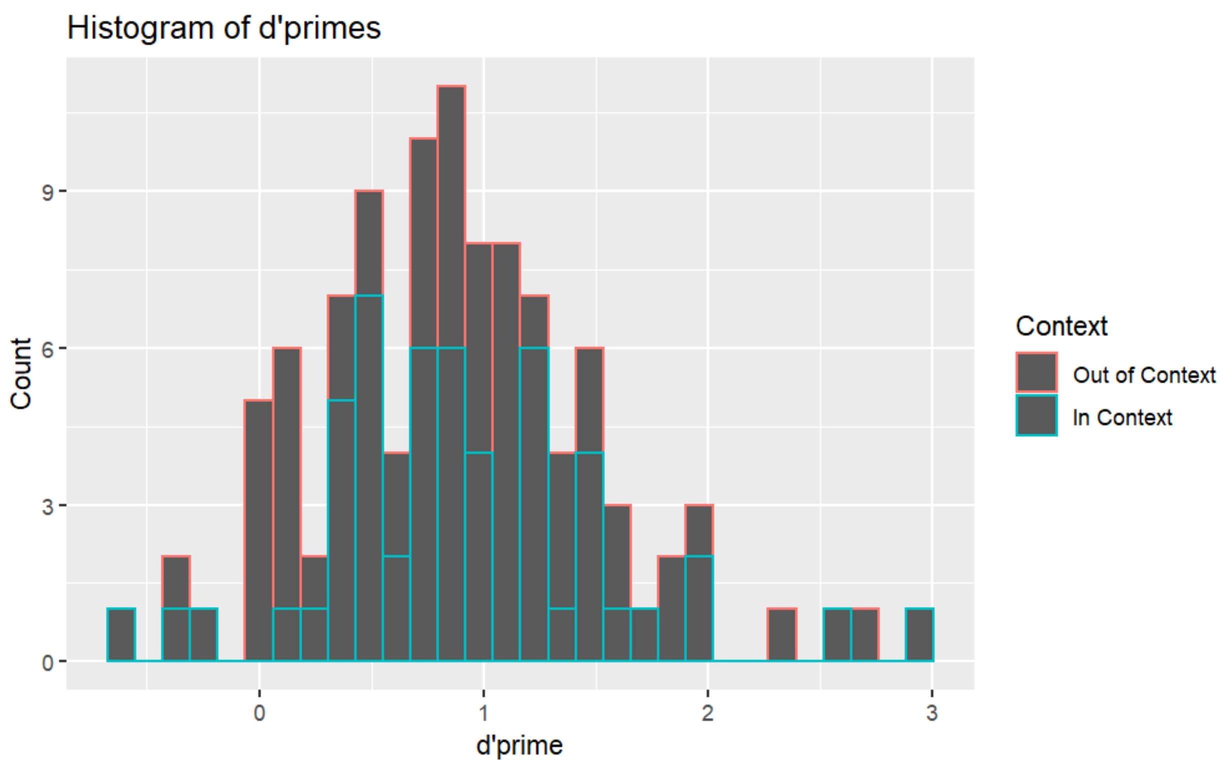
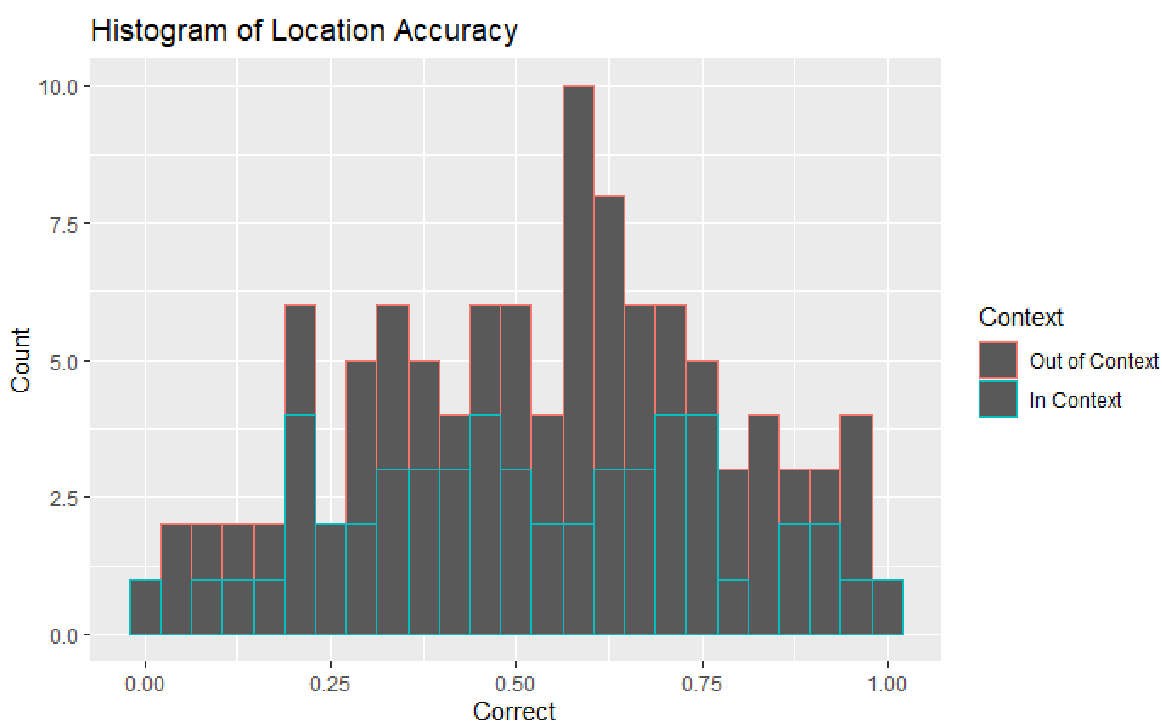


Figure A2

Histogram of Location Accuracy



Assumption Checks

Independence of Observations. The design ensures independence of observations as every participant participated in the experiment once and therefore every participant was linked to only one d'prime and location accuracy score.

Test of Sphericity. As d'prime and location accuracy only have two levels each (in- and out-of-context) compound symmetry is not an issue here and Mauchly's test of sphericity is not included.

Multivariate Normality. The QQ plots in Figure A3 and A4 show a minor violation of normality, more so for Location Accuracy. There are no outliers in location accuracy. There are four outliers within the d'primes but they are not extreme. According to Verma (2015, pp. 55), Shapiro Wilks is suitable for a sample size of around 50 participants however is extremely sensitive. Shapiro-Wilks shows no violation of normality for d'primes or location accuracy, see Table A2.

Table A2

Shapiro-Wilks Test

	dprime		Location Accuracy	
	W	p	W	p
Out-of-context	.961	.089	.968	.176
In-context	.967	.163	.979	.516

Figure A3

QQ plot of d'primes by context

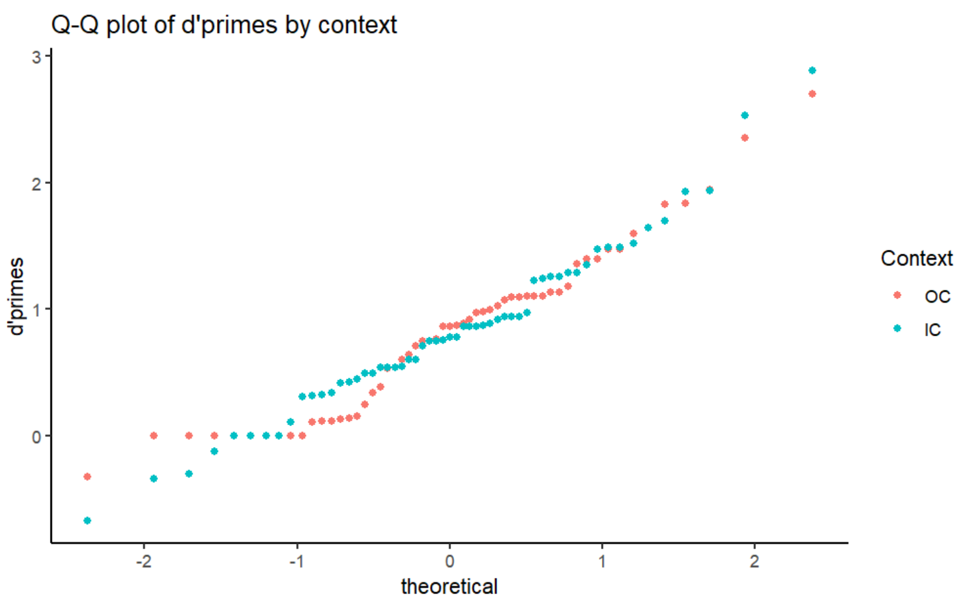
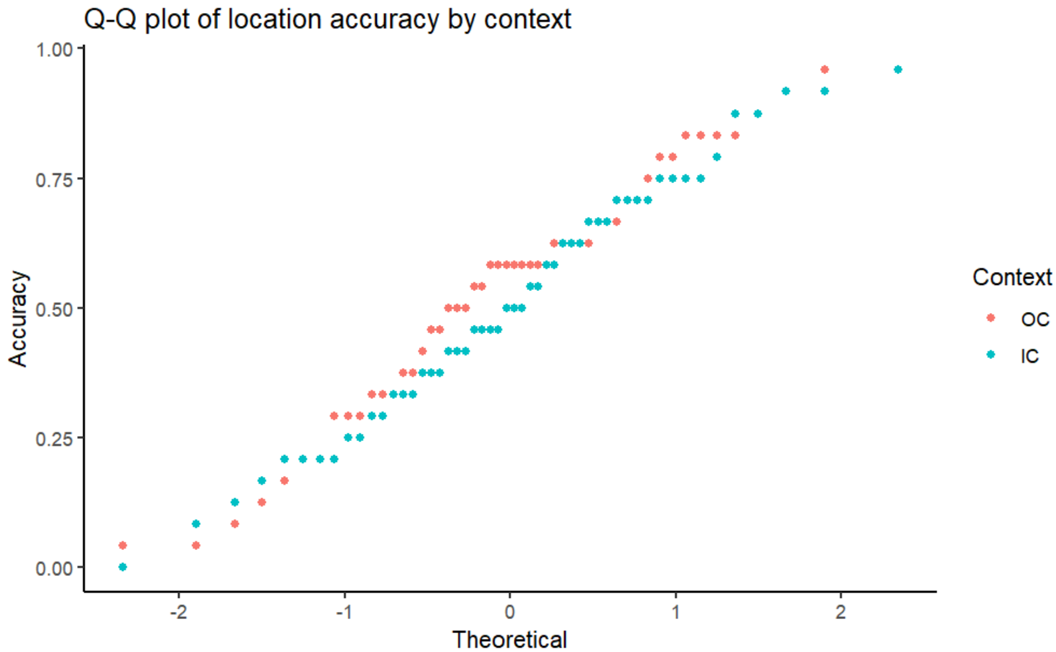


Figure A4

QQ plot of location accuracy by context


Q-Q plot of location accuracy by context
Accuracy
1.00
0.75
0.50
0.25
0.00
-2
-1
0
1
2
Theoretical
Context
OC
IC

Appendix B

Assumptions and preliminary analysis for Experiment 2

Preliminary Analysis

For the second experiment, one person was deleted as they used a camera according to their comments. Another two were deleted because they did not do the task, indicated the same way as in Experiment 1. This leaves a sample size of 49.

Table B1 and Figure B1 and B2 give again a first impression of what the data looks like. For d'prime it indicates that there may be a better change detection for the in-context condition. For location accuracy, participants are better at indicating the change in location in-context trials. Here as well the location accuracy is better in no-change trials, so a better indication of those trials compared to change trials.

Table B1

Descriptive Statistics of Experiment 2

Condition	Cue direction	Mean of Location Accuracy (SD)	Mean of d'prime (SD)
In-context	Anti-clockwise	.38 (.48)	.82 (1.03)
	Clockwise	.37 (.48)	.94 (1.13)
Out-of-context	Anti-clockwise	.33(.47)	.80 (1.02)
	Clockwise	.35 (.48)	.74 (.92)

Note. Variable *same* is integrated into the d'prime of the primes analysis and was removed for the analysis of Location Accuracy as there is only one possible correct location in which was not of interest.

Figure B1

Histogram of d'primes

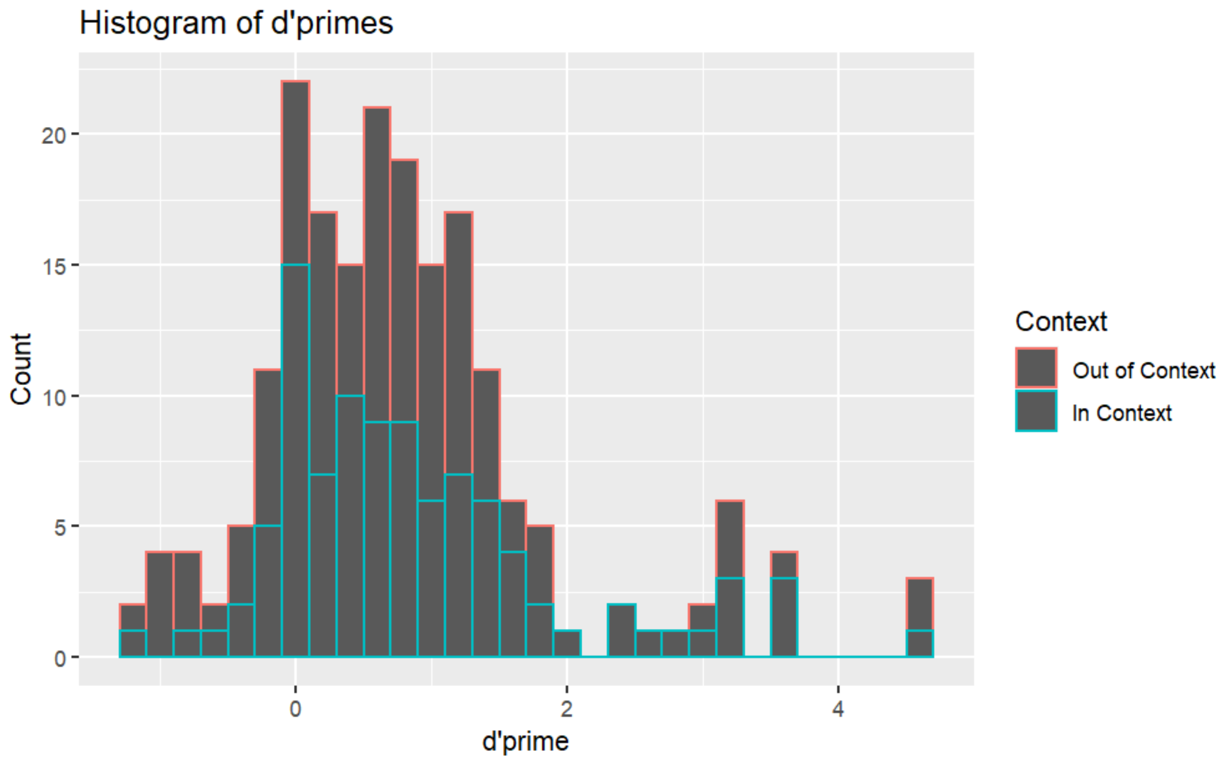
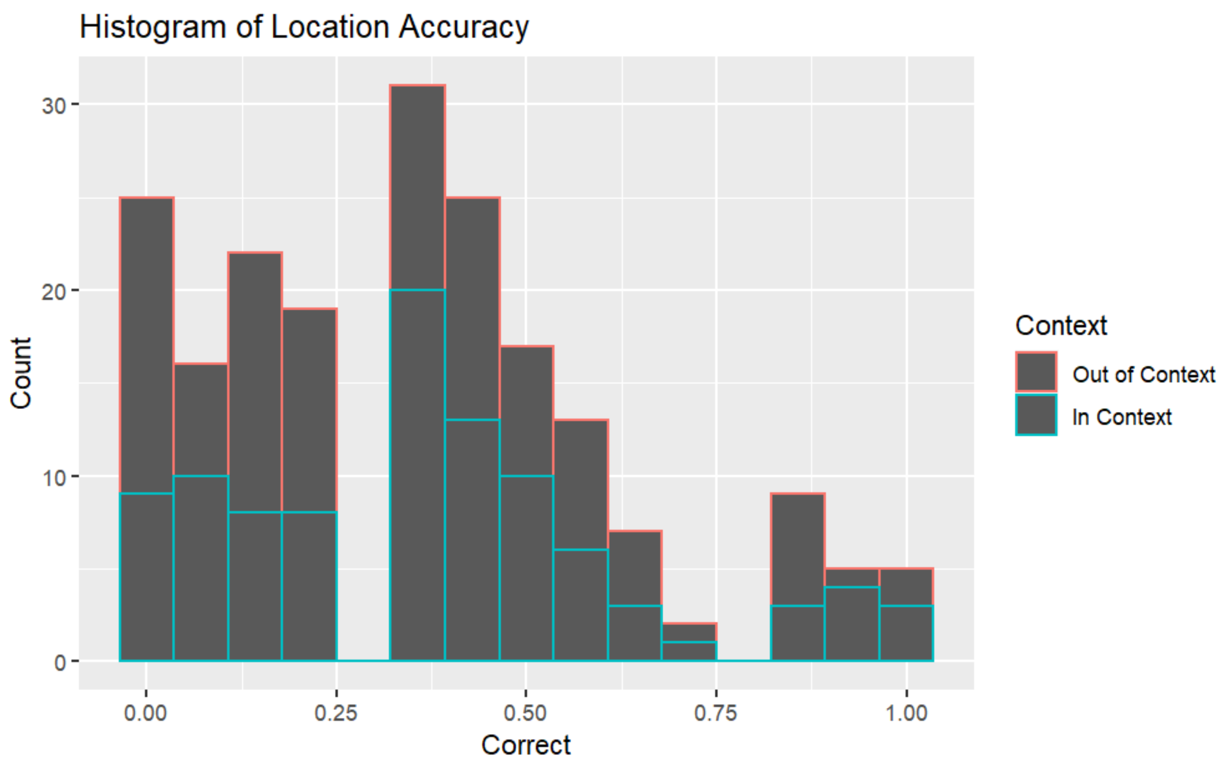


Figure B2

Histogram of Location Accuracy



Assumptions

Independence of Observations. Independence of Observations is ensured by design as every participant participated in the experiment once and therefore is only linked to one d'prime and location accuracy.

Test of Sphericity. As d'prime and location accuracy only has two levels each (in and out-of-context, change and no change trials, cue direction clock and anticlockwise) compound symmetry is not an issue here and Mauchly's test of sphericity is not included.

Multivariate Normality. Figure B3 and B4 show a minor violation of normality. There are no outliers in location accuracy. There are around 14 outliers within the d'prime but they are not extreme. According to Verma (2015, pp. 55), Shapiro Wilks shows a violation of normality for d'primes and location accuracy. Shapiro Wilks is extremely sensitive and suitable for smaller sample sizes of 50 or less, this experiment has slightly more. However, additionally, to the repeated measures ANOVA, a Wilcoxon Signed Rank Sum will be performed due to violations.

Figure B3

QQ plot of d'prime

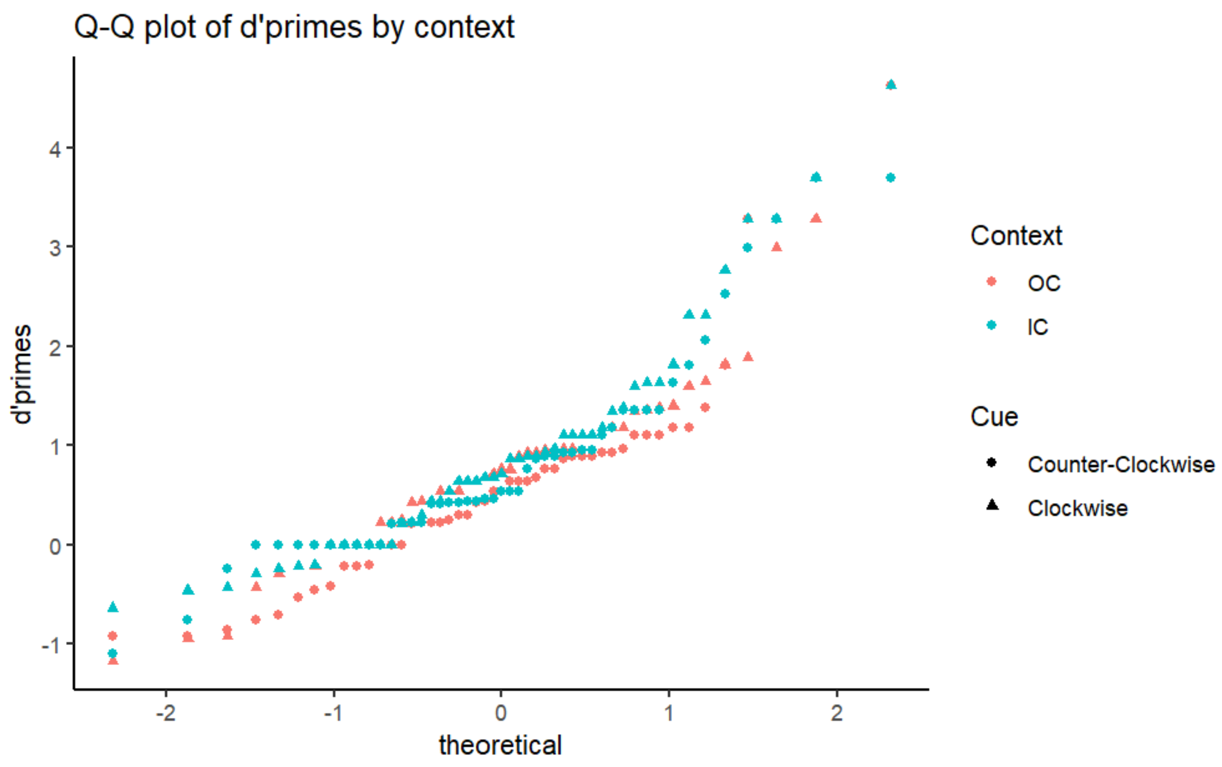
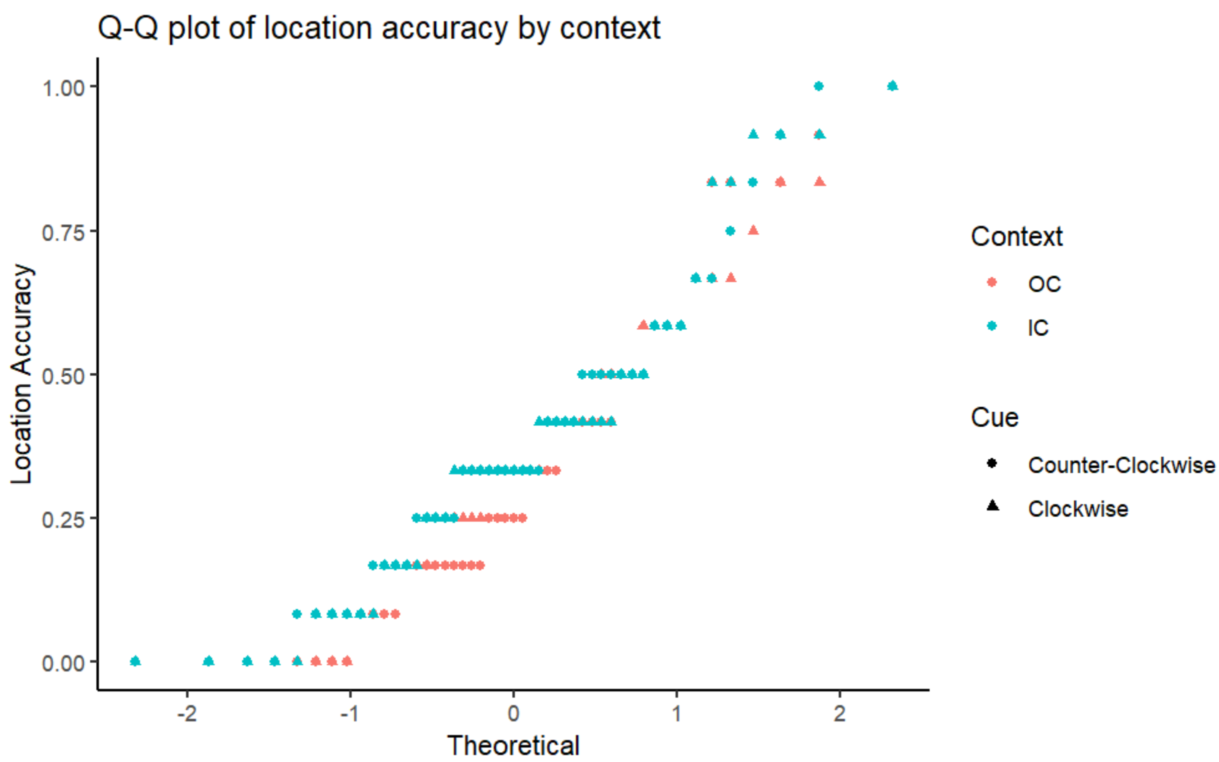


Figure B4

QQ plot of Location Accuracy


Q-Q plot of location accuracy by context
Location Accuracy
1.00
0.75
0.50
0.25
0.00
-2
-1
0
1
2
Theoretical
Context
OC
IC
Cue
Counter-Clockwise
Clockwise

Appendix C

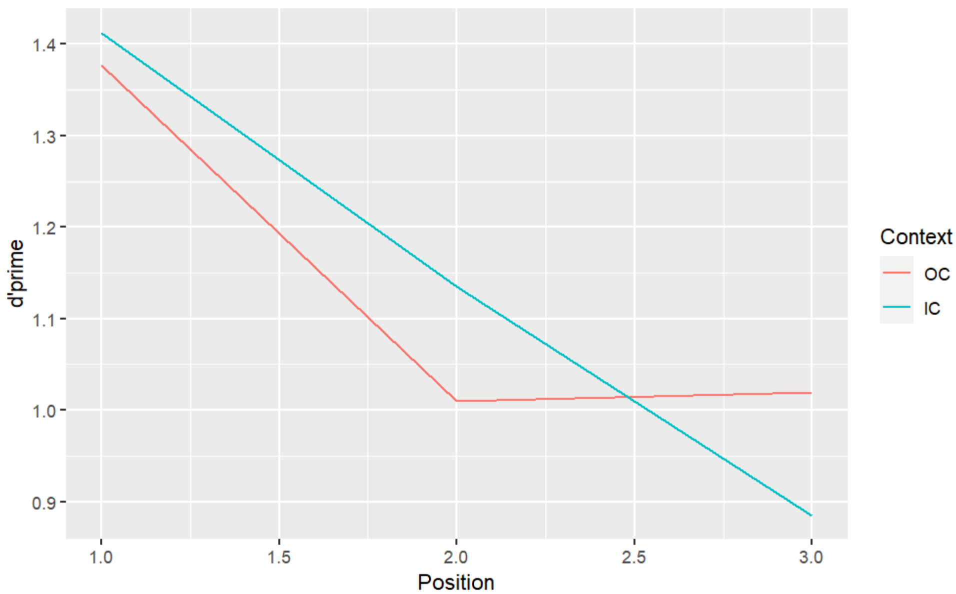
Exploratory Analysis Experiment 1

Position Manipulation

Change detection. Figure 9 indicates that there may be a main effect of position as well as an interaction between context and position. It was evaluated whether there was a difference in change detection between positions (high, middle, low). The main effect of position was significant (F (1.76, 89.90) = 8.99, p < .001, η^2G = .030) but the interaction between position and context was not (F (1.97, 100.29) = .58, p =.558). There is a significant difference between the low and middle positions (*mean difference* =.343, p = .029) and low and high positions (*mean difference* =.122, p < .0001) but not between the middle and high positions.

Figure C1

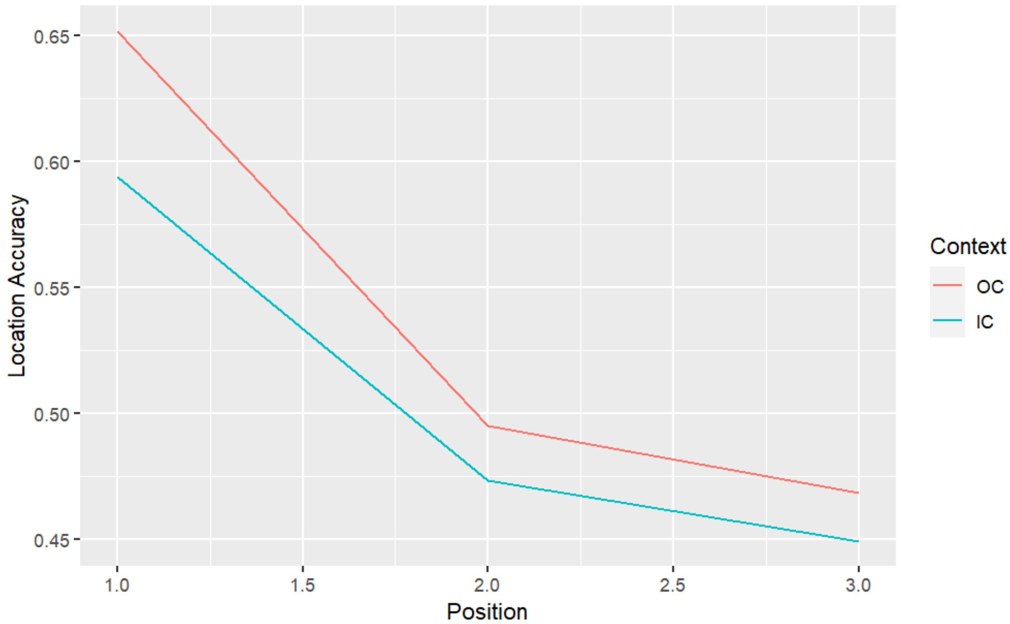
D'primes of overall position preference



Location Accuracy. Figure 10 indicates that there seems to be a difference between positions and sameness of screens as well as an interaction between them. There is a significant difference again for position (F (1.96, 107.95) = 22.71, p < .001, η^2G = .053) but none between the interaction of context and position (F (1.90, 104.63) = 1.32, p = .271). There is a significant difference between low and middle context (*mean difference* = .079, p < .0001) and low and high context (*mean difference* = .093, p < .0001).

Figure C2

Location Accuracy of position preference

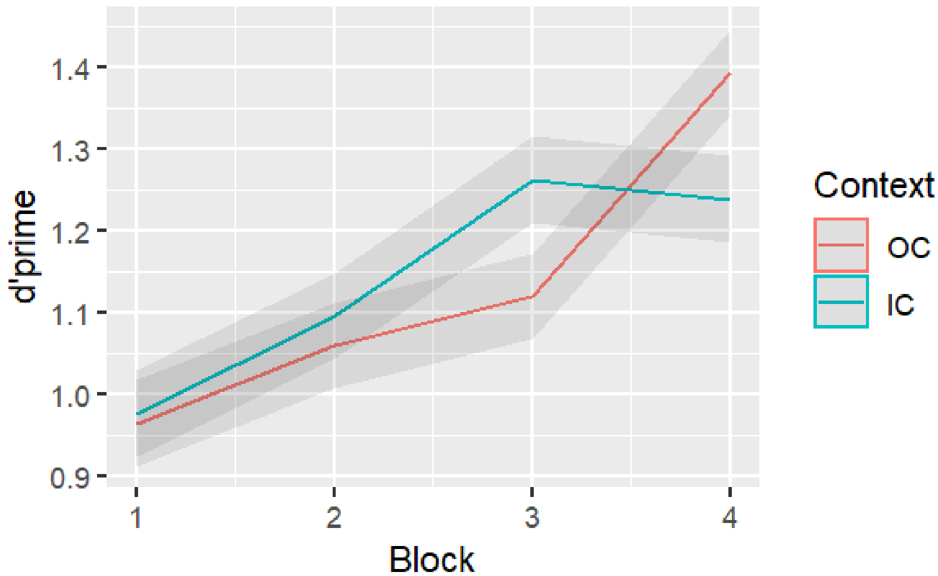


Effect of Time

Change detection. Figure 11 indicates that change detection over time improves. Interestingly, there seems to be a performance decline for in-context objects and a performance improvement for out-of-context performance in block 3. The repeated measures ANOVA, though shows that there is no significant difference between blocks however results are approaching significance (F (2.66, 135.84) = 2.29, p = .088). There is no interaction between context and time (F (2.90, 148.09) = .52, p = .661).

Figure C3

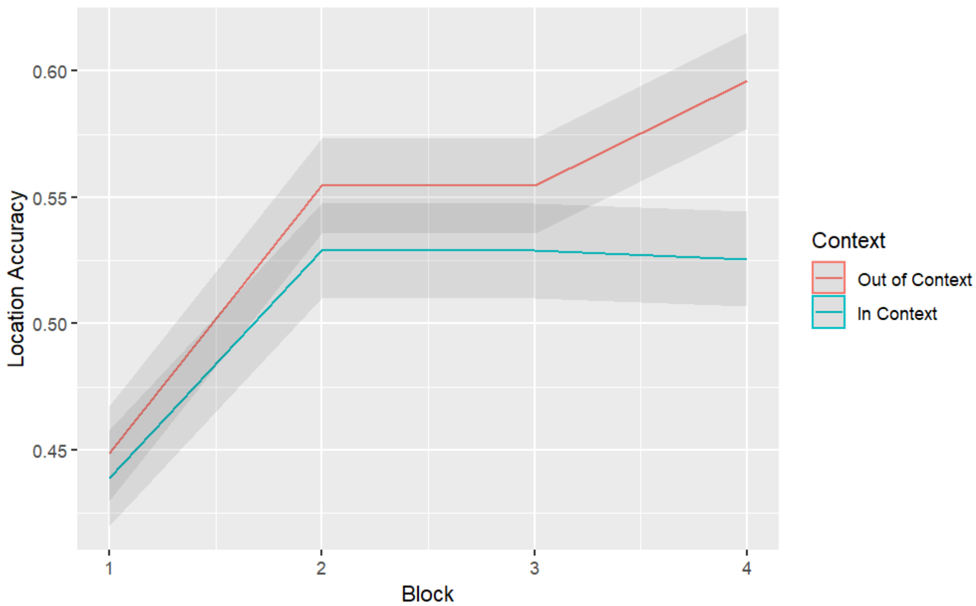
D'primes over time



Location Accuracy. Figure 12 indicates that participants got better over time in localising the change. After block three, participants seemed to perform better in the out-of-context condition than in the in-context condition. The results are significant for the main effect of blocks or time (F (2.89, 147.59 =6.66, $p < .001$, $\eta^2G = 0.025$) but not for the interaction between context and time (F (2.90, 150.59 = 2.90, $p = .572$). The differences are between Block 1 and 2 (*mean difference* = -.098, $p = .009$), Block 1 and 3 (*mean difference* = -.098, $p = .016$) and Block 1 and 4 (*mean difference* = -,117, $p = .003$).

Figure C4

Location Accuracy over time



Appendix D

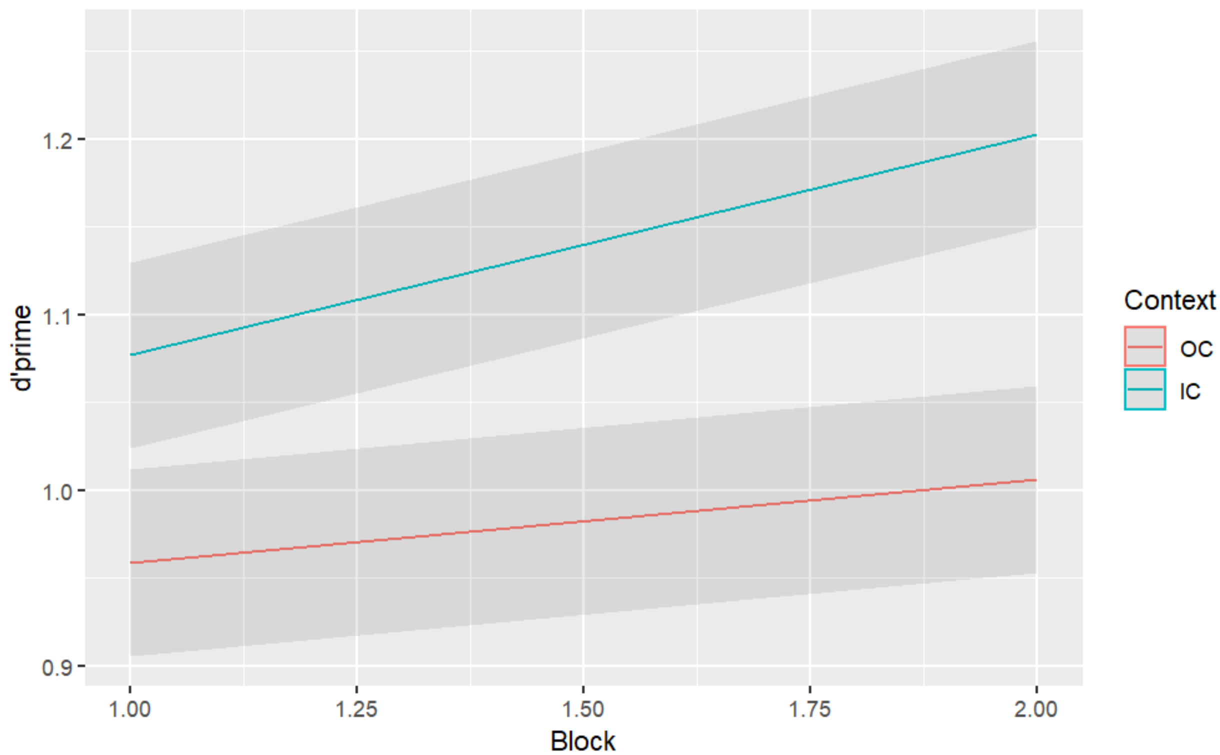
Exploratory Analysis Experiment 2

Effect of Time

Change Detection. Figure 15 indicates that change detection improves over time. The repeated measures ANOVA though shows that there is no significant difference between blocks (F (1, 48) = .410, p = .524), as well as there is no interaction between context and time (F (1, 48) = .670, p = .419).

Figure D1

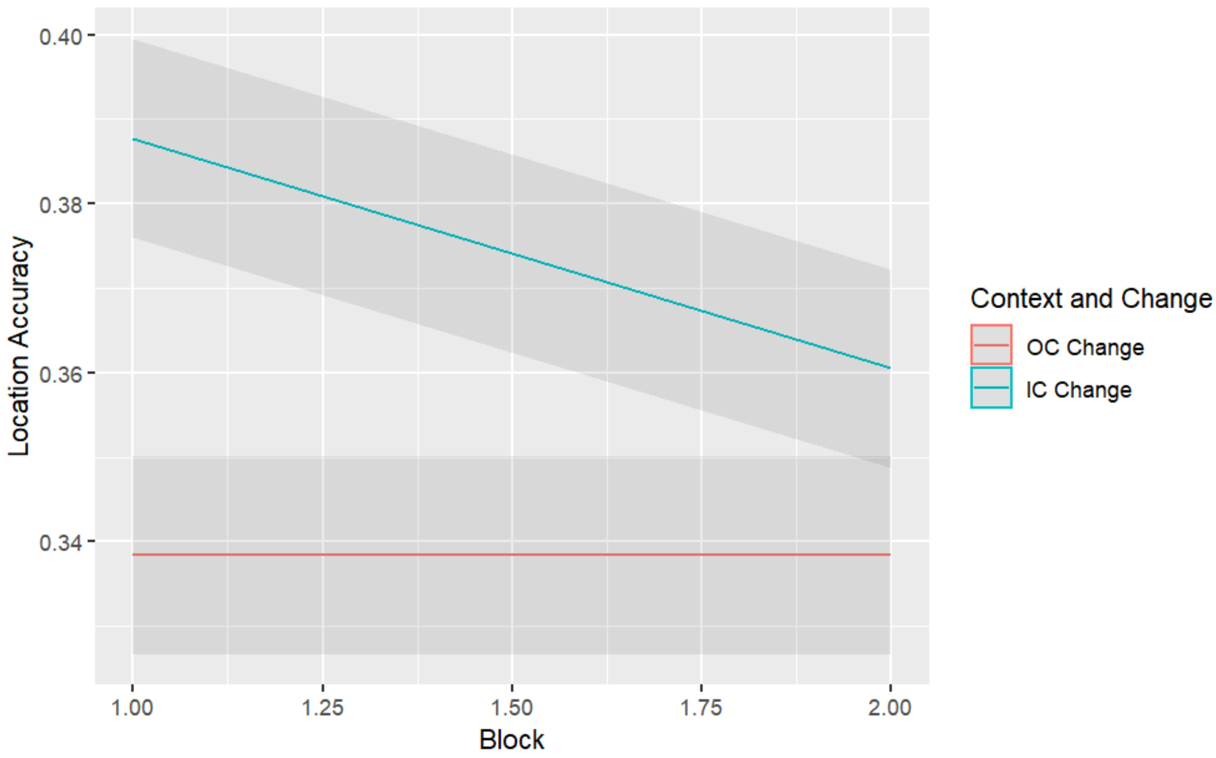
D'prime per context over blocks



Location Accuracy. Figure 15 indicates that there may be a small improvement over time for change trials, however, a decline in location accuracy for no-change trials. In-context and out-of-context. The repeated measures ANOVA indicates no difference between blocks and no significant improvement over time F (1, 48) = .410, p = .524).

Figure D2

Location Accuracy per context over blocks


Location Accuracy
0.40
0.38
0.36
0.34
1.00
1.25
1.50
1.75
2.00
Block
Context and Change
OC Change
IC Change

Appendix E

Table E1

Table of Comments

Comments collected at the end of the first experiment
checking if I saw unfamiliar symbols
looking for rotation and item change
-
I went around the circle with my eyes and tried to notice the outstanding characteristics of the objects (orientation, colour etc.). But in between there was a red line that kept showing and distracting me because I felt like it was pointing at the right answer.
I looked at all pictures at the same time and then a red line came, pointing to where the change usually occurred
no
just gazing at the centre.
I would simply look at all of them by looking in the middle, and when I saw the red line appear, I would reproduce myself with the most rough characteristics about the object. Like say 'yellow muffin, or blue board', or 'side view turtle'. But I've only come up with this strategy halfway into trial-block 3 I believe.
-
First I tried quickly looking at all the objects. Then I tried looking at 3 objects in a triangle, and hoping I would vaguely remember what was in between those. Then I tried focussing on the above 2 and the below 2. And then I tried seeing each row as 1 object, so I looked at the above 2 at the same time, then at the middle 2, then at the below 2.
yes, When I saw the red line I thought about the object I just saw under the block
no
Tried to look shortly at all of the figures, but noticed that it did not work very well because of the short period of time to look at them
I just tried to focus on colour/side
Sometimes I tried to see the whole picture, as in, all the pictures as one whole and I had the idea that worked better than trying to see all the pictures individually.
I only find out that the arrow is pointing to the item that is about to change or not. So over time I focused more on that. Also I got a feeling for the two kinds each item can become, so I had a bit of a learning curve throughout the experiment. I tried to actively look at each item before they disappear

I was looking at the bottom part most of the time.
look at the order of the colours they are in, and look if its the same in the second order of pictures and just look at all the images in a whole & see if something has changed (the first one worked better for me i think)
I tried to notice the changes
remembering the colours
I tried several different things but none of them seemed to be working too wel
I tried to pick one characteristic that stood out to me in each object.
No special strategy
no, very quick
-
No
i let my eyes glide in a circle over the objects
DO NOT COUNT THE RESULTS OF THIS EXPERIMENT! I did not do it seriously.|
Once I memorized all the different objects and their variation, I made mental shortcuts as to which one I was presented. then when the red line flashed I kept note of which variation I had looked at, and then looked if it changed or not. this was only doable after 3 trials or so though, as it takes a little bit of time to memorize the pictures.
I tried to remember the shape and/or colours of the images.
mainly focusing on the center
I didn't use a strategy, but I was thrown off by the red line appearing after the mask in each case.
In the first few seconds see the objects as a whole. So observing the whole picture instead of looking to each object separately. Then when there are a few seconds left, quickly observe all the objects as individuals and look at them separate
ghghg
no, I just focused on the middle and waited if I noticed any changes in the third image.
I did not
Tried to focus on the dot so I can see all objects and then waited for the change
no strategy
later, when i recognized that most objects have a second, similar representation, I remembered specific details about those. For example: rabbit (black or brown), turtle (from side or frontal) etc.
I looked at 2 items against eachother and if 1 changes I would see it
staring at the center instead of looking at each individual object

In the 4th trial, I looked at whether the object indicated by the red line changed.
Later I realized that I should focus on colors of for example the rabbit or the balloon.
I did not
Firtst i tried staring in the middle of the screen. Then i just focussed on either the top or bottom pictures.
Color associations and direction of most objects in relation to circle
i made a quick circle with my eyes around the objects and than looked at the middle
nope
I paid attention to where the line was pointing. Sometimes I didn't really consciously perceive a change, I just acted on instinct and that seemed to work quite well.
no
Op gegeven moment had ik door dat elk item twee versies had ongeveer, maar het bleef echt heel moeilijk./ At some point I realized that each item had approximately two versions, but it remained really difficult.
no strategy used
no
no
-
no

Appendix F

Table F1

Comments of Experiment 2

Comments collected at the end of experiment 2
No
I don't have, trials was difficult and its difficult for me to detecting changes at short time
I tried to look at the very center of the circle to see as many elements as possible at once but it was difficult and several times I focused only on the top or only on the bottom of the circle
I dont used any strategy i was just trying to remember thats all
I tried to just glance at the colors of the objects and spot if they change
YES, I TRIED TO LOOK AT FOR DIFFERENT OBJECTS AND FOCUS ON THEM TO SEE IF THE CHANGE
Yes. I tried to say aloud all the objects to try to make them remembered in my memory
i was confused whole experiment was very hard for me to find a change
No
Looking at only 3 tiles at a time to maximize accuracy on it...
I tried to memorize all of them, and pay extra attention to colors and shapes.
It was hard for me to remember all the things this quick, first i was trying to remember 3 random of them, then i switched to just looking at the middle of the screen and trying to recreate the image to guess what changed. And that worked better for me.
Overall it was a difficult activity for me to dictate the changes however I tried to memorize the colors should they change on the objects as well as just try to cram where they are situated however I wasn't too good at that. Thank You
I decided on a strategy of only paying attention to three consecutively adjacent objects, as all five were a bit much to pay attention to all at once. there after if one of the object was different, I would select it as the changed object. Otherwise if the was a more obviously notable changed object I would then pick that one, but ultimately I would not select any object but the box bellow.
I did not use any strategy
I just looked around and tried to remember various colours, not shapes
I tried to visualize the items by colours which later proved to be difficult.
i tried varies strategy like colour grouping and item similarties but it seems like non of them work.
Not focusing on any of the items and just trying to see the changes

Well I observed from the practicing trial that there was a pattern here, the objects that change positions were in a specific colour such that an object would change from blue to orange and there other ones were not affected
i did not use a strategy, i tried to memorise as much as i can
I was paying attention to colors, at first i was looking in the middle to try to memorise every picture but photo appearing in the middle was distracting, so i decided to go through every picture and try to remember colors of it. After a while i knew to what image things might change, for example instead of white rabbit there was black one.
I tried my best to remember exactly what I saw and closed my eyes n when I open them I could see what was different. I did get confused as to whether anything was changing at all.
Toward the end I began to try and group objects of similar colours together to help me remember which images were used. This did help but also meant that if there weren't objects of similar colours presented, I did not have time to try and memorise what was available.
I tried to focus more on a specific part of the circle of items. I found the study to be really hard.
i don't think of it as an strategy but i just look mostly straight to the middle and if my peripheral vision saw something slightly different, that was what i would end up choosing
I didn't. It was hard coming up with a strategy.
-
I was picking 3 objects each time and trying to remember them
i was focusing on a middle of square so when something changes i could detect that something was wrong. then i was using hint to know if im right
For most of the presented trail, I struggled detecting the changes
It was too fast but I tried to concentrate more on the objects that were around the clue objec.
no
no i just focused really hard
I looked at each picture set, in a clockwise manner. I briefly scanned each image.
NO, I didn't use strategy but I did a quick analysis of the first frame and tried to apply the mental picture I took with the third frame.
try to memorize every object, change in colors
First recognise by colour, then by object. I looked at half the circle at a time (Top 3 then bottom 3) making it easier.
After a while i realized i couldn't focus on all the six objects so i would focus on 4 of them (top 3 plus the bottom center one), hoping for probability
Try to find which images changed to what

I tried to look from the right to the left because my left brain works better.

I tried to look at the middle so I could remember a whole picture and see how it changes rather than remember every element, but I think i could not focus well and the change was too quick for me to adjust.

I used a camera. There was no time to memorise the small chances in the objects

I analyzed and looked everything quickly before clicking the buttons.

tried to memorize what was the objects substitute (ex.: skull and FootBall)

Looking at 3 or 4 objects at once plus at the one in the middle to see if any of them changed. If not then I picked some other one that was most probable for me

Not really i just tried to focus on colors and shapes overall

no strategy

-

The strategy would be to associate neighboring colors with trying and remembering the previous situation.

At first I tried to memorize the objects, but then I realized it was easier to memorize the color patterns. Either way, this was very challenging for me.