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Priming Pragmatic Enrichments

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Contents

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Summary

The work presented in this thesis uses structural priming to investigate pragmatic enrichment. Chapter 2 looks at the role the alternative plays in the derivation of scalar implicatures. We investigate whether the salience of the alternative is sufficient for the derivation of scalar implicatures or whether an additional usage mechanism is required. Chapter 3 focuses on the derivation of one particular category of implicature known as *ad hoc* implicatures. *Ad hoc* implicatures are different from traditional scalar implicatures in that they do not have a predefined scale from which to draw alternatives. We test whether specific alternatives are used in the derivation of *ad hoc* implicatures or whether a general *anything else* alternative is used. Chapter 4 investigates interlocutor alignment in the production of implicatures. Since implicature comprehension can be primed we extend this by investigating implicature production. The findings of the work presented here demonstrate that structural priming can be extended beyond its traditional application to syntax and semantics and can be used to provide insight into pragmatic enrichments.

Publications

Rees, A & Bott, L (2018). The role of alternative salience in the derivation of scalar implicatures. *Cognition, 176,* 1-14.

Rees, A & Bott, L. (2017). Structural priming is a useful but imperfect technique for studying all linguistic representations, including those of pragmatics. Commentary on Branigan & Pickering "An experimental approach to linguistic representation." *Behavioral and Brain Sciences.*

Rees, A & Bott, L (2017). Priming implicit communication. *Proceedings of the 39th Annual Conference of the Cognitive Science Society, London UK.*

Rees, A & Bott, L (2017). A visual world priming study of Gricean implicatures. *The Technical Report of Language and Thought of the Institute of Electronics, Information and Communication Engineers, 117 (149),* 109-114.

Bott, L, **Rees, A**, & Frisson, S (2016). The time course of familiar metonymy. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42,* 1160-1170. DOI: 10.1037/xlm0000218

Rees, A & Bott, L (submitted). Priming implicit communication.

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Introduction

The human communicative ability is impressive. Every day we engage in multiple conversations, interacting successfully with a number of people and more often than not we are able to engage in these communicative exchanges with very little difficulty. This is surprising since speakers are not always explicit. That is, speakers often convey more than is explicitly encoded in an utterance. Consequently, listeners are required to undertake additional processing in order to reach the speaker's intended meaning.

How we make sense of the unsaid has been a topic of great interest to linguists, philosophers, and psychologists alike. The main tenet of this thesis is to examine pragmatic enrichment, specifically implicatures, using structural priming. I first present a discussion of pragmatics and implicatures before discussing structural priming.

Pragmatics

Communication between two interlocutors is often characterised in the following way: one person, the speaker, has an idea that they wish to communicate to their partner, the hearer. The speaker's message is encoded into a linguistic signal that they then produce. The hearer receives this signal and decodes it to reach meaning (e.g. Levelt, 1989). Arriving at the speaker's intended meaning however, is not straightforward. What speakers intend to say often goes beyond the literal meaning of the words they utter. For example "Can you pass the salt?" is rarely used to assess the addressee's ability to pass the salt, on asking this question the speaker is usually requesting the salt. In order for the addressee to reach the correct interpretation they must recognise the speaker's communicative intent as being a request.

Whilst some utterance meanings are straightforward and encoded in the literal meaning of the words used, many rely on extralinguistic information in order to be comprehended as the speaker intended. Many expressions are ambiguous and their meaning depends upon the context in which they are uttered. For example when asking where someone is, the reply "By the bank" could have two different interpretations depending upon the speaker's location. If they are in a city centre this is likely to be interpreted as meaning by a financial institution whereas, if they are in the countryside this interpretation is far less likely. Thus the context in which the reply was uttered could disambiguate the meaning. This information, however, is not structurally encoded in the utterance.

Similarly, comprehending non-literal language, such as metaphors and idioms, requires going beyond the linguistic input. For example, by saying "My computer is a dinosaur," it is unlikely that the speaker means they have a dinosaur for a computer but that their computer is old. In saying "it's raining cats and dogs" the speaker is conveying that it is raining heavily, not that there are cats and dogs falling from the sky. These interpretations do not form part of the explicitly coded content of the utterances and thus require individuals to go beyond the literal meaning (Gibbs, 1994; Glucksberg & McGlone, 2001; Searle 1979; Grice, 1989).

In order to make sense of most linguistic encounters we must look at factors outside of the linguistic content and instead look at how the language was used, the context in which it was uttered. The study of how language is used is known as pragmatics. One of the most influential figures in pragmatics was Grice. Grice emphasised the importance of inference in communication. In order for listeners to understand utterances more often than not they must infer what the speaker meant. That is, a listener must go beyond that which is explicitly encoded in the message to infer the speaker's meaning.

How listeners understand what a speaker intends when the speaker has not been explicit is rooted in what Grice called the Cooperative Principle (Grice, 1989). Conversation is an inherently cooperative activity where both speaker and listener work together to achieve a common goal of understanding. The cooperative principle outlines standards of rational interaction:

"…make [your] conversational contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which you are engaged" (Grice, 1989, pp.41).

Grice proposed a more specific set of conversational maxims. The maxims expand upon the Cooperative Principle by characterizing acceptable conversational contributions:

Quantity: *(1) make your contribution as informative as is required, (2) do not make your contribution more informative than is required.*

Quality: *(1) make your contributions true, (2) do not say what you believe to be false, (3) do not say that for which you lack evidence.*

Relation: *be relevant.*

Manner: *(1) be perspicuous, (2) avoid obscure expressions, (3) avoid ambiguity, (4) be orderly.*

Whilst these maxims may guide rational interaction, they are not necessarily adhered to. In everyday conversation speakers often appear to flout the maxims. Despite the apparent disregard for the conversational maxims listeners often interpret utterances as consistent with the maxims in order to preserve the assumption of cooperation. Deviation from the maxims can indicate to listeners that the speaker is using an implicature. As a result, the listener is required to make an inference. Consider the following examples:

(1) A: Are John and Mary coming to the party?
B: John is coming to the party.
=> *Mary is not.*

(2) A: How did Betty get on with her exams?
B: She passed some of them.
=> She passed some *but not all* of them.

In (1), the explicit content of speaker B's utterance only partially answers speaker A's question since only John is referred to. Although B's reply does not explicitly answer A's query about both John and Mary, A is likely to conclude that John is coming and Mary is not. In order for A to reach this interpretation, she must make an inference. A asked about both John and Mary but B only answered explicitly about John's attendance. Therefore B's utterance is less informative than required and violates the maxim of Quantity (be as informative as is required). Assuming that B is a rational and cooperative speaker then he must have a reason for violating the maxim. For example, if B does not know whether Mary will attend then by saying nothing he is observing the maxim of Quality (do not say that which you do not have evidence for). In order for A to infer that Mary is not coming to the party she must assume that speaker B is in a position to know whether or not Mary is coming to the party, this is known as the epistemic step (Chierchia, Fox, & Spector, 2012; Sauerland, 2004).

A standard approach to how this inference is derived is as follows: (i) the listener computes a basic (literal) meaning of an utterance, (ii) recognises that an alternative phrase could have been used, (iii) negates this alternative, (iv) combines the basic meaning with the negated alternative. Continuing with the example above, A recognises that B could have said "John and Mary are coming to the party" (the *alternative*). Since B did not say this, and assuming that he is in a position of knowledge and is being cooperative, A can infer that "John and Mary are coming to the party" is not true. Thus, combining what is said, *John is coming to the party*, with the negation of the alternative,

John and Mary are coming to the party, the listener arrives at the interpretation that *John but not Mary is coming to the party*. This is an example of a scalar implicature.

Scalar implicatures

This thesis is concerned with one particular type of Gricean implicature known as *scalar* implicatures. Scalar implicatures arise when a speaker has been less than maximally informative. This is usually triggered when a speaker uses a semantically weaker term from an entailment scale[1] (Horn, 1972; Gazdar, 1979; Hirschberg, 1985; Matsumoto, 1995). For example, in (1), *John is coming to the* party is semantically weaker than *John and Mary are coming to the party*. Scales can be contextual[2], as in this case, or lexical. Take (2) for example. Speaker B uses *some* which is weaker than the alternative *all*. Following the same reasoning as for (1), since B did not say *all*, A can infer *not all*, which results in the inference that Betty passed *some but not all* of her exams.

Implicatures have a number of distinctive properties which distinguish them from literal meaning. These are: calculability, cancellability, reinforceability, nondetachability, nonconventionality, and universality. The first of these, calculability, is the ability to construct an argument using the maxims to demonstrate how the implicated meaning arises. This can be seen in the descriptions above. The second, cancellability, refers to the ability to explicitly cancel the implicature. In (2) the implicature that arises is *Betty passed some but not all of her exams*. It is possible to cancel this in a subsequent clause by stating the stronger alternative: Betty passed some of her exams, in fact she passed them all. It is not possible to cancel entailments. Take (3):

(3) Sarah has been to Paris.
-> Sarah has been to France.

The sentence Sarah has been to Paris entails that Sarah has been to France. Attempting to cancel the entailment results in a nonsensical sentence; Sarah has been to Paris, but she has not been to France. The cancellation of implicatures however, does not result in nonsensical sentences. Similarly it is possible to reinforce an implicature by explicitly adding the implicated content. Take example (2) again, explicitly stating the implicated content does not give a rise to the same sense of redundancy that repeating the coded content of an utterance does (Levinson, 2000). For example, to say that Betty

[1] An entailment scale consists of terms which are ordered based on their semantic strength. Stronger terms on the scale entail weaker terms e.g. <some, all>, <or, and>, <warm, hot>, <cool, cold> . The terms on the right entail terms on the left.
[2] Some work suggests that ad hoc implicatures such as these are not necessarily derived in the same way as other prototypical implicatures in that they may not rely on a specified set of alternatives. I will return to this point in Chapter 3.

passed some of her exams, but not all of them does not give rise to the sense of redundancy that Sarah has been to Paris and she has been to France does.

Implicatures are nondetachable from the explicit form used. This is because implicatures are a consequence of the semantic content rather than the linguistic form. Expressions that contain the same coded content will carry the same implicatures; changing the wording does not remove the implicature. The example from Grice is try (1989, p.43). Try implies that there was a failure or the risk of failure. The implicature that arises from tried to do x also arises with attempted to do x. Similarly the same sarcastic interpretation in response to a waitress dropping a plate arises in (4) and (5).

(4) Oh good job!

(5) Well done!

This differs from presuppositions which are associated with specific words or phrases. Changing the word itself may affect the presupposition as seen in (6) and (7). The presence of too in (6) presupposes that there is someone else who likes jam sandwiches, removing too in (7) removes this presupposition.

(6) Louise likes jam sandwiches too.
=>There is someone else who likes jam sandwiches.

(7) Louise likes jam sandwiches.

Finally Universality, the cooperative principle and conversational maxims that make up Grice's rational theory of communication are fundamental assumptions which are required in order for successful communication. Consequently they should hold across cultures and thus be universal (Levinson, 2000).

Research on scalar implicatures typically focuses on how a listener processes the implicature and whether or not there is a cost to deriving an implicature (e.g. Bott & Noveck, 2004; Bott, Bailey, & Grodner, 2012; Breheny, Ferguson, & Katsos, 2013; Breheny, Katsos, & Williams, 2006; Degen & Tanenhaus, 2015; Grodner, Klein, Carbary, & Tanenhaus, 2010; Huang & Snedeker, 2009; Noveck & Posada, 2003; Tomlinson, Bailey, & Bott, 2014). This thesis takes a different approach and focuses on the priming of implicatures.

Priming

The production and comprehension of language does not occur in isolation. Our previous linguistic encounters can influence how a sentence is understood or a speaker's choice of utterance. People are often repetitive in their language use; commonly during a

conversation interlocutors will repeat phrases or entire sentence structures they have previously encountered in the interaction. For example Levelt and Kelter (1982) found that people were more likely to include the preposition at in their reply when asked "At what time does your shop close?" than if they were asked "What time does your shop close?" This phenomenon is known as priming.

In a seminal study Bock (1986) investigated structural priming under the guise of a memory task. Participants were presented with a sentence that they had to repeat (prime) and then they had to describe a picture (target). The form of the prime sentence was varied; sentences were either active or passive (e.g., "One of the fans punched the referee", or "The referee was punched by one of the fans") or used double object or prepositional object structures (e.g. "The man is reading the boy a book", or "The man is reading a book to the boy"). Participants then had to describe a target picture which could be described using either form (active or passive and double or prepositional object). Bock found that the form of the sentence reliably affected the form of the target description. Active descriptions were more likely after active primes and less likely after passive primes. Similarly, double object constructions were more likely following double object than prepositional object primes. Since Bock's initial study researchers have used priming to investigate a wide range of linguistic phenomenon.

Priming effects are found throughout the language system: in written and spoken production (e.g. Branigan, Pickering, & Cleland, 1999; 2000; Branigan, Pickering, McLean & Cleland, 2007; Brennan & Clark, 1996; Pickering & Branigan, 1998), comprehension (e.g. Arai, van Gompel, Scheepers, 2007; Branigan, Pickering, & McLean, 2005; Myslin & Levy, 2016; Scheepers & Crocker, 2004; Sturt, Keller, & Dubey, 2010; Thothathiri & Snedeker, 2008; Tooley & Traxler, 2010) and across languages (e.g. Flett, Branigan, & Pickering, 2012; Hartsuiker, Beerts, Loncke, Desmet, & Bernolet, 2016; Hartsuiker & Westenberg, 2000; Lobell & Bock, 2003; Scheepers, 2003). The results of priming studies have proved informative about the organisation and working of the language system (Branigan & Pickering, 2017; Pickering & Ferriera, 2008).

Priming effects are usually explained in terms of the activation of representations. When a stimulus is first encountered the representations that are associated with it become activated. These representations retain some activation across time. When a subsequent stimulus is encountered, if it is shares some features with the previous stimuli then it will activate similar representations. Since those representations would have residual activation from being used recently they reach the activation threshold faster. If the processing of one stimulus affects the processing of a subsequent stimulus then these

two stimuli must share some dimension of representation within the language processor. Priming can only occur if the language processor is sensitive to the dimension along which the two stimuli are related.

Typically, priming studies have focused on syntax and semantics (Branigan & Pickering, 2017) however, aspects of pragmatics, such as scalar implicatures, can also be investigated using priming (Bott & Chemla, 2016; Rees & Bott, 2017). Bott and Chemla (2016) used a sentence-to-picture paradigm where participants selected one of two pictures based on their interpretation of a sentence (based on Raffray & Pickering, 2010). The sentence-picture combination was such that in some prime trials participants were obliged to derive an enriched interpretation (a scalar implicature) of the sentence in order to select the correct card and in other prime trials no enrichment was required. In the target trials the sentence-picture combination was ambiguous with respect to enrichment and thus provided participants with the choice to enrich their interpretation of the sentence or not. Participants were more likely to derive the enrichment in the target trial if the prime trial had obliged the derivation of an enrichment. Scalar implicatures are typically thought of as pragmatic. That they can be primed, just as syntactic structures can be, suggests that there are representations specific to pragmatic enrichments. We make use of the primability of scalar implicatures to investigate the nature of pragmatic enrichments.

Chapter overview

Chapter 2: The role of alternative salience in the derivation of scalar implicatures. This chapter presents work extending that of Bott and Chemla (2016). Implicature derivation is often characterised as a two-step process in which the alternatives are identified and then negated. However, the independence of these two processes is unclear. We test between two models in an attempt to clarify this. In the first model the identification and use of alternatives are not independent processes. The derivation of implicatures depends upon the identification (or salience) of the alternatives. Once the alternative is sufficiently salient an implicature arises. We call this the salience model. In the second model the identification and use of alternatives are two distinct stages. The derivation of implicatures requires the alternative to be salient and an independent usage mechanism must also be salient. We call this the combination model. We present three experiments using a structural priming paradigm with alternatives and implicatures as primes. We show that adults can be primed to derive implicatures when the alternative is the prime and that this occurs at an equal rate to when the implicature is the prime. We

interpret these findings as evidence in favour of the salience model and suggest that there is not an independent usage mechanism.

The work presented in this chapter has been published as Rees, A & Bott, L (2018). The role of alternative salience in the derivation of scalar implicatures, Cognition, 176, 1-14.

Chapter 3: Deriving ad hoc implicatures. This chapter focuses on a particular type of enrichment known as ad hoc implicatures. Ad hoc implicatures differ from prototypical scalar implicatures because they are contextually based and thus do not have a clearly defined set of alternatives in the same way that, for example, quantifiers do. Nevertheless, similar priming effects are seen in ad hoc implicatures. In this chapter we aim to first investigate how priming affects the processing of implicatures since previous priming investigations have relied on metalinguistic judgement tasks. Secondly, we test between two explanations for how ad hoc implicatures are derived. The first explanation is that temporary ad hoc scales are constructed to provide the necessary alternatives for ad hoc implicatures to be derived. The alternative approach is that rather than involving specific contextually based alternatives there is a general "anything else" representation which is negated in order to derive the implicature. We present one reaction time and two eye tracking experiments to address these questions. We show that priming has a facilitatory effect on implicature processing, as reflected in faster reaction times, and that rather than generating scales on an ad hoc basis individuals make use of a general "anything else" representation.

Experiments 2 and 3 from this chapter appear in Rees, A & Bott, L (2017). A visual world priming study of Gricean implicatures. The Technical Report of Language and Thought of the Institute of Electronics, Information and Communication Engineers, 117 (149), 109-114.

Chapter 4: Structural alignment of pragmatic enrichment in dialogue. In this chapter we focus on implicatures from a speaker's perspective. Much of the research into implicatures focuses on how a listener derives the implicature and does not consider the factors which may influence the speaker's choice to use the implicatures. We extend work showing that during dialogue speakers become aligned with respect to their syntactic choices and investigate whether speakers also become aligned with respect to pragmatics. That is, we look whether interlocutors become aligned in their use of implicatures. We present four experiments that use a confederate scripting priming paradigm and show that speakers do become aligned.

Experiments 2 and 3 from this chapter appear in Rees, A & Bott, L (2017). Priming implicit communication. Proceedings of the 39th Annual Conference of the Cognitive Science Society, London UK.

Chapter 2: The role of alternative salience in the derivation of scalar implicatures.

People often communicate much more than they explicitly say. For example, consider the following exchanges.

(1) A: Are John and Mary coming to the party?
B: John is.
=>Mary is not.

(2) I ate four doughnuts.
=> I ate exactly four doughnuts.

(3) Betty passed some of her exams.
=> Betty passed some but not all of her exams.

In (1), B answers A's question about John coming to the party. Although B has not explicitly answered A's query about Mary's attendance, his utterance communicates that Mary is not coming. In (2), the listener can infer that the speaker ate exactly four doughnuts, even though the speaker did not explicitly say exactly four, and in (3), the listener can conclude that Betty passed some but not all of her exams, even though the speaker did not explicitly say not all.

Enrichments such as those above are commonly known as scalar implicatures. In each case the listener generated an enriched meaning based on the alternative to what the speaker said, that is, something that the speaker could have said but did not. There are many accounts of how implicatures can be derived but most assume something like the following, inspired by Grice (1989): (i) The listener computes the basic meaning of an utterance, (ii) recognises that an alternative phrase could have been used, (iii) negates the alternative, and (iv) combines this with the basic meaning. For example, in (1), Speaker A recognises that B could have said "John and Mary are coming to the party" (the alternative). Since B did not say this, and assuming that she is being cooperative, A can infer that "John and Mary are coming to the party" is not true. Thus, combining what is said, John is coming to the party, with the negation of the alternative, it is not the case that John and Mary are coming to the party, the listener arrives at the meaning that John but not Mary is coming to the party. Similar reasoning can be used to derive the enrichment seen in the other examples. In (2), since the speaker said four the listener can infer that not five, not six, not seven is the case, and conclude that the speaker means four but no more. In (3) the speaker could have said all, but since they did not, the speaker can infer not all.

Implicatures are optional: the listener chooses whether to incorporate an implicature into the sentence meaning. For example, in (3), if the preceding discourse had been about whether Betty would pass any of her exams, the listener would likely not derive the not all inference (since the not all part would be largely irrelevant). Understanding how and why certain contexts cause people to enrich the basic meaning of expressions has been a fundamental research goal in pragmatics (e.g. Chierchia, 2013; Geurts, 2010; Grice, 1989; Horn, 1972; 1989; Levinson, 2000) and psycholinguistics (e.g. Bott, Bailey, & Grodner, 2012; Bott & Chemla, 2016; Bott & Noveck, 2004; Breheny, Katsos & Williams, 2006; Breheny, Ferguson & Katsos, 2013; Degen & Tanenhaus, 2015; Gotzner, Wartenburger, & Spalek, 2016; Grodner, Klein, Carbary, & Tanenhaus, 2010; Huang & Snedeker, 2009a; Tomlinson, Bailey & Bott, 2013). In our study we address the role of the alternative in this process. We test whether the salience of the alternative entirely determines whether an expression will be enriched, or whether an additional, independent usage mechanism is justified.

Combination and salience models of implicature

Most researchers agree that there are two stages to the implicature process. The first is that a relevant alternative is retrieved from the lexicon or the context, or constructed. The second is that this alternative is negated and combined with the basic meaning of the sentence. However, it is not clear how the second stage depends on the first. The second stage could apply automatically once the first stage is complete, so that the implicature is always derived if the alternative is sufficiently salient, or the second stage could be activated independently of the first. We refer to the former possibility as the *salience model*, since the implicature depends purely on the salience of the alternative, and the latter as the *combination model*, since the implicature depends on a combination of the salience of the alternative and the activation of an independent usage mechanism that uses the alternative, i.e. negates the alternative (see Figure 1)[3].

[3] QUD in Figure 1 refers to question under discussion which is one possible factor that contributes to activation.

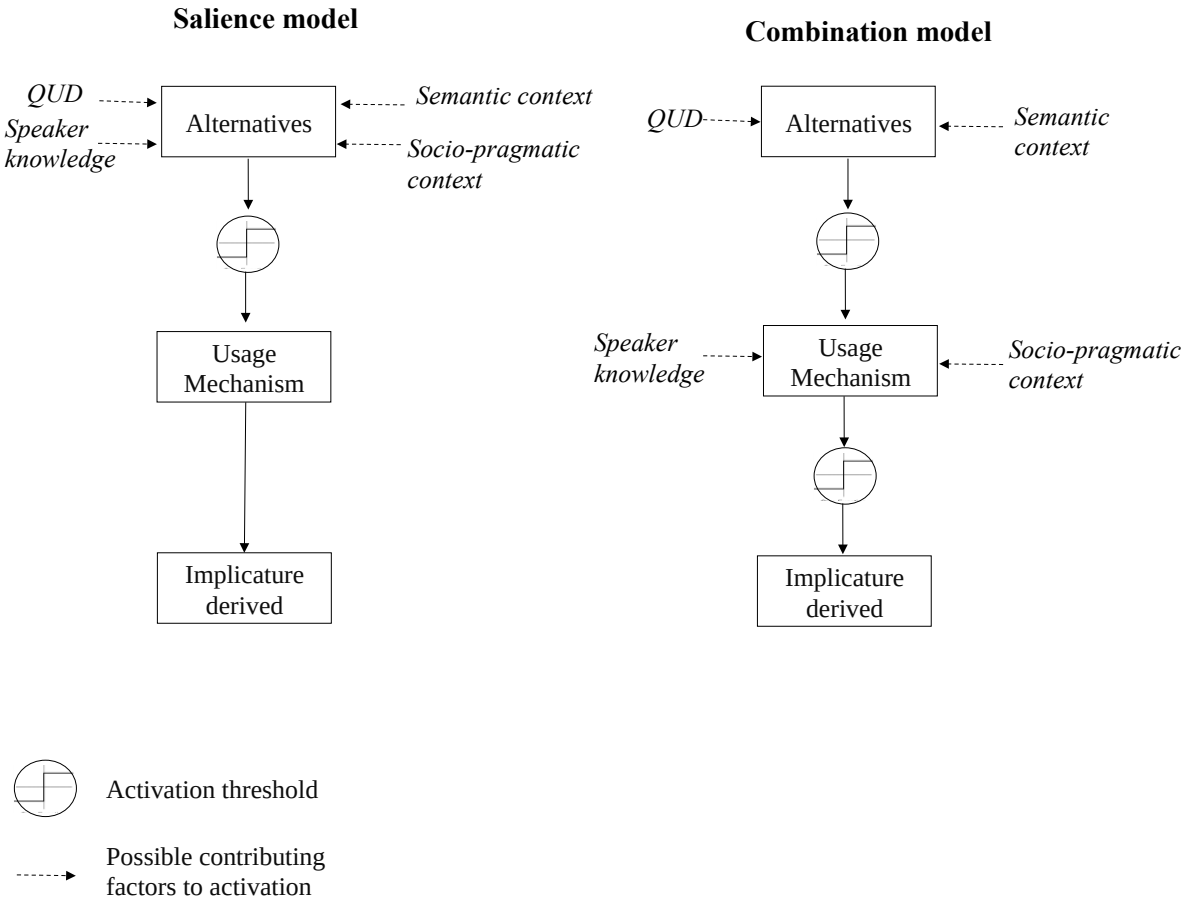

Figure 1. Salience and combination models. Alternatives have varying levels of activation. For the salience model, the usage mechanism is automatically applied after the alternatives obtain sufficient activation to exceed a threshold but for the combination model, the alternatives and the usage mechanism are required to exceed a threshold. Note that both models have the same number of processing steps but the combination model assumes the usage mechanism can be independently activated whereas the salience model does not.

Both models assume that alternatives have varying degrees of activation. For the salience model, if the activation of any one alternative exceeds a threshold, the usage mechanism will be applied, and the implicature will be computed. The usage mechanism is not modulated independently of the activation of the alternatives. The combination model also assumes that the alternatives have varying degrees of activation and a threshold, but additionally assumes that the usage mechanism does. For the salience model, contextual factors (e.g., the question under discussion, whether alternatives have been mentioned in the discourse, speaker knowledge) affect the activation levels of the alternatives, but for the combination model, contextual factors affect activation levels of the alternatives and/or the usage mechanism, independently. Both models explain how the implicature arise in some circumstances but not others. For example, in (1) the salience model explains the implicature by assuming that the alternative (*John and Mary are going to the party*) is sufficiently active that it exceeds the threshold necessary to trigger the usage mechanism and so generate the implicature. The combination model also requires alternatives to be sufficiently active but additionally assumes that the usage mechanism is active. Similarly, consider a situation where an implicature would not arise. In (1), assume that B knows information about John but knows nothing about Mary, and the listener is aware of this. Under these conditions the *not Mary* implicature does not arise (the competency assumption; see Grice, 1989, and Sauerland, 2004). The salience model explains the absence of implicatures by assuming that the absence of speaker knowledge suppresses activation levels of the alternatives to such a degree that the usage mechanism is not triggered. The combination model explains this by assuming either that the alternatives are not sufficiently active, or that speaker knowledge directly suppresses the usage mechanism. The crucial difference between the two is that with the independent usage mechanism, the combination model has an extra method of accommodating contextual factors, such as speaker knowledge or alternative relevance.

Implicature theories from the formal pragmatics literature can be broadly mapped on to the salience/combination distinction. Among the salience models are Grice's original account and its more recent developments, the Neo-Gricean models (Horn, 1972; Levinson, 2000). Grice's account assumes that if there is linguistic material that is relevant and more informative than the basic expression, this material should be designated an alternative. Subsequently the alternative is combined with the basic meaning of the sentence using domain general reasoning processes. Because there is no mechanism for blocking the implicature from arising after the alternative has been made active, the usage

mechanism should not be thought of as independent from the activation of the alternative. Thus Grice's model can be classified as a salience model. While Neo-Gricean accounts provide more detail on how the alternative is formed, the basic assumptions regarding the automatic application of the usage mechanism are the same. There is no mechanism proposed for blocking the implicature after the alternative has been identified and so the usage mechanism cannot be considered independent. This seems particularly clear with regards to Levinson, who presents extensive arguments in favour of implicatures being the result of default reasoning processes. If a usage mechanism were able to block the implicature from arising in certain contexts, the system would no longer be a default model. Recent grammatical models of implicatures should also be considered salience models for the same reason. Indeed, Chierchia et al. (2012) explicitly identify with a salience model, "providing alternatives are active, such alternatives are obligatorily factored into meaning… if the alternatives are not active the plain unenriched meaning is used and no scalar implicature comes about." (p.2304).

Other formal accounts are more readily mapped onto combination models. These typically assume an independent usage mechanism to explain the effects of relevance or speaker knowledge. Sauerland (2004) and the structural theory of alternatives (Katzir, 2007; Fox & Katzir, 2011) could sensibly be implemented in this way. According to Sauerland, upon encountering an utterance such as (3) "Betty passed some of her exams", individuals first compute a primary implicature, in which the speaker is assumed to be uncertain about whether a stronger statement holds e.g. it is not the case that the speaker believes that Betty passed *all* of her exams. Under the right epistemic conditions, the primary implicature is then strengthened to a secondary implicature e.g. the speaker believes that it is not the case that Betty passed *all* of her exams. An independent usage mechanism could be linked to the assessment of epistemic context so that it is only activated when the context is appropriate.

Structural theories of alternatives also assume multiple steps in the derivation process. For Fox and Katzir (2011), the set of alternatives is first determined by structural linguistic or discourse factors (e.g. sentence complexity) but at a later stage, conversational relevance filters out inappropriate alternatives. As with Sauerland, an obvious implementation of this would be for relevance to affect the probability of the usage mechanism being activated. More generally, researchers often describe the implicature process as a series of discrete stages (e.g. Breheny, Ferguson, & Katsos, 2013; Geurts, 2010; Katsos & Bishop, 2011), with the usage mechanism described as separate from the identification of alternatives. For example, Katsos and Bishop (2011) say, "The

first step involves determining whether the speaker could have made a more informative statement….The second step involves the negation of the more informative statement that was identified in the first step." (p. 68). Similarly, Breheny, Ferguson, and Katsos include speaker knowledge as a separate step in implicature generation (Table 1, p.424). While we doubt these researchers are committed to a combination model, the exposition implies some degree of independence between the formation of the alternatives and their negation, such that the usage mechanism might be affected by factors other than the salience of the alternatives.

The forgoing discussion demonstrates that both salience and combination models are plausible implementations of formal pragmatic models. There is no reason to choose one model over the other on the basis of a consensus in the formal literature. However, the models discussed above were not intended as mechanistic, psychological accounts and in many cases the question of whether there is an independent usage mechanisms depends more on implementation than the structural properties of the theory. For example, we classed Fox and Katzir (2011) as a combination model, but conversational relevance might act to prune the set of alternatives as part of the initial stage of alternative generation, rather than the later stage of alternative usage. Consequently Fox and Katzir could still be implemented in a system where the usage mechanism was automatically activated on the basis of the activation levels of the alternatives. We therefore emphasise that we are not testing any particular formal model but the broad implementation principles behind the salience/combination distinction.

Alternatives in scalar implicatures

There have been no previous attempts to test between the salience and combination models but there is experimental evidence of the importance of the alternative more generally. Much of this comes from the developmental literature. Developmental data suggest that children have difficulty generating scalar implicatures (e.g. Huang & Snedeker, 2009b; Noveck, 2001; Papafragou & Musolino, 2003) and there is now converging evidence that at least part of the reason is children's difficulty in generating appropriate alternatives (Barner, Brooks, & Bale, 2011; Chierchia, Crain, Guasti, Gualmini, & Meroni, 2001; Gualmini et al., 2001; Skordos & Papafragou, 2016).

A particularly convincing example of this is Skordos and Papafragou (2016). They tested whether the accessibility and relevance of alternatives affected five-year-old's ability to generate scalar implicatures. Children completed a sentence-picture verification task where children were presented with a picture and had to judge the felicity of the description provided. The critical sentences were underinformative statements involving

some. Accessibility of the alternative was manipulated by varying the order of trials. In the *mixed* condition trials using *some* and *all* were intermixed so that *all* was accessible during the evaluation of *some*. In the *some-first* condition all of the trials using *some* were presented before trials using *all.* When the alternative, *all*, was made more accessible to children they derived more scalar implicatures than when the alternatives were not accessible. Consistent with Barner, Brooks, and Bale (2011), this result demonstrates that the accessibility of the alternative partly determines whether children derive the implicature. Skordos and Papafragou go further than demonstrating that accessiblity is important, however. In later experiments they show that the alternative needs to be relevant, as well as accessible. Relevance was determined by the sentence evaluation criteria. In the *all* relevant condition, the task required children to process the quantifier to determine whether the sentence was true, whereas in the *all* irrelevant condition, they heard the same sentences but the composition of the picture meant that the quantifier was not relevant (the truth of the sentence depended on only the predicate). Skordos and Papafragou observed higher rates of the implicature in the *all* relevant condition than the *all* irrelevant condition, even though *all* was accessible in both cases. A further experiment revealed that an equally high rate of implicatures was derived when a relevant *none* was used instead of *all*.

Skordos and Papafragou (2016) provide an important demonstration of how children are influenced by the salience of the alternative. Their results are consistent with the salience and the combination model, however. The salience model could explain the results by claiming that *all* was made more active in conditions where there was a high rate of implicatures. In Experiment 1, repeated processing of *all* in the *all* condition raised activation levels; in Experiment 2, depth of processing for *all* was greater in the relevant condition than the irrelevant condition, and activation levels were greater as a consequence; and in Experiment 3, the semantic association between *none* and *all* raised activation levels of *all* (more generally, the set of quantifiers was activated when the question-under-discussion was recognised as being about quantifiers).

While there is general agreement that the salience of the alternatives is important in the adult processing literature, alternatives have received far less direct interest than in the developmental literature. Indirect evidence of the role of the alternative salience is given by Chemla and Bott (2014). They tested whether free choice inferences were a form of complex scalar implicatures using a sentence verification task. In one block participants completed a free choice task where they were presented with a scenario and a sentence using disjunction and had to judge the truth of the sentence based on their knowledge and

the scenario. The veracity of the sentence depended upon whether or not participants derived a free choice inference. In the other block participants completed a similar task but using scalar implicatures rather than free choice inferences. Chemla and Bott found that while scalar implicatures were delayed relative to literal controls (replicating Bott & Noveck, 2004), free choice inferences were not. They concluded that either free choice inferences were a completely different phenomenon from scalar implicatures, or that the alternatives used to derive free choice inferences were sufficiently salient to the participant that retrieving them was not a costly process. Under the latter explanation, the cost observed when people derive scalar implicatures can at least partially be explained by the inaccessibility of the alternative. If the alternatives are salient, implicatures can be computed quickly, whereas if the alternatives are not as salient, implicatures will cause a processing delay (see also van Tiel and Schaeken, 2016). While this theory relates to processing cost, and not implicature rates, it nonetheless suggests that alternative salience is important for adult processing of implicatures.

Bott and Chemla (2016) also argued that the salience of the alternative was important. They tested whether people could be primed to derive scalar implicatures, in the same way that they can be primed to produce particular syntactic structures (e.g., Bock, 1986; Bock, Dell, Chang, & Onishi, 2007; Branigan, Pickering, & Cleland, 2000; Thothathiri & Snedeker, 2008; see Pickering & Ferreira, 2008 for a review). Participants saw prime trials, in which they derived either an implicature interpretation (a strong interpretation) or a non-implicature interpretation (a weak interpretation), and target trials in which the sentence was ambiguous between a strong and a weak interpretation. Target trials appeared subsequent to prime trials. They found that the prime sentence influenced the interpretation assigned to the target sentence such that a strong prime trial led to more strong target interpretations than a weak prime trial. They proposed several explanations for the priming effect but one involved the strong prime making the alternative more salient to the participant, which in turn elevated the rate of implicatures.

In summary, there is a range of evidence suggesting that the salience of alternatives is important for deriving scalar implicatures but little direct evidence to distinguish between the salience model and the combination model. In our study we provide a direct test between them. The logic is explained in the next section.

Retaining activation levels across time

The salience and the combination models are not easy to distinguish empirically. Variable activation levels of the alternatives can explain many findings, and these are present in both models. To test between them then we make a further assumption about

the usage mechanism. We suggest that just as the alternatives maintain activation levels across time, the usage mechanism also maintains activation levels across time. This means that if the usage mechanism has been used earlier in the discourse, activation levels should remain high, and if it has been suppressed, they should remain low. The rationale for this assumption comes from research on structural priming (see Pickering & Ferreira, 2008; and Branigan & Pickering, 2017, for reviews). These studies demonstrate that many linguistic structures maintain activation levels in just this way (e.g. active and passive syntactic structures, Bencini & Valian, 2008; transitive and dative syntactic forms, Bock 1986; animacy assignments, Bock, Loebell, & Morey, 1992; conceptual level structures for configurations in a maze, Garrod & Anderson, 1987; scopal interpretations with "every", Raffray & Pickering, 2010, and Chemla & Bott, 2014). For example, Branigan and Pickering (1998) showed that when a confederate used a double object structure to describe a picture ("give the man the book"), participants were more likely use a double object structure in subsequent trials than a prepositional structure ("give the book to the man"). Activation levels of the double object structure were retained across time so that when the participant needed to choose a structure, the double object structure was more active than the prepositional structure.

The consequence of assuming that activation levels are maintained across time and linguistic space is that the combination model now predicts the usage mechanism can be primed by recent use. If the usage mechanism has been used recently in the discourse, it should have higher activation levels than if it has not. Since higher activation levels translate as a greater probability that the usage mechanism will be triggered (see Figure 1), the more recent the application of the usage mechanism, the more likely the usage mechanism is to be applied to the current interpretation. The basic logic of our design follows that of researchers in structural priming who claim that the presence of a priming effect reflects the presence of a structure, and conversely, the absence of a priming effect reflects the absence of a structure (Branigan & Pickering, 2017; Pickering & Ferreira, 2008).

In our study we adapted Bott and Chemla's (2016) paradigm to test whether the usage mechanism can be primed. A priming effect would support the combination model, and the absence of one would support the salience model.

Current Study

Participants completed a picture-sentence matching task. They were presented with two pictures and a sentence and had to select which picture best matched the sentence. Participants' interpretation of the sentence was indicated by their picture selection. There

were prime trials and target trials. Target trials were presented immediately after prime trials. The correct interpretation of the sentence in prime trials was unambiguous, but in target trials participants could choose between an implicature reading (a *strong* interpretation) and a non-implicature reading (a *weak* interpretation). A priming effect was shown when the type of prime trial influenced the interpretation of the target trial.

There were three types of prime: strong, weak, and alternative. In strong and weak prime trials, sentences contained a scalar trigger term, e.g. "some" (see Figure 2). In alternative prime trials, sentences contained a more informative alternative to the scalar term, e.g. "all". In strong trials, the picture configuration meant that the most relevant interpretation was a strong reading (implicature) e.g. *some but not all.* In weak trials the relevant interpretation was a weak reading (non-implicature) e.g. *some and possibly all*, and in alternative prime trials, the relevant interpretation was the alternative reading, e.g., *all*.

Target trials consisted of a picture corresponding to the weak interpretation of the sentence, and a picture with the words, "Better Picture?" (modelled on the "hidden box" paradigm of Huang, Spelke, & Snedeker, 2013; see Figure 2). If participants felt that there was a picture that better matched the sentence than the one shown, they could select the "Better Picture" option. Thus, weak interpretations of the sentence were measured by selecting the weak picture and strong interpretations by selecting the "Better Picture" option. Priming of scalar implicatures occurred when there were more strong target interpretations subsequent to a strong prime than a weak prime.

Three categories of expression were used: quantifiers, numerals, and *ad hoc* constructions. All three are argued by some authors to be types of scalar implicature (e.g., Hirschberg, 1991; Horn, 1972, 1989; van Rooij & Schulz, 2006). In particular, sentences using these expressions admit strong and weak readings and the strong reading can be derived using a Gricean reasoning process. For example, the weak interpretation of "There is a V" is *there is a V and possibly other letters*, and a relevant alternative (in the context presented in Figure 2) is "There is a V and a C." Combining the negation of the alternative, *there is not a V and a C,* with the basic meaning of the sentence, *there is a V and possibly other letters*, yields the strong meaning, *there is a V and nothing else*. A similar reasoning process applies to the numbers. We used a range of scalar implicature expressions, rather than the prototypical *some*, because we wanted to test whether our findings applied to a range of scalar trigger expressions.

According to both the salience and the combination models, alternative and strong prime trials should increase the salience of the alternative relative to the weak prime

trials. In the alternative trials, the alternative is made explicitly available, and in the strong trials, the alternative is made implicitly available by forcing the participant to derive a scalar implicature. Therefore the rate of implicature in target trials should be higher following alternative and strong prime trials than weak trials. The models make different predictions for the priming caused by the strong relative to the alternative prime, however. The salience model assumes that the rate of implicature is entirely dependent upon the activation of the alternative. Since the alternative prime makes the alternative active, and the strong prime also makes the alternative active (via the scalar implicature), the alternative and the strong prime should lead to equal rates of implicature. In contrast, the combination model assumes that activation of alternatives is only one component of what determines whether an implicature is derived. The other is activation of the usage mechanism. Assuming the usage mechanism maintains its activation levels across trials (as described above), it should continue to be active after a strong prime (which triggers the usage mechanism), but not an alternative prime (which does not). For the combination model then, the alternative prime should raise the activation of the alternative, leading to a certain amount of priming, but the strong prime should raise the activation of the alternative and of the usage mechanism, subsequently leading to more priming than the alternative alone. Thus the combination model predicts greater priming following the strong prime trials than the alternative prime trials.

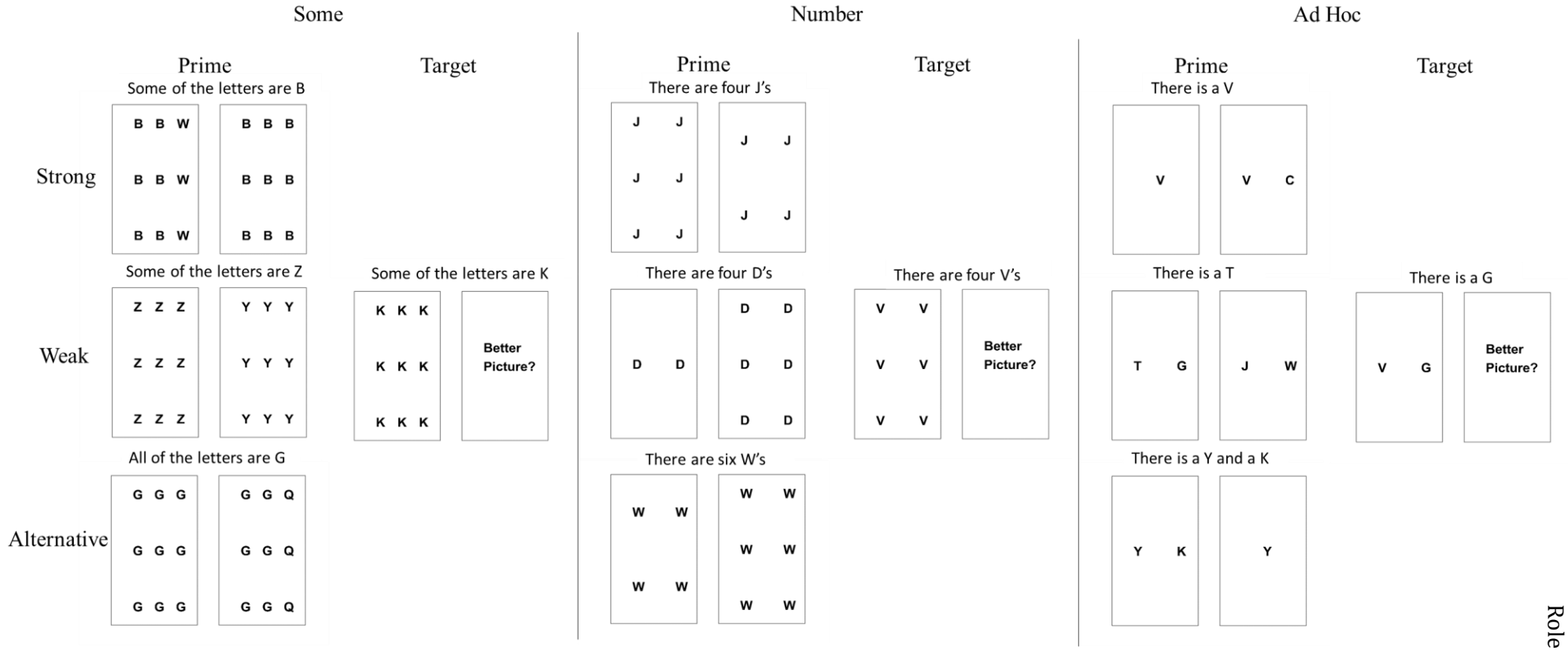

Figure 2. Example primes and target for each implicature category. Left to right: some, ad hoc, and number. Primes top to bottom: strong, weak, and alternative.

Experiment 1

Method

Participants

One-hundred Cardiff University undergraduate students participated for course credit (93 female, average age 19.4 years). All participants were native English speakers.

Materials

Each trial consisted of a sentence presented above two pictures. Participants had to match the sentence to one of the pictures. Pictures consisted of rectangles containing either letters or the text "Better Picture?"

Three expression categories were used: *some*, number, and *ad hoc*. The expressions have a weak meaning that can be enriched to form the strong meaning. Table 1 shows example expressions, together with plausible alternatives and the subsequent implicature.

Implicature category	**Expression**	**Alternative**	**Implicature**
Some	Some	All	Some but not all
Number	There are N	N+1,+2…	N exactly
Ad hoc	There is an X	X and Y	There is an X and nothing more

Table 1. Experimental stimuli.

Prime trials consisted of two pictures with letters inside. There were one, two, four, six, or nine letters depending upon the implicature category of the prime. Pictures with letters could either be strong, weak, or false depending upon the predicate of the sentence.

Strong prime trials involved a strong and a weak picture. Strong primes involved a strong and a weak picture, and weak prime trials involved a false and a weak picture. Alternative primes had the same picture configuration as strong primes (see below for description of picture configurations).

For each implicature category there were two possible sentence frames (see below). One was used in the strong and the weak primes and the other was used in the alternative prime trials. As a result of this, although the types of pictures used in the alternative primes were the same as those in the strong primes, the sentence frame meant that alternative primes had a false and a weak picture rather than a strong and a weak picture.

Some prime trials. For *some* prime trials the sentence frames were "Some of the letters are [letter]" for strong and weak primes and "All of the letters are [letter]" for alternative prime trials. The two pictures in *some* prime trials contained nine letters. These pictures could be strong, weak, or false depending on the sentence predicate. The nine letters in strong pictures were made up of six letters which matched the predicate

and three other letters. Weak pictures contained nine letters that matched the predicate. False pictures also contained nine but these were different from the predicate.

Number prime trials. Strong and weak prime trials used the sentence frame "There are four [letter]'s". Alternative trials used "There are six [letter]'s". Strong pictures contained four letters, weak pictures contained six letters, and false pictures contained two letters. All of the letters matched the predicate.

Ad hoc prime trials. The sentence frame in strong and weak prime trials was "There is a [letter]". The alternative trials used "There is a [letter] and a [letter]". Pictures contained either one or two letters. Strong pictures contained a single letter. Weak and false pictures contained two letters. The letter in the strong picture was the same as the predicate. Weak pictures contained one letter that was the same as the predicate and one that was different. Both of the letters in false pictures were different from the predicate.

Target trials. Target trials also contained two pictures. One contained letters and was a weak picture. The other was a "Better Picture" option, similar to the covered box paradigm (e.g. Huang et al., 2013). The sentence frame in target trials was the same as the one used in strong and weak prime trials. Consequently, if participants selected the picture with letters this was consistent with a weak (non-implicature) interpretation of the sentence. Selecting the "Better Picture" option corresponded to a strong (implicature) interpretation.

Design

There were three types of expression (*some*, number, *ad hoc*). For each there were three types of prime (strong, weak, alternative). Consequently there were 3 (expression) x 3 (prime) = 9 conditions.

There were two primes for every target. This was done to boost the effect of the prime. Thus an experimental item was a triplet of two primes and a target. In prime trials the position of the correct picture was systematically varied (left or right) to prevent participants from becoming biased to pictures in a particular position. The positions were crossed so that there were 4 patterns of correct responses across the two prime trials (left-left, right-right, left-right, or right-left). Consequently each condition had four prime combinations. This resulted in 4 (combinations) x 9 (conditions) x 3 (triplets) = 108 experimental trials. Triplet presentation was randomised so that the order was different for each participant.

Thirty-six single filler trials were included. Filler trials were a mixture of prime and target trials which were indistinguishable from their experimental counterparts. The only

difference between filler and experimental target trials was that instead of a weak picture the filler trial had a false picture. The false picture had the same configuration as a weak picture but the letters were inconsistent with the sentence predicate. The filler target trials would therefore give participants the opportunity to select "Better Picture" and thus consider this as an acceptable response.

Procedure

The experiment was run as an online questionnaire using Qualtrics Survey Software. Participants were told to "select the picture which best matches the sentence" and to select the "Better Picture" option if the picture did not match the sentence. Participants were shown examples of prime and target trials with the correct image selected. The examples were accompanied by an explanation of why the selection was correct.

Participants responded by clicking a box under the appropriate picture with the mouse. Participants then clicked the "next" button to show the next trial.

Results

Analysis Procedure

Responses to target trials were removed if the corresponding prime trial was not answered correctly. In Experiment 1, 4% of the data was removed for this reason. Consequently, during pairwise comparisons these participants were not included in the analysis. The remaining data underwent a logit transformation.

Data were analysed using 3x3 ANOVA with prime type (strong, weak, and alternative) and expression (*some*, *ad hoc*, and number) as within-subjects factors. We used Bayes factors to interpret the nonsignificant findings (Dienes, 2011, 2014; Rouder, Speckman, Sun, Morey, & Iverson, 2009). We used the default JZS prior (Rouder et al., 2009) for all analyses. The JZS prior is a non-informative objective prior that minimises assumptions regarding expected effect size. Bayes factors using the JZS prior (0.707) were calculated using JASP (JASP Team, 2016). Bayes factors > 3 suggest 'substantial' evidence for the alternative hypothesis and Bayes factors < 0.33 indicate 'substantial' evidence for the null hypothesis (Dienes, 2011, 2014).

Analysis and Discussion

Figure 3 shows the rate of implicature to targets as a function of prime and expression. Three patterns are noteworthy. First, the overall rate of implicature varied across expressions, as shown by a main effect of expression, $F(2, 186) = 51.64$, $p < .001$. For *ad hoc* expressions, there was a clear bias towards the weak interpretation, whereas for *some* and the numbers the split was more even (although still biased towards weak interpretations). This pattern corresponds with our intuitions, in that the weak

interpretation seems particularly salient for the *ad hoc* expressions, but it is not obvious what causes this result. We return to explanations of this effect in the General Discussion.

Second, rates of strong interpretations were higher following strong and alternative prime trials than weak primes, as shown by the main effect of prime, F (2, 186) = 32.24, p < .001. Planned comparisons showed that rates of implicature were significantly higher following strong primes than weak primes, t (99) = 6.67, p < .001, illustrating the basic priming effect observed by Bott and Chemla (2016). There was also significantly greater rates of implicature following alternative primes than weak primes, t (99) = 6.69, p < .001.

Finally, there was no difference between rate of implicature following strong and alternative primes, t (99) = .13, p =.89, BF = 0.11. That the BF was less than 0.33 suggests strong support for the null hypothesis, and consequently, support for the salience model.

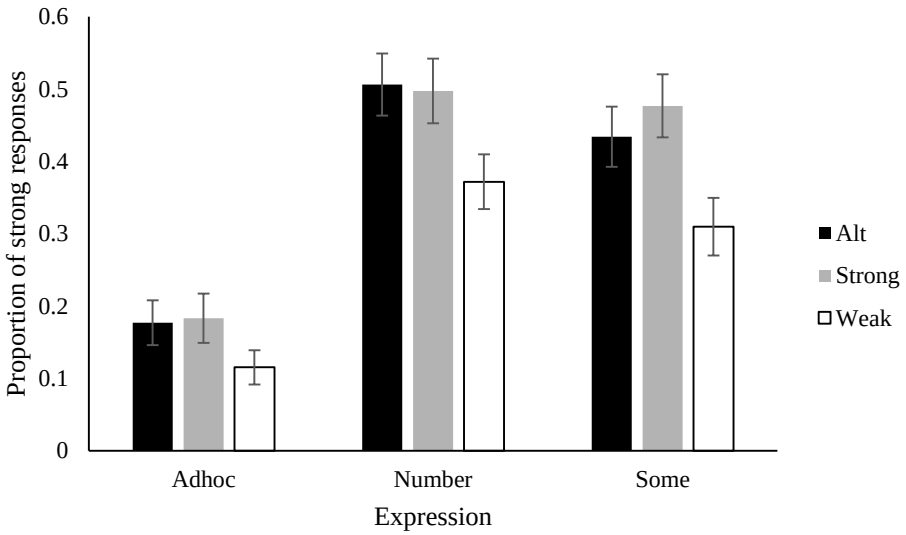

Figure 3. Proportion of strong (implicature) responses to target trials by expression. Error bars show standard error.

While there was no significant interaction between prime and expression F (4, 372) = 2.00, p = .094, BF = 1.84), the BF suggests that the experiment was insensitive in this respect. We therefore considered each expression separately. As Figure 3 shows, the same pattern was found across each. There were significantly higher rates of implicature following strong and alternative primes than weak primes for *ad hoc,* number, and *some* expressions, t (95)'s > 2.69, p's < .009; t (99)'s > 4.38, p's < .001; t (97)'s > 4.51, p's < .001, respectively, and no difference between strong and alternative primes across expressions, t (95) = .44, p = .66, BF = 0.12; t(99) = .20, p = .84, BF = 0.11; t (97) = .94, p = .35, BF = 0.17. In short, the data suggest that the alternative prime was just as effective as the strong prime, regardless of whether the expressions were considered separately or as a whole.

Individual participant details

It is possible that the priming effects reported above were due to participants changing interpretation only once during the experiment. Perhaps a participant started the experiment with a particular interpretation, strong or weak, but then switched to a different one after they realised that in this particular context the opposite interpretation was more appropriate. They then maintained the alternative interpretation throughout the experiment. This would be a global priming effect linked to particular experimental contexts, rather than a local priming effect. To investigate this we examined how often individual participants switched from one interpretation to another across the experiment. Figure 4 shows the results.

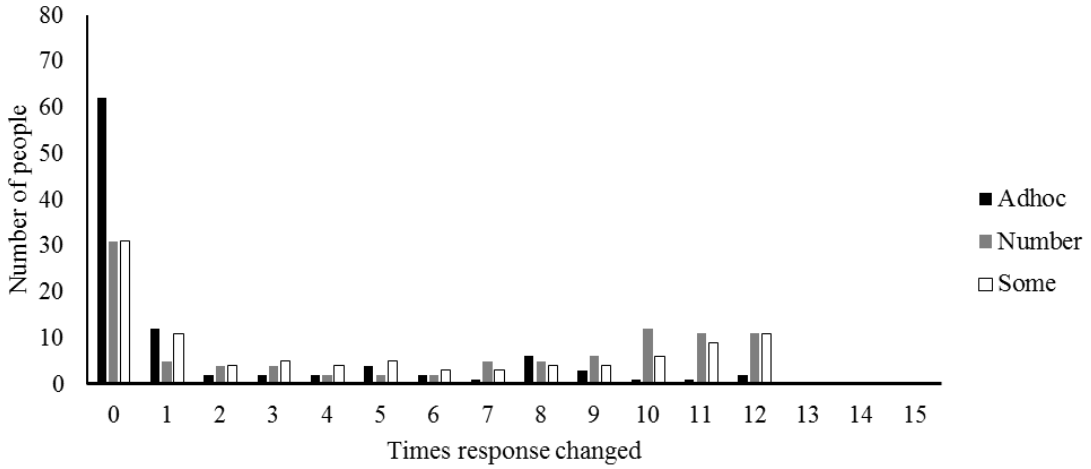

Figure 4. Frequency of response changes.

Consider first the *some* expressions. Out of 100 hundred participants, 31% maintained the same interpretation throughout the experiment (either strong or weak). A further 11% changed only once, but the remaining 68% changed at least twice, such as from strong to weak and back again to strong. The results for the numbers are similar. Around a third could not be primed at all, but around two thirds changed interpretation at least twice. There were more participants who could not be primed for the *ad hoc* expressions, 62%, and 12% changed only once, but nonetheless 26% changed at least twice. The average priming effects consequently cannot be due to participants changing their interpretations once only.

Discussion

There were significantly more strong interpretations after a strong prime than a weak prime, replicating Bott and Chemla (2016), and significantly more after the alternative than the weak prime. Crucially, the rate of strong interpretations did not differ between the strong and alternative interpretations, and the Bayes Factor analysis suggests

that this was not because the experiment was insensitive to reasonable effect sizes. Consequently the result supports the salience model.

The findings from Experiment 1 suggest that alternative and strong prime trials raised the activation of the alternative so that on subsequent target trials, participants were more likely to derive scalar implicatures. In Experiment 2 we test a different explanation based on the visual structure of the pictures.

Experiment 2

The strong and alternative primes in Experiment 1 exposed participants to a strong picture. For example, the strong *some* prime and the alternative *some* prime exposed participants to a picture with nine letters, three of which were different to the others (*some but not all*). In contrast, the weak prime did not expose participants to a strong picture. Thus, a possible explanation for our findings (and those of Bott & Chemla, 2016), is that exposure to the strong picture caused participants to reject the weak option in the target trial. Perhaps participants became aware that a strong interpretation of the target sentence was possible after having seen a strong picture. While this explanation is similar to the salience explanation, it assigns the locus of the effect to the pictures, and not the sentence interpretation, and to an awareness of a strong interpretation, and not the alternative.

To test the strong picture explanation we altered the false picture configuration for weak primes. Weak primes now consisted of a weak picture and a false strong picture, that is, a picture that had a strong configuration but was false by virtue of the sentence predicate. Thus all three primes involved a strong configuration picture.

Method

Participants

One hundred participants took part. Fifty participants were recruited online (via Prolific.ac.uk) and were paid, and fifty students were recruited for course credit from Cardiff University. Demographic information is only available for the online participants (29 male, average age 25.6 years). All stated they were native English speakers.

Design and Procedure

The design and procedure were the same as for Experiment 1 except for the construction of the weak primes. Weak primes consisted of a weak picture and a false picture, but unlike Experiment 1, the false picture had a strong configuration. The letters in the false picture were inconsistent with the sentence predicate (see Figure 5).

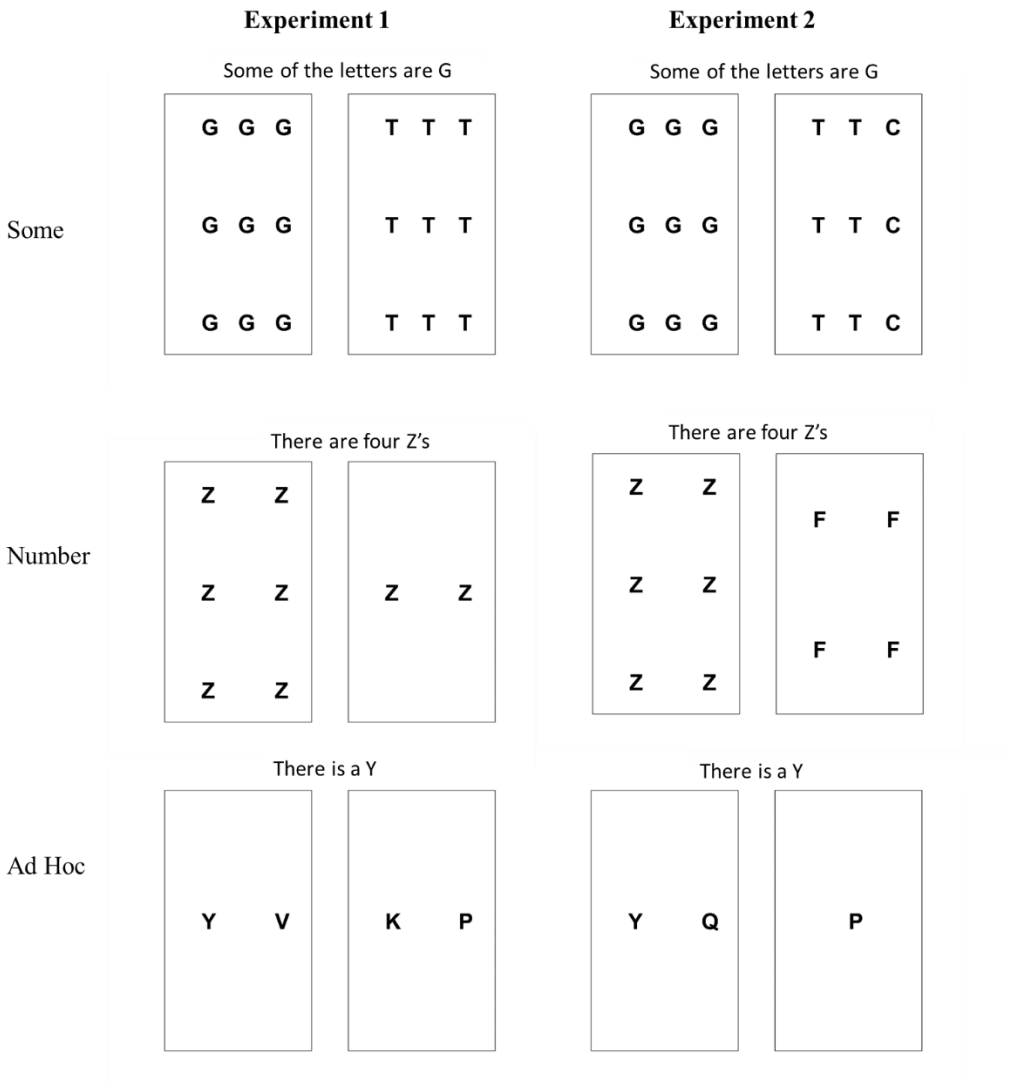

Figure 5. Change in weak prime stimuli from Experiment 1.

Results

Target trials with an incorrect preceding prime trial were removed from the analysis, as in Experiment 1. This accounted for 3% of the data. The remaining data underwent a logit transformation.

The main findings from Experiment 1 were replicated (see Figure 6). There was a main effect of prime type, F (2, 184) = 49.56 p < .001, and expression, F (2, 184) = 39.58, p < .001. The main effect of prime was caused by significantly lower implicature rates following the weak prime than following the strong or the alternative primes, t (99) = 7.60, p < .001 and t (99) = 8.35, p < .001 respectively, combined with no difference between rates of implicature following strong or alternative primes, t (99) = .13, p = .90, BF = 0.11, in support of the salience model. The main effect of expression was driven by significantly lower rates of implicature for the *ad hoc* expressions compared to the *some* and number expressions. Unlike Experiment 1, there was a significant interaction between prime type

and expression, F (4, 368) = 4.24, p = .002. We investigated this by testing the effect of the prime on each of the expressions.

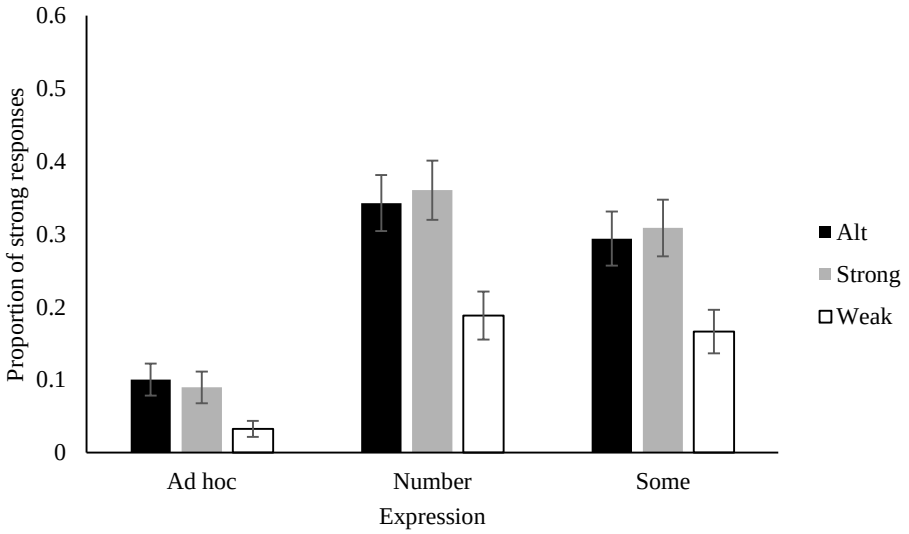

Figure 6. Proportion of strong (implicature) responses to target trials by expression. Error bars show standard error.

The interaction was driven by a significantly smaller effect of the strong/alternative prime on the *ad hoc* expressions compared to the *some* and number expressions. This is likely caused by floor effects for the *ad hoc* implicatures (overall, rates of implicature were lower in this experiment than in Experiment 1). When we removed *ad hoc* expressions from the analysis the interaction was no longer significant F (4, 369) = 0.58, p = .56, BF = 0.05.

More importantly, the same pattern of priming was found across all the expressions, just as in Experiment 1. There were significantly higher rates of implicature following strong and alternative primes compared to weak primes t (94)'s > 2.66 p's < .009, t (99)'s > 6.55, p's < .001, t (97)'s > 4.92, p's < .006, and there was no difference between strong and alternative primes across expressions, t (94) = 1.34, p = .18, BF = 1.31; t(99) = -.42, p = .68, BF = 0.12; t (97) = -.30, p = .77, BF = .29, for *ad hoc*, number, and *some* expressions, respectively, in support of the salience model. Note that although the Bayes Factor for *ad hoc* expressions suggests that there is only limited support for the null hypothesis, the potential effect is in the opposite direction to the prediction of the combination model. The combination model predicts a greater rate of implicature following a strong prime than an alternative prime, the opposite of the results here.

Individual participant details

We conducted a similar type of individual participants analysis as that in Experiment 1. Figure 7 shows the results. Overall the pattern is very similar to Experiment

1 although there is an increase in the number of participants who maintained the same response throughout the experiment. Nonetheless, for *some* and the numbers around half of participants changed their response at least twice in the experiment, and for *ad hoc* expressions 15% changed their response at least twice. As in Experiment 1 our results cannot be explained by participants changing response only once during the experiment.

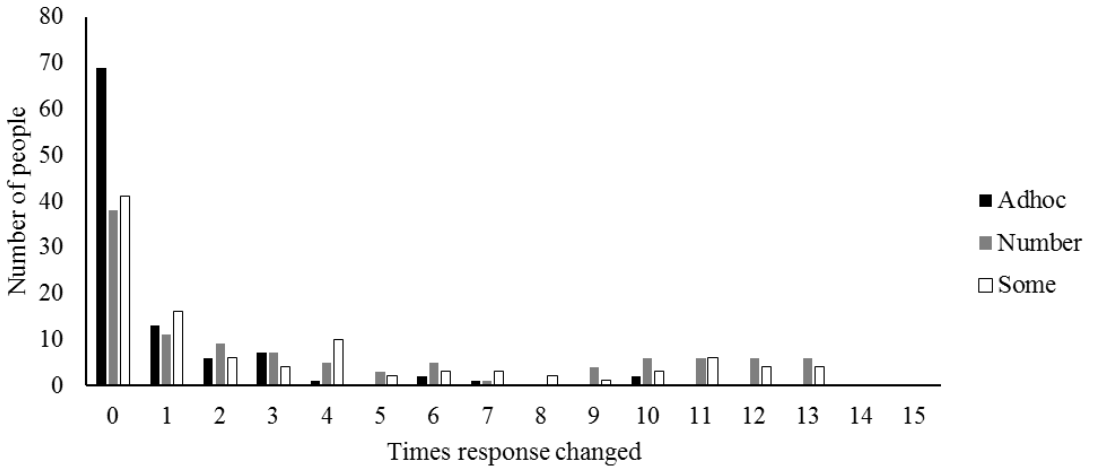

Figure 7. Frequency of response changes.

Summary

The priming effects we observed in Experiment 1 were replicated in Experiment 2. This provides more support for the salience model. Moreover, since the weak prime involved the same letter configurations as the strong prime, the priming effects cannot be explained solely by a visual priming effect.

Overall the rate of implicature was lower here than in Experiment 1, by around 10% (compare Figure 6 with Figure 3). This occurred across all three expression types. Could the cause of the lower rates of implicature be due to the change in the weak prime? This seems unlikely because in Experiment 2 there were more images corresponding to a strong interpretation than in Experiment 1. If anything, more strong images should have raised the implicature rate because participants would have been more aware of what a "better picture" might be. Consequently we attribute the difference across experiments to sampling variability (see Antoniou, Cummins, & Katsos, 2016, for a discussion of individual differences in scalar implicatures).

In Experiment 3 we test whether the priming effects might be due to a bias towards preserving a configuration->reference label mapping across trials.

Experiment 3

Consider the weak *some* prime in Figure 2. Here, the correct picture is made up of nine letters of one type (Z's). In the subsequent target trial the weak picture also has nine letters of the same type. Consequently, if the participant selects this picture they will have selected a picture with the same configuration (nine letters) and the same reference label (*some*) as the prime. In contrast, the correct response for the strong *some* prime has six letters of one type and three of another, but the weak picture in the target has nine letters of one type. If the participant selects the weak picture, they will have selected a card with a different configuration but the same label (*some*). This might feel incongruous because different pictures generally have different labels, and the participant might assume that since the label (*some*) is the same as the previous trial, the picture should also have the same configuration. Consequently they may prefer to select the "Better Picture" option. The strong-weak priming effect might therefore be explained by a desire to keep the configuration->reference label mapping consistent across trials. The alternative-weak priming effect can also be explained in this way. With the alternative *some* prime trial, the correct prime has nine letters, and the weak picture in the target trial also has nine letters. However, the label has changed between prime and target. In the prime trials, a picture with nine letters was described with the label *all* but in the target, a picture with nine letters was described with *some*. Thus, to maintain a consistent configuration->reference label mapping, the participant would select the "Better Picture" option. A similar form of reasoning can be used to explain the effects in the other expressions.

To test this hypothesis we altered the target trials so that instead of a scalar sentence, such as, "Some of the letters are A's," they contained an alternative sentence, such as, "All of the letters are A's" (see Figure 8). The target trials consisted of a weak picture, in which the letter configuration was consistent with the predicate (e.g., all nine letters were A's), and the "Better Picture" option. The prime trials remained the same as in Experiment 2.

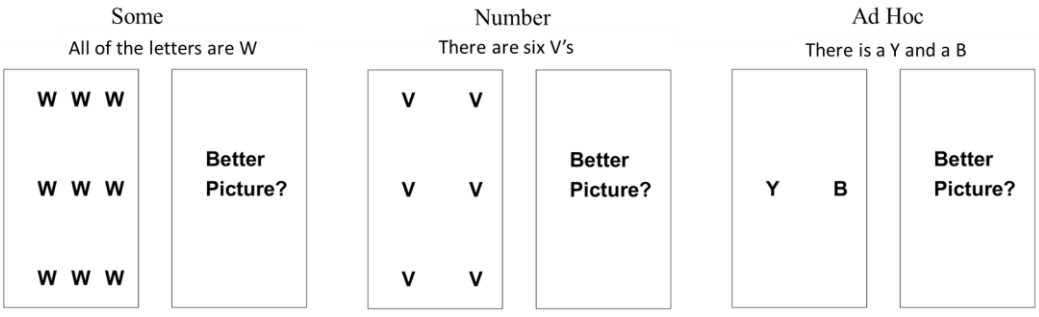

Figure 8. Experiment 3 Target trial configuration for some, number, and ad hoc expressions.

Consequently, when target trials were preceded by strong primes both the correct prime picture and the label were different between prime and target. Hence the weak picture in the target trial could be selected without breaking the configuration->reference label mapping. Similarly, when target trials were preceded by alternative primes, the weak picture could also be selected since configuration and label would be consistent across prime and target. However, when target trials were preceded by weak primes, selection of the weak picture in the target would be inconsistent with preserving the configuration->reference label mapping. Both prime response and weak target response have the same configuration but they would use different labels (see Figure 9). Hence in this case, a participant seeking to maintain a consistent mapping would choose the "Better Picture" option. The overall pattern of responding predicted by the configuration mapping hypothesis is that strong and alternative primes should lead to a low rate of "Better Picture" selections, while weak primes should lead to a high rate of "Better Picture" selections.

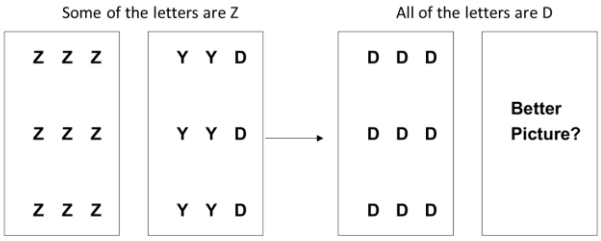

Figure 9. Example weak prime->target for Experiment 3.

Method

Participants

Twenty-five participants were recruited online from Prolific.ac.uk and were paid (15 male, average age 34.7 years).

Design and Procedure

The design and procedure were the same as in Experiment 2.

The sentence frame used in target trials was modified so that the sentence always used the alternative terms: *some* "All of the letters are [letter]"; number "Six of the letters are [letter]"; *ad hoc* "There is a [letter] and a [letter]".

Thirty-six filler trials were included. Twelve of the filler trials had a similar construction as target trials but consisted of a false picture and a "Better Picture" option. In these trials participants should always select the "Better Picture" option. This was to ensure that participants considered the "Better Picture" as a valid choice in target trials.

The remaining fillers were indistinguishable from prime trials. As in previous experiments, they served to break up the prime-prime-target structure.

Analysis and Discussion

The proportion of "Better Picture" selections following alternative, strong, and weak primes was 0.00, 0.01, and 0.02 respectively (for comparison, "Better Picture" selections to the false filler trials were at ceiling, 1.00). If there were a strong bias towards maintaining a consistent configuration-> reference label mapping across trials we would have observed a large increase in "Better Picture" selections following the weak prime. Since we did not, we can be confident the effects we observed in Experiments 1 and 2 were not due to a similar bias.

The configuration -> reference label hypothesis is part of a wider issue about visual similarity in priming tasks. Perhaps there is a general bias for people to select targets that are visually similar to the prime, irrespective of the sentence. In Experiments 1 and 2, the pattern of results we observed could be explained by an account along these lines. Participants chose the weak option in target trials after a weak and an alternative prime, which are structurally similar (e.g., in *some* trials, the weak prime has 9 identical letters, as does the weak target option), and the "Better picture" option after the strong prime, for which the weak target is not structurally similar (e.g., in *some* prime trials, the strong option has 6 letters of one type and three of another, but the weak option in the target does not). The results of Experiment 3 argue against this hypothesis, however. If visual similarity were the only explanation for the priming effect, strong primes should have been followed by a high rate of "Better Picture" responses (strong prime options differ substantially to the alternative target options) relative to weak and alternative primes (weak and alternative primes are structurally similar to the alternative target options), but these were not the results we observed. It might be possible to argue for a weak visual similarity account of our findings, however, in that the target cards were unambiguous in Experiment 3, and possibly the role of visual similarity is greatly weakened when the sentence is unambiguous. Our response is to note that the priming effects we observed in Experiments 1 and 2 were extremely large and if a visual bias were to exist, we would have expected to observe priming effects of some degree in Experiment 3, even if they were smaller effects, but we observed nothing at all. Furthermore, other researchers using extremely similar paradigms (but with ambiguous sentences) also conclude that visual similarity alone cannot explain their priming effects (see Bott & Chemla, 2014; Feiman & Snedeker, 2016; and Raffray & Pickering, 2010).

More generally, the results of Experiment 3 illustrate that the effects of the prime are restricted in ways that are theoretically sensible. The primes do not affect every target response. They only alter responses when there is a meaningful linguistic link between prime and target. Participants were not so influenced by a pragmatic need to please the experimenters that they altered their responses whenever they saw two consecutive primes, for example. Nor were they misunderstanding the role of the "Better Picture" option. They used the "Better Picture" option when they could think of a better picture that matched the meaning of the sentence, and not for other reasons.

General Discussion

This study tested between a salience model of implicature, in which the implicature decision is entirely determined by the activation of the alternative, and a combination model, in which an independent mechanism that uses the alternative also plays a role. While we found strong evidence that an active alternative primed implicatures, there was no evidence that the usage mechanism could also be primed. This pattern occurred in three types of scalar implicatures (*some*, numbers, and *ad hoc*) and across two experiments. We also conducted a third experiment to eliminate a possible relabelling explanation of the priming effect. Since none of our findings require the more complex, combination model, we favour the salience model.

An obvious concern is that our conclusion is based on the absence of an effect rather than an observed effect. There are two, connected, issues here. First, how can we be sure that our experiments were sufficiently powerful to detect a reasonably sized effect? And second, how do we know how large the usage priming effect should be? The answer to these questions lies partly with the Bayes Factor (BF) analysis that we used to test the null findings. The logic behind the BF is that the experimental hypothesis (in this case that there is priming of the usage mechanism) makes effect size predictions, as does the null hypothesis (that there is no usage priming), and the BF is the ratio of the likelihood of the experimental hypothesis explaining the data to the likelihood of the null hypothesis explaining the data. Under the effect size assumptions we made, and the data we observed, the odds were much higher in favour of the null hypothesis than the experimental hypothesis. Note that standard frequency-based statistics (p-values from e.g. t-tests) do not allow researchers to state evidence in favour of the null hypothesis (Rouder et al., 2009), as we do here, for a variety of reasons, such as the fact that p-values under the null hypothesis do not converge to a limit as sample size increases. With respect to the effect size, the analysis we report assumed an effect size distribution centred around a medium

effect (a non-informative prior), but unless effect sizes of the usage priming mechanism are taken to be exceptionally small, the analysis always favoured the salience model.

A related issue is whether an independent usage mechanism exists but cannot be primed. This would be a mechanism that was affected by factors other than the salience of the alternative, but would not be sensitive to recent activity. Clearly, such a mechanism would not be observable with the paradigm used here. While we cannot eliminate this explanation, a large range of linguistic representations and processes have been successfully primed using similar paradigms (e.g., active versus passive forms, Bencini & Valian, 2008; transitive and dative syntactic forms, Bock 1986; animacy assignments, Bock, Loebell, & Morey, 1992; conceptual level structures for configurations in a maze, Garrod & Anderson, 1987; scopal interpretations with "every", Raffray & Pickering, 2010; semantic coercion, Raffray, Pickering, Cai, & Branigan, 2013) and a non-primeable usage mechanism would be noteworthy for this reason alone. Furthermore, research on priming often has the tacit assumption that if the representation or mechanism of interest cannot be primed, no such representation exists (Branigan & Pickering, 2017; Pickering & Ferreira, 2008). For example, Raffray et al. (2013) suggest that a failure to find priming of noncompositional semantic-to-syntactic mappings would mean that there was no difference between compositional and noncompositional mappings. The difference between our study and those of other researchers is that we have drawn conclusions from negative observations rather than positive observations, but the logic of our study is identical. Finally, the priming effects shown in this study exclude the possibility that scalar implicature mechanisms in general are impervious to priming; the usage mechanism in particular would have to be non-primeable.

Priming scalar implicatures

We observed substantial priming of scalar implicatures. When the target trials were preceded by either the strong or the alternative prime trials, there were more implicatures relative to when the target was preceded by a weak prime. Whilst it is clear that scalar implicatures were primed, there are several potential explanations for why.

The first is that strong and alternative primes raised activation levels of the alternatives during target trials, whereas weak primes did not. Consequently more alternatives exceeded the threshold in the strong and alternative conditions, thereby resulting in more implicatures. This is the account we presented in the Introduction. The second is that participants were primed to view the context as one in which informativity, or precision, was important. Implicature derivation requires individuals to be sensitive to informativity. The listener must be aware that a speaker could have been more

informative, i.e. could have used a stronger expression, and that the speaker was aware that they were less informative than they could have been. Accordingly the prime trials may have altered participants' assumptions about acceptable levels of informativity (precision). The strong prime could have generated a context in which an informative, or precise, interpretation was expected. In target trials the expectation of informativity is best satisfied by the "Better Picture" option. Conversely the weak prime generated a loose, or "good enough" context. Consequently, in target trials, participants could have believed the weak image was good enough after the weak prime, since this satisfied the contextual demands. Alternative primes might also generate a precise context because the sentence was maximally informative, thus encouraging a more precise response to the subsequent target.

We cannot distinguish the two explanations from the data but the local priming effects we observed argue against the informativity account. We used a within-subject design in which the primes varied within the same experimental context. The individual participant analysis confirmed that participants switched between strong and weak interpretations of the same expression. Alternatives might be expected to vary in activation across short time intervals (i.e. locally) because linguistic contexts can change rapidly in dialogue (the same alternative might be active in one context but not in another a few seconds later). In contrast, precision is more likely to be a property of a global context, such as the style of individual speakers (e.g. X speaks precisely, Y does not), individual listeners (e.g. children might be tolerant of imprecision, and so are less likely to derive an implicature, relative to adults, as in Katsos & Bishop, 2011), or situational factors (e.g. one should be precise when describing experiments in reports, but loose is fine when texting).

A further explanation is that the priming effect was driven entirely by priming of the weak interpretation. Perhaps participants derived the strong interpretation by default, and were then reminded of the weak interpretation following the weak prime. There are two arguments against this explanation, however. The first is that responses were biased towards the weak interpretation, if anything, not towards the strong interpretation. This is particularly clear for the *ad hoc* expressions. Here, the overall proportion of strong responses was 0.15 in Experiment 1 and 0.08 in Experiment 2. If the default were indeed the strong interpretation, we would have expected much higher proportions of strong interpretations overall. The second is that participants repeatedly switched between strong and weak interpretations of the target within the task, as illustrated by the individual participants analysis. This means that strong and alternative primes must have

shifted responses from weak to strong, at some point, rather than from strong to weak only. Participants responded weak after weak primes, and then strong after alternative/strong primes, then returned to weak after weak primes etc. The weak prime hypothesis could not explain the effect of switching from a weak response to a strong response.

The explanations above do not challenge the salience account. Whether activation, informativity, or default implicatures are the root cause of the priming effect, none require an independent usage mechanism. The final possibility we consider however, is a dual explanation model, which uses alternative activation and a usage mechanism. Consequently it supports a combination model. The dual explanation account proposes that the priming effect in the strong condition was caused by a combination of primed usage mechanism and primed alternatives, whereas that in the alternative condition was caused solely by the primed alternatives. The reason why the effect was the same size across conditions is that the alternative priming effect was greater in the alternative condition than the strong condition, which was then offset by priming of the usage mechanism. We argue against the dual explanation account, however, for the following reasons. First, it is more complex than the salience account but explains no more data. The dual account requires one set of factors to explain the alternative priming effect and another to explain the strong priming effect, and that these produce the same sized effects (in three expression types). In contrast, the salience account proposes one set of factors that explains both sets of effects, and the reason the effects are the same size is that they have the same underlying cause.

Second, the combination account assumes that the alternative priming effect is smaller in the strong condition than the alternative condition, and we see no reason for this assumption to be true. Note that the reason cannot be that the alternative was considered more often in the alternative condition because participants must have generated the alternative in the strong prime trials to select the correct response (and we omitted trials in which this did not happen). Thus the alternative must have been more active in the alternative condition, over and above that which caused the implicature to be triggered. One potential reason is that participants read the alternative in the alternative condition but derived it themselves in the strong condition. Perhaps comprehension is a more effective prime than production. But there is no evidence that comprehension-to-production priming (as in the alternative condition) is more effective than production-to-production priming (as in the strong condition). Certainly, structural priming studies demonstrate that comprehension to production priming exists (e.g. Branigan, Cleland and

Pickering, 2000), but there are many production-to-production priming studies showing extremely large effects (e.g., Pickering & Branigan, 1998; see Pickering & Ferreira, 2008, for a review) and it is difficult to see why using comprehension procedures should prime production procedures more than production procedures themselves. A similar argument can be made from the education literature. Researchers have shown that re-reading text (comprehension) is not as effective a learning aid as self-generating answers (production; e.g., Dunlosky et al. 2013). One reason for this could be that production makes the information more salient than comprehension, contrary to the dual explanation account assumptions.

The dual explanation account of our findings is logically possible but we do not find any reason to reject the more parsimonious salience explanation. We found no difference between conditions using three expressions and we feel that the onus is now on proponents of the combination model to find positive evidence of an independent usage mechanism.

Alternatives in scalar implicatures

Our findings help to clarify and extend previous work on alternatives in scalar implicatures. Skordos and Papafragou (2016) found that when children were exposed to relevant alternatives, the rate of implicatures increased, but not when they were exposed to the same alternatives but in an irrelevant context. Our data suggests the salience model provides the best explanation for these findings. In the relevant condition of Skordos and Papafragou, it was necessary to process the quantifiers deeply in the training block to correctly match the picture to the sentence. Activation levels of the quantifiers were consequently high. Conversely, in the irrelevant condition, processing could be much more shallow, and quantifier activation levels were consequently low. In the subsequent testing block, high activation levels of the alternatives in the relevant condition translated into high rates of implicature. While this does not conflict with Skordos and Papafragou's claim that the deficit in children's processing lies in their understanding of relevance (as compared to a deficit in lexical retrieval of the alterative), it shifts the locus of the explanation away from how alternatives are used by children towards how activation levels are computed, and how this might differ between adults and children.

Our study also extends Skordos and Papafragou (2016) by demonstrating that alternative activation is a determiner of scalar implicatures in numbers and *ad hoc* scales, not just *some*. This is important because it suggests that the process by which strong and weak meanings are related in numbers and *ad hoc* implicatures is the same as in *some*. While *some* is the prototypical scalar implicature, there is some controversy about

whether the strong number meaning (*exactly* N) is derived from a lexically specified weak number meaning (*at least N*), as in standard scalar implicatures (e.g., Horn, 1972; 1989), or whether the weak meaning is derived from a lexically specified strong meaning (e.g., Breheny, 2008, Geurts, 2006; and see Huang, Spelke & Snedeker, 2013, for psychological evidence). Since strong interpretations can be primed in similar ways for numbers and *some*, the most straightforward conclusion is that the derivation and representation processes are also similar.

This is not to say that there were no differences between the different expressions in our task. While priming effects were similar across expressions, *ad hoc* expressions had a much lower rate of implicature than *some* or the numbers. One explanation is that the alternative for *ad hoc* expressions was more difficult to derive than the alternative for the other expressions (see Bott & Chemla, 2016, for a similar point). For *ad hoc* expressions, the alternative required adding material to the sentence (e.g. the alternative to "There is an A," was, "There is an A and a D") whereas for *some* and the numbers, the alternatives involved replacing an element of the sentence with another element (e.g. the alternative to "Some of the letters are As" was "All of the letters are As"). Expansion could be more complex for the language processor than replacement. This mirrors Katzir (2007), who argues that there is a fundamental difference between alternatives formed from replacement and those formed by the addition of material.

There are some problems with this explanation, however. One is that in the alternative prime condition, participants were presented with the alternative structure immediately prior to the target. The difficulty involved in generating an alternative for the *ad hoc* expressions must have been minimal in this condition, yet differences across expressions were large. Another is that the developmental data isn't consistent with the claim that *ad hoc* alternatives are more difficult to derive than *some* alternatives (*all*). Barner, Bale and Brooks (2010) showed that while 4 year old children had difficulty retrieving the alternative for *some* (as did Skordos & Papafragou, 2016), they easily constructed the alternative for context dependent conditions, which were similar to the *ad hoc* expressions used here. If the alternative for *some* is easy to derive, one might expect it to be acquired early. Consequently, it might be that complexity plays no part in the construction of alternatives after all, and instead, the *ad hoc* alternatives are less salient for some more general contextual reason.

Another possibility is that the difference in rate of implicatures across expressions is due to differences in the baseline activation of an independent usage mechanism. Participants might have had less experience with generating *ad hoc* implicatures than

quantifiers and numbers, which in turn would lower the baseline activation for the usage mechanism in these cases. We cannot rule this explanation out completely but we make two arguments against it. First, this explanation requires a separate usage mechanism for each expression (a separate usage mechanism for *ad hoc* implicatures, quantifiers, and numerals). Accounting for the difference in implicature rates on the basis of the salience of the alternatives requires only a single usage mechanism for all three expressions. The salience explanation is therefore more parsimonious. Second, if the different usage mechanisms obtain different levels of baseline activation through experience, it is not clear why they could not be primed in our experiment. Developmental priming of structures is generally assumed to operate using the same mechanism as short term priming (Pickering & Ferreira, 2008) and in which case, a structure that is susceptible to developmental priming should also exhibit short term priming.

Our results also bear on the interpretation of Bott and Chemla (2016). Recall that Bott and Chemla observed priming of implicatures within the same expression (e.g. from *some* to *some*), just as we did. However, they also found that different sorts of implicatures primed each other (e.g., *some* primed numbers). They suggested that this effect could be explained in two ways. The first assumes that a usage mechanism was primed. The strong prime trials elevated the activation of the usage mechanism so that when reading the ambiguous target trials, participants were more likely to use the alternative, i.e. combine it with the literal meaning. This explanation is consistent with a combination account, in which alternative salience and alternative usage make different contributions to the rate at which people derive implicatures. The second was that an alternative search mechanism was primed. In the former, a mechanism could be triggered to search for alternatives so that the mechanism was more active after a strong prime trial than a weak prime trial, regardless of whether the expressions were of the same type. This explanation is compatible with the salience model. Since we found no evidence for the primeable usage mechanism, our data suggest that the search mechanism was the more likely explanation for Bott and Chemla's between expression priming results.

Finally, Katsos and Bishop (2011) found that in some contexts, children were aware of alternatives but chose not to derive the implicature (they were more "tolerant" of underinformative sentences than adults). This finding is difficult to reconcile with our conclusion: If there is no independent usage mechanism, how can people be aware of the alternative but not derive an implicature? We are not confident of the answer but we suggest the difference might lie in a cancellation mechanism. While scalar implicatures might always be derived given sufficient salience of the alternative, there might be a

cancellation mechanism that applies after the fact, as in traditional defeasement. It might be this mechanism that differs across adults and children, not the initial derivation of the implicature.

Scalar implicatures and representations

Scalar implicatures are typically described in terms of mechanisms, such as deriving the alternatives and adherence to maxims, in keeping with pragmatics tradition, whereas structural priming researchers refer to representations, in keeping with syntax and semantics. However, Bott and Chemla (2016; see also Rees & Bott, 2017) suggest that implicatures could also be seen as meaning-based representations that can be primed (similar to Raffray and Pickering's (2010) account of scopal ambiguity priming). They note that the processor could access a representation for scalar implicature, [S + not(Alt(S))], where S corresponds to the sentence and Alt a more informative sentence (an alternative), and that this representation could be linked to trigger expressions such as *some*. Both the link between the trigger expression and the representation itself could be primed, much like the representations and links assumed in the structural priming literature (e.g. between verbs, such as *give*, and syntactic frames, such as double object constructions, see Pickering & Branigan, 1998). We agree that it is useful to consider implications in this way but our results argue against the equivalence of the representations proposed in the structural priming literature and an [S + not(Alt(S))] implicature representation, as we describe below.

That there are meaning-based representations associated with scalar implicatures is indisputable. Since implicatures are part of what is communicated, implicatures must be represented by the listener. However, our results demonstrate that this representation is not independent from the material that gave rise to it, in the sense proposed by researchers in the structural priming literature. It is not a static, pre-existing frame that is waiting to be filled by appropriate content, as it is in a syntactic frame. Two aspects of our finding give rise to this conclusion. First, if there were such a representation, we should have been able to prime it. We used the same method that has been used to discover independent representations in the structural priming literature yet we saw no evidence of a primeable implicature representation. Second, we found that alternatives primed scalar implicatures. Although this does not conflict with the existence of an [S + not(Alt(S))] representation, there is no evidence that structural priming representations, such as syntactic frames, are influenced by an alternative (indeed, syntactic frames do not have alternatives in the same way that utterances do). Overall, our work suggests that

implicature representations are quite different to those proposed in the structural priming literature (c.f. Rees & Bott, 2017).

Default scalar implicatures and salience

The salience account is similar in many respects to the Neo-Gricean, default model (e.g., Levinson, 2000; Horn, 1972). In both cases, the implicature is obligatorily derived (i.e., by default) providing the alternative is salient. How then, does the salience account explain the processing cost associated with scalar implicatures, as observed by Bott and Noveck (2004) and others (e.g., Breheny, Katsos & Williams, 2006; Huang & Snedeker, 2009)? The default model, as expressed by Bott and Noveck, stated that the implicatures are always derived, but that they can sometimes be cancelled. Thus there is no explanation for why the weak interpretation of a sentence can ever be faster to understand than the strong interpretation, as per their results. Under the salience account, however, the strong interpretation will only arise if the alternative is sufficiently salient. If the context does not sufficiently raise the salience of the alternative, the strong interpretation will not arise. Thus, in the literal conditions of Bott and Noveck, the argument would be that the alternatives were not sufficiently salient, and so no implicature was derived. Conversely, in the implicature conditions, the alternative was made salient, and so the alternatives were negated, incorporated into the sentence etc., with the accompanying processing cost. Politzer-Ahles and Gwilliams (2015) and Degen and Tanenhaus (2015) make similar arguments. Of course, this is only a hypothesis, and we look forward to further work testing whether processing costs associated with scalar implicatures are reduced when alternatives are salient.

Summary

The aim of these studies was to investigate the role that alternatives play in the derivation of implicatures. Previous work has focussed on how the alternatives are used, whereas here we focussed on the role played by salience. Our study makes two important contributions. (1) We demonstrate that adults are sensitive to the salience of alternatives when deriving scalar implicatures. This is a local effect, not dependent on using different speakers or contexts to vary salience, and applies across a wide range of purported scalar implicatures. (2) We find no evidence of a usage mechanism that applies independently of the salience of the alternative. We thus suggest that the rate of scalar implicature is determined entirely by the salience of the alternative.

Chapter 3: Deriving *Ad Hoc* implicatures.

Scalar implicatures arise when a speaker uses a less than maximally informative term. Consider the example "Betty passed some of the exams". Since the speaker did not say that "Betty passed all of the exams" the implicature that Betty passed *some but not all* of the exams arises. This is considered scalar because the quantifiers *some* and *all* form a lexical scale <some, all>, which is ordered on informativity, where *all* is the informationally stronger alternative to *some*. In Chapter 2 we saw that raising the salience of the alternative aids the derivation of scalar implicatures. Adults were primed to derive a scalar implicature and when the alternative was the prime derivation occurred at a similar rate as when the scalar implicature was the prime. This pattern is seen in different categories of enrichment and suggests that providing the alternative is sufficiently salient an implicature will be derived. These effects were seen in metalinguistic interpretation judgements which occur at the end of processing. Consequently these results cannot tell us about the online *linguistic* processing of implicatures or how priming may affect processing.

The experiments presented in this chapter focus on one particular type of enrichment, *ad hoc* enrichments. *Ad hoc* enrichments differ from prototypical scalar implicatures because they are contextually based and thus do not have a clearly defined set of alternatives in the same way that quantifiers do. Nevertheless, similar priming effects have been seen previously in *ad hoc* enrichments. Thus the aims of the experiments presented in the chapter are twofold. First we want to investigate how priming influences the processing of implicatures, if indeed it does. Secondly we test two explanations for how *ad hoc* enrichments are derived.

Ad hoc implicatures

Not all implicatures that arise are based on lexicalised scales. Many expressions can be enriched from contextually based alternatives; the enrichment occurs on an *ad hoc* basis. Take the following:

(1) A: I hear Helen's husband is rich and intelligent.
B: Well, he's rich.
=>He's not intelligent.

(2) A: Are Mary and John coming to the party?
B: John is.
=>Mary is not coming.

(3) A: Where are the cakes?
B: Charlie ate some of them.
=>Charlie ate some but not all of the cakes.

In these examples B's replies imply that (1) Helen's husband is *not intelligent* and (2) *Mary is not coming to the party.* There are no established scales that would allow for these implicatures to be derived. The implication in (1) depends on A's previous statement about him being rich and intelligent. If instead A had said that Helen's husband was rich and handsome B's response would have given rise to a different implicature, *not handsome.* This is in contrast to (3), if instead of cakes Charlie ate some of the cookies, the same implicature (that he ate *some but not all*) would arise.

Some authors suggest that *ad hoc* implicatures can be derived in the same way as implicatures arising from quantifiers or numerals (e.g. Bott & Chemla, 2016; Hirschberg, 1991). The alternatives for *ad hoc* implicatures are contextually based rather than lexicalised (e.g. Hirschberg, 1991; Stiller, Goodman, & Frank, 2014) but an *ad hoc* scale can be constructed e.g. <rich/intelligent, rich & intelligent>, <Mary/John, Mary & John>. The stronger element in the scale can then be negated, e.g. not (rich & intelligent), just as in quantifier implicatures, e.g. not (all). Linguistic support for the claim that *ad hoc* implicatures are derived in the same way as quantifier implicatures comes from the observation that they behave similarly in different linguistic environments, such as defeasement, e.g. (4), embedding in the antecedent of the condition, e.g. (5), and negation (6).

(4) John's coming. But that's not to say that Mary isn't; I just don't know.
=/=> Mary is not coming to the party.

(5) If John's coming, then I'm not!
=/=> Mary is not coming to the party.

(6) John's not coming.
=> Mary is coming.

Support for this also comes from a number of experimental results. The experiments in Chapter 2 found that there was no difference in rates of implicature derivation following the alternative prime trial or the strong (implicature) prime trial for quantifier, numeral, or *ad hoc* implicatures (although the rates of enrichment overall were significantly lower for *ad hoc* implicatures). Similarly, Bott & Chemla (2016) found that *ad hoc* implicatures primed quantifier and number implicatures, suggesting overlapping methods of derivation.

Although *ad hoc* implicatures appear to share many of the same characteristics as quantifier and numeral enrichments there are some interesting differences too. First, the developmental trajectory seems to be different. Children often have difficulty generating quantifer implicatures (e.g. Huang & Snedeker, 2009; Noveck, 2001; Papafragou & Musolino, 2003), in part due to their difficulty in generating appropriate alternatives (Barner, Brooks, & Bale, 2011; Chierchia, Crain, Guasti, Gualmini, & Meroni; 2001; Gualmini et al, 2001). Children seem unaware that their knowledge of scalar terms (e.g. all) is relevant when interpreting other scalar terms (e.g. some). In contrast, they seem to have no difficultly deriving *ad hoc* implicatures (Stiller, Goodman, & Frank, 2014), or number implicatures (Papafragou & Musolino, 2003). For example, Stiller et al used a referent selection task where they presented children with three characters and a label such as "My friend has glasses". One of the characters wore glasses and another wore glasses and a hat. They found that children selected the character with the single item (glasses) more often than the other characters suggesting that the children had made the implicature that "My friend has glasses *but no hat*," just as adults do.

Second, there is some evidence that *ad hoc* implicatures and quantifier implicatures are processed differently. The most direct comes from van Tiel and Schaeken (2016), who tested whether exhaustivity in *it*-clefts are processed in the same way as quantifier implicatures (and other sorts of enrichments). Exhaustivity in *it*-clefts is exemplified in (7).

(7) It was Mary who ate a pizza.
=> *Nobody other than Mary ate pizza.*

Here, the cleft, "It was…" emphasises that it was only Mary that ate the pizza. Whilst some argue the clefts semantically force the exhaustivity (much like *only*) (Atlas & Levinson, 1981; Büring & Križ, 2013; Bolinger, 1972; Hedberg, 2000; Percus, 1997; Velleman et al, 2012), there is growing support for an implicature-based explanation (Drenhaus, Zimmermann, & Vasisth, 2011; Destruel & Farmer, 2015; DeVeaugh-Geiss, Zimmermann, Onea, & Boell, 2015; van Tiel & Schaeken, 2016), involving the construction of alternatives. If *it*-clefts are implicature based, the exclusivity in *it*-clefts should incur a processing cost similar to that seen for scalar implicatures (e.g. Bott & Noveck, 2004; Degen & Tanenhaus, 2011; Tomlinson, Bailey, & Bott, 2013; but see also Grodner, Klein, Carbary, & Tanenhaus, 2010). However, if exclusivity is reached without recourse to the alternatives then there should be no processing cost associated with exclusivity in *it*-clefts. van Tiel and Schaeken (2016) found that deriving a scalar implicature incurred a processing cost whereas

exclusivity in *it*-clefts did not. This would suggest that exhaustivity in *it*-clefts arises without consultation of possible alternatives.

Finally, there is a computational problem associated with deriving *ad hoc* implicatures in the same way as quantifier implicatures (see Geurts, 2010). Since *ad hoc* implicatures do not have a predefined lexicalised scale of alternatives in the same way as prototypical scalar quantifier implicatures do, there are theoretically an indefinite number of alternatives to be considered. Take the following example (from Geurts, 2010):

(8) A: What did you have for lunch?
B: I had some strawberries.

While B's reply would give rise to the implicature that she did not eat all of the strawberries it is also likely to also imply that she *only* ate strawberries. If A were deriving an implicature by considering the set of possible alternatives, she would have to negate an indefinite number of alternatives, such as, "I had some strawberries and a biscuit", "I had some strawberries, a biscuit, and a sandwich." It is not clear how the language processor could deal with this potentially infinite set.

Ad hoc implicatures without specific alternatives

The foregoing discussion presented the argument that *ad hoc* implicatures are derived by considering alternatives to what the speaker said, in much the same way as alternatives are used in quantifier implicatures. But we also noted important differences between the two phenomena. If *ad hoc* implicatures are derived in the same way as quantifier implicatures, why are there different developmental trajectories and processing signatures? Furthermore, how does the processer solve the problem of infinite alternatives? One way of reconciling these findings is to argue that *ad hoc* implicatures involve consideration of alternatives but not those of the same sort as quantifier implicatures. Thus there is partial overlap, but not complete overlap, with quantifier implicatures. In particular, *ad hoc* alternatives might require consideration of general alternatives, but not specific alternatives. Consider (1) again below

(1) A: I hear Helen's husband is rich and intelligent.
B: Well, he's rich.

Following the standard Gricean approach, the inference in (1) would be *He's rich but not intelligent*. However the implicature may instead be a type of exhaustive inference, *He's rich but nothing else* (Geurts, 2010). Following this logic the inference in (8) could be *I had strawberries and nothing else*. Exhaustive inferences could be derived by considering a

general alternative, e.g. *could the speaker have said anything else to be more informative?*, rather than specific alternatives, e.g. *why didn't the speaker say rich and intelligent?* Or *why didn't the speaker say strawberries and a biscuit?* This would avoid the need to consider an infinite number of alternatives since the only alternative needed would be a general *anything else* alternative. It would also differ from quantifier implicatures where the speaker makes a specific implication e.g. *some but not all*.

To address the question of how *ad hoc* implicatures are derived we present three experiments focusing on implicature processing. The first experiment looks at reaction times and the final two use the visual world paradigm. The main aim was to identify whether ad hoc implicatures are derived using exhaustive inferences (the *exhaustive account*) or a specific alternatives-based approach (the *specific account*), such as the standard account of quantity implicatures.

Experiment 1

The experiments in Chapter 2 investigated the role the alternative plays in the derivation of scalar implicatures. Participants derived implicatures at equivalent rates when the alternative was made salient and when they derived an implicature in the previous trial. This would suggest that *ad hoc* implicatures are derived by using specific alternatives, contrary to the exhaustive account discussed above. However there are several points to keep in mind with regards to the results of Chapter 2. Firstly, the proportion of ad hoc implicatures derived was significantly lower than for quantifiers and numerals. Thus the behaviour of the *ad hoc* implicatures was different to those of the quantifiers. The reason could be that the underlying derivation process is also different. Secondly, the task of asking participants for a "better picture" might obscure some of the derivation process. In prime trials participants were asked to decide which picture matched the sentence. In target trials participants were presented with one picture and then the option to choose a different picture if they thought there was a picture which would match the sentence better. This is odd because it is a different task from the prime trials; participants do not necessarily have to derive an implicature, they only have to decide that the picture they are provided with is not appropriate. Finally, the conclusions of Chapter 2 were based on interpretation judgements. Conclusions might be different when considering processing information.

In Experiment 1 we adapted the priming paradigm from Chapter 2 for processing. There were three primes (strong, weak, and alternative) and two targets (strong and weak). Target trials did not include a "better picture" option and consequently they were indistinguishable from the prime trials. According to the *specific account, ad hoc*

implicature derivation requires the use of specific alternatives. If this is the case, alternative prime trials should prime implicature derivation in the strong target trials to a similar rate as following strong primes because alternative primes provide participants with the specific alternative structure. This would be reflected in similar reaction times following strong and alternative primes. Reaction times to strong targets following strong and alternative primes would be faster than following weak primes (Noppeney & Price, 2004; Smith & Wheeldon, 2001; Wheeldon & Smith, 2003) and the opposite pattern would be expected for weak targets.

According to the *exhaustive account* however, specific alternatives are not involved in ad hoc implicature generation. Consequently alternative primes should not prime implicature derivation. Thus we would expect no difference in reaction times following alternative and weak primes; responses to strong targets should be fastest following strong primes and responses to weak targets should be slowest following strong primes.

Method

Participants

Forty-five Cardiff University undergraduate students participated for course credit. All participants were native English speakers.

Design & Materials

Each trial consisted of a sentence presented above two pictures. Participants had to match the sentence to one of the pictures.

There were two possible sentence frames for prime trials: “There is a [letter]” for strong and weak primes and “There is a [letter] and a [letter]” for alternative prime trials. Pictures contained either one or two letters (Figure 1). These pictures could be strong, weak, or false depending on the sentence predicate. Strong pictures contained a single letter. Weak and false pictures contained two letters. The letter in the strong picture was the same as the predicate. Weak pictures contained one letter that was the same as the predicate and one that was different. Both of the letters in false pictures were different from the predicate. There were three types of prime: strong, weak and alternative. Strong primes involved a strong and a weak picture, and weak prime trials involved a weak and a false picture. Alternative primes had the same picture configuration as strong primes, but due to the different sentence frame used, alternative primes had a weak and a false picture. Target trials were the same as strong and weak prime trials. For weak trials the correct response was to select the picture with the letter that matched the predicate. For strong trials the correct response was the picture with the single letter, which matched the predicate.

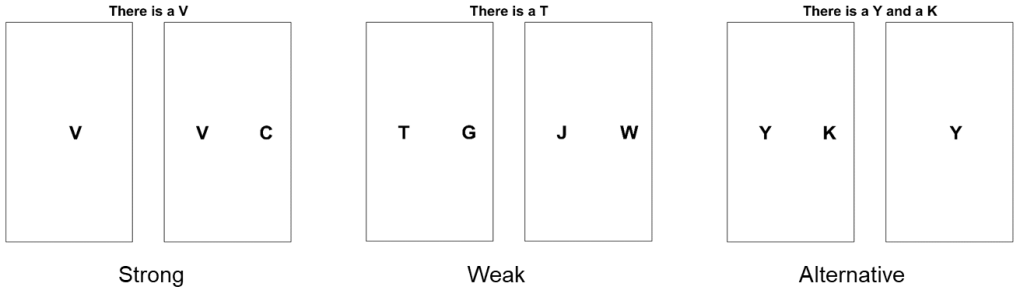

Figure 1. Example trials.

There were three types of prime trial (strong, weak, alternative) and two types of target trial (strong, weak). Thus there were 3 (prime) x 2 (target) = 6 distinct prime-target trial combinations.

For each combination there were 12 examples, this resulted in 12 (examples) x 6 (combinations) x 2 (pairs) = 144 experimental trials. An additional 36 alternative-target pairs were included along with 72 filler items. The alternative-target pairs consisted either a strong, weak, or alternative trial followed by an alternative trial. Figure 2 shows a filler item. This ensured that each type of trial was seen an equal number of times and prevented participants developing a response bias to mixed and complete displays. The inclusion of filler trials equalised the number of full set and partial set picture selections. Experimental and filler items were presented randomly. Sixteen practice trials were included at the beginning of the experiment, participants were unaware of the practice trials. The practice trials were not obviously different from the rest of the experiment.

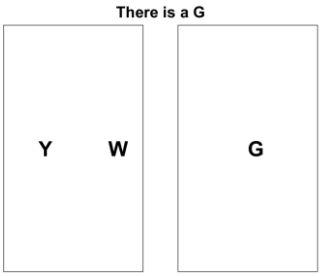

Figure 2. Example filler trial.

Procedure

The Experiment was run using Psychtoolbox-3 on MATLAB 2013b. Participants were told they would *"be presented with a sentence and two pictures. The task is to select the picture which best matches the sentence shown."*

In a trial an image pair and a sentence would be shown to a participant (Figure 3). The participant had to select which picture they felt best matched the sentence and respond using a key press. The pictures would stay onscreen until participants made a response. There was a 500ms interval between the presentation of items.

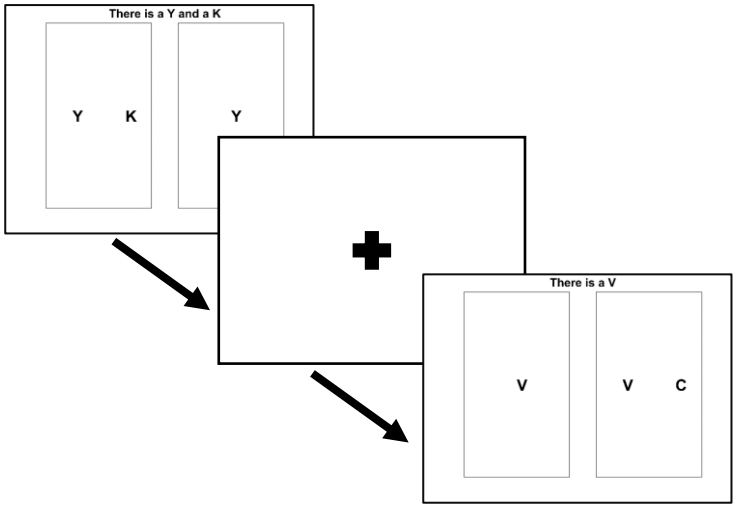

Figure 3. Example prime target sequence.

Results

A total of 3240 responses were made. Responses were not included in the analyses if the target trial was incorrect, if the previous prime trial was incorrect or if the response time was not between 0.3 – 3 seconds, this accounted for 11.7% of the data. The reaction times to the remaining trials were logged and analysed. A 3 x 2 ANOVA was run on the data with prime type (alternative, strong, weak) and target type (strong, weak) as within participant factors. There was no effect of prime (F (2, 88) = 2.62, p = .078, BF = .255) or target (F (1, 44) = 1.47, p = .232, BF = .311). There was a significant interaction between prime type and target type (F (2, 88) = 22.75, p < .001).

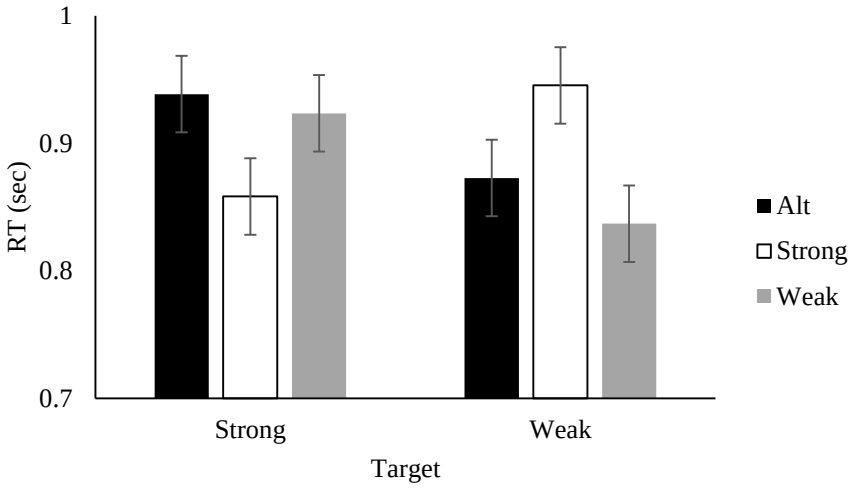

Figure 4. Reaction time in seconds to each target type following each prime trial. Error bars show standard error.

The effect of prime was significant for strong targets (F(2, 88) = 6.61, p = .002). Response times to strong targets were significantly affected by prime types. Responses were significantly slower to strong targets following weak and alternative primes

compared with strong primes ($t(44) = 2.51$, $p = .016$; $t(44) = 3.56$, $p = .001$). There was no significant difference between responses following weak and alternative primes ($t(44) = -.80$, $p = .428$, BF = 0.218).

The effect of prime was significant for weak targets ($F(2, 88) = 17.82$, $p < .001$). Response times to weak targets were significantly affected by prime types. Responses were significantly faster following alternative and weak primes compared to strong primes ($t(44) = 3.92$, $p < .001$; $t(44) = 6.15$, $p <. 001$). There was no significant difference between response times following alternative and weak primes ($t(44) = -1.66$, $p = .103$, BF = .577).

It is possible that switching between tasks would affect response times independently of our manipulation. Thus we compared reaction times to "congruent" trials and "incongruent" trials. We pooled responses from "strong-weak" and "weak-strong" combinations to create "congruent" trials. We pooled responses from "strong-strong" and "weak-weak" trial combinations to create "incongruent" trials. We did not include alternative trials in this analysis because of the added complication of a different sentence frame; strong and weak trials used the same sentence frame, only the interpretation of the sentence differed. There was a significant difference in response times between congruent and incongruent trials ($t(44)=5.66$, $p<.001$). Participants were faster when the task was congruent than incongruent.

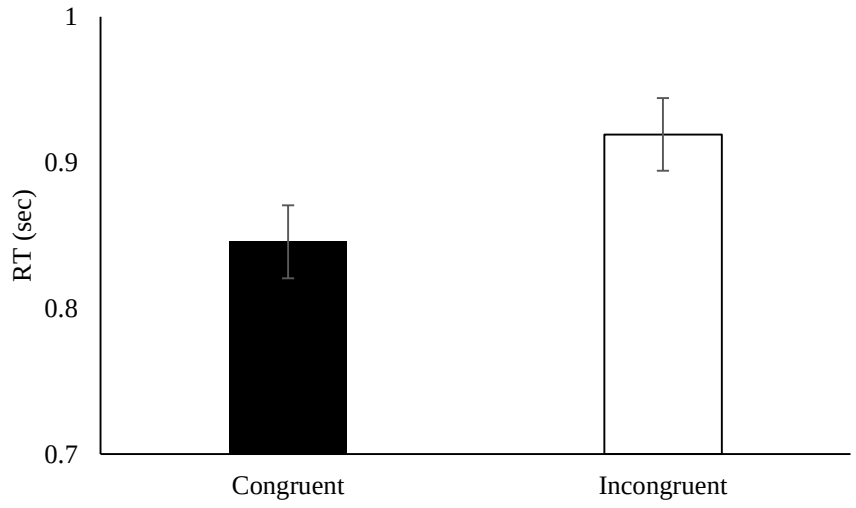

Figure 5. Reaction time in seconds for congruent and incongruent tasks.

Discussion

Participants responded fastest to strong targets following strong primes; there was no difference in response times following alternative or weak primes. This was borne out in the Bayesian analysis. The results suggest that the derivation of *ad hoc* implicatures

does not involve the alternative since there was no difference in speed of implicature derivation following alternative and weak primes. Only deriving the implicature in the previous trial facilitated subsequent implicature derivation. Thus ad hoc implicatures appear to be a type of exhaustivity inference.

Reaction times are a more sensitive measure of processing than interpretation judgements but they are still based on sentence final judgements. They consequently provide limited information about the mid-sentence processing effects. .We therefore turn to an even more fine-grained measure of processing, visual world eyetracking (e.g. Arai, van Gompel, & Scheepers, 2007; Eberhard, Spivey-Knowlton, Sedivy, & Tanenhaus, 1995; Traxler & Tooley, 2008).

Experiment 2

The aim of Experiment 2 was to test whether implicature priming could be observed using a visual world paradigm. Because there have been no previous demonstrations of implicature priming using visual world eyetracking we wanted to be sure that priming was observable with this method. In Experiment 3 we return to the more specific question about exhaustive vs specific *ad hoc* processing.

Participants were presented with a set of four cards and heard a description. The task was for the participant to identify the card being described. In all trials the cards followed the structure shown in Figure 6 and all descriptions took the form "The card with the [object]".

Experimental items involved prime->target pairs. Prime trials could refer to either the A card (e.g. the pencil) or the AB card (e.g. the book and the pencil). In these cards the A object was duplicated (the pencil in Fig. 6) and consequently descriptions of the A card ("The card with the [A]") were ambiguous between the A and AB card. In the Figure 6 the A card description was "The card with the pencil." Since there is a pencil in both the A and AB card this description is ambiguous; it is not clear which card is being described. In order for listeners to correctly identify the card being described they were required to make an inference, thus the A card trials were implicature trials. Descriptions of the AB card were not ambiguous because they referred to the unique item ("The card with the [B]"). In Figure 6 the AB card description was "The card with the book." Since there is only one card containing a book this description is unambiguous, thus

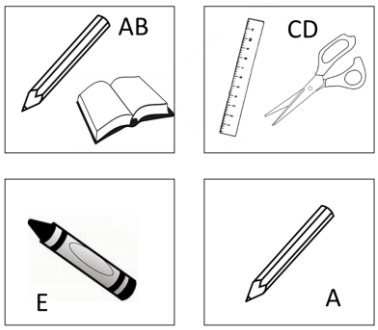

Figure 6. Example item with card labels.

the AB card trials were no-implicature trials. The target trials always referred to the A card.

In order to identify the correct card in target trials participants were required to make an inference. It was predicted that participants would be faster to identify the correct card following primes where they had derived an implicature (A primes) than following primes where no implicature was derived (AB primes). Thus we expect more looks to the target card at an earlier time point following implicature primes than no implicature primes.

Method

Participants

Forty-two participants were recruited from the Cardiff University population. Five participants were excluded for having fewer than 75% valid trials.

Design & Materials

Experimental items referred to the A and AB cards. Prime trials referred to either the A or the AB card and target trials always referred to the A card. The A cards were implicature trials and AB cards were no implicature trials. These were organised into 32 prime->target pairs (16 AB primes and 16 A primes). Prime and target trials were indistinguishable from each other so the participants were no aware of the relation between the two trials. The card being described appeared in all four positions and equal number of times in prime trials and target trials. The correct card was in the same position in both prime and target for 25% of trials. Experimental items were counterbalanced so that in prime trials each set of four cards had an A description and an AB description. Target trials were the same. Items were counterbalanced so that participants heard either the A or the AB prime description.

In the experimental items the A card was described 48 times whereas the AB card was only described 16 times. This was because A card trials were both prime and target trials whereas AB card trials were only primes. Consequently filler trials were included to prevent biasing participants to the A card. Filler trials referred to the AB, C, and DE cards. To ensure that each card type was selected an equal number of times there were 32 AB, 48 C, and 48 DE cards. The correct card was rotated in each of the four positions to prevent participants becoming biased towards a particular position.

At the start of the experiment there were 16 practice items (4 of each card type) to allow participants to get used to the experiment. These items were indistinguishable from the main experiment. Consequently there were 32 (prime x target pairs) + 128 fillers + 16 practice items = 208 trials. Experimental pairs and filler items were presented randomly.

Audio descriptions were recorded by a female native British English speaker. She was given a script to read from and did not see the items.

Procedure

Participants were seated in front of a 23 inch colour monitor with an independent eye tracking system (Tobii TX300) running at 120 Hz sampling rate. Viewing was binocular and eye movements were recorded from both eyes simultaneously. Participants completed a 9 point calibration at the start of the experiment.

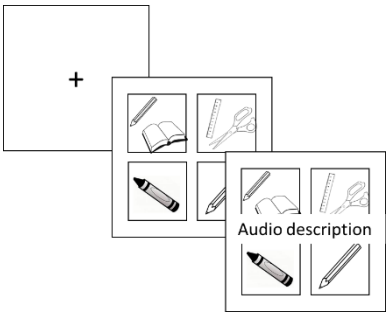

Figure 7. Example trial sequence

The experiment was controlled using MATLAB 2014a. Each trial began with a centrally located fixation cross presented for 2000msec before the trial was automatically initiated (see Figure 7). At this point the fixation cross was replaced by a set of four cards and after a 25ms delay the description was played. The picture stayed on screen, and eyes were tracked until participants made a selection.

Data processing

For analysis, any samples that were deemed invalid (e.g. due to blinks or head movement) were removed from the data. The spatial coordinates of the remaining samples were used to calculate the location of the eye-gaze. These samples were aggregated into packets of 25ms.

For each packet the proportion of looks to the target card was calculated as a proportion of looks to all other areas. This was done by first scoring each sample (8ms) as looking to target or not, then totalling the samples looking to target and dividing by the total number of samples in the packet.

Results

The data were split into two sections: before referent and after referent. We analysed 250ms prior to referent onset, and each time bin from referent onset to 1 second after. Average referent offset was 475ms after onset. Figure 8 shows proportion of time looking to target in each 25ms bin from 250ms before referent onset to 1 second after referent onset.

Figure 8. Proportion of time looking at target from -250 ms to 1 second from referent onset. 0ms is referent onset. The black line refers to looks following an implicature (A card) prime. The white line refers to looks following a no implicature prime (AB prime).

Before referent

A repeated measures ANOVA was run from 250ms before referent onset to 25ms before onset. Time and condition were included as within-participants factors. There was no effect of time or prime for participants (F_1 (9, 324) = .69, p = .716; F_1 (1, 36) = .001, p = .970) or items (F_2 (9, 279) = 1.13, p = .342; F_2 (1, 31) = .39, p = .535). There was a significant interaction between time and condition for both participants and items (F_1 (9, 324) = 2.328, p < .015; F_2 (9, 279) = 2.50, p = .009). The interaction was examined further by comparing the prime at each time point individually. There was a significant difference between the primes at 200ms prior to referent onset for participants, with more looks to the target following no implicature primes (t_1 (36) = 2.03, p = .05). There was also a significant difference between the conditions at 75ms prior to referent onset, with there being more looks to the target following implicature primes, for items (t_2 (31) = 2.42, p = .022). There was no significant difference at any other time point prior to referent onset (t_1*'s* (36) < 1.43, p*'s* > .116; t_2*'s* (31) < 1.87, p*'s* > .072).

After referent

A repeated measures ANOVA was run from referent onset to 1 second after. Time and prime were included as between-participants factors. There was no main effect of prime for participants or items (F_1 (1, 36) = .13, p = .726; F_2 (1, 31) = .96, p = .336). There was a main effect of time for participants and items (F_1 (40, 1440) = 15.11, p < .001; F_2 (40, 1240) = 13.62, p < .001). There was a significant interaction between time and prime for participants (F_1 (40, 1440) = 1.51, p = .022) and items (F_2 (40, 1240) = 1.62, p = .009). The

interaction was examined further by comparing the prime at each time point individually. There was a significant difference between the primes for both participants and items at 625ms (t_1 (36) = 2.23, p = .030; t_2 (31) = 2.04, p = .050) and 675 ms after referent onset (t_1 (36) = 2.61, p = .013; t_2 (31) = 2.96, p = .006). In each case there were more looks to the target following the implicature than the no implicature prime. At no other time points was there a significant difference between primes for participants. Table 1 below shows the other time points in which there was a significant difference between primes for items.

Time (ms)	**df**	**t_2**	***p***
800	31	2.35	.026
825	31	2.45	.020
900	31	2.02	.052
1000	31	2.26	.031

Table 1. Significant t-test values by items.

Discussion

Experiment 2 demonstrated facilitatory priming for implicature processing. Participants looked to the target card more often and quicker following prime trials that required an implicature. Thus participants are faster to derive an implicature after recently deriving one.

Interestingly we found an interaction prior to the referent onset. In the 175ms preceding referent there are more looks to the target following an implicature prime. This may be accounted for through a visual priming explanation; after the implicature prime participants may be more drawn to the A card since this is the card that they previously selected. This pattern is switched during the articulation of the referent; participants look at the target more following a no implicature prime trial. What is happening here is unclear however, it could be a reflection of early prediction.

Experiment 3

Experiment 3 tested between two possible accounts of how ad hoc implicatures are derived. One, the *specific account*, includes the use of specific alternative sentences, just as in quantifier implicatures, and the other, *the exhaustive account*, does not. To test between these accounts we used a visual world paradigm, as in Experiment 2, but we changed the primes. In this experiment there were two types: (1) no implicature (weak) and (2) alternative. No implicature primes were the same as in Experiment 2; they referred to the AB card using a simple noun phrase. Alternative prime trials also referred to the AB cards but they used the alternative structure; instead of using a simple noun phrase a conjunction was used e.g. “The card with the book and the pencil.” Target trials referred to

the A cards and thus required participants to derive an implicature, just as in Experiment 2.

Chapter 2 showed that participants were equally likely to derive an implicature after previously making an implicature and if the alternative was made salient. Consequently, it is expected that if *ad hoc* implicature derivation involves the use of a specific alternative structure then this should prime the derivation of implicatures in the subsequent trial. Thus, following alternative primes participants should derive the implicature quicker. Therefore there should be more looks to the target card earlier following the alternative than the no alternative primes. However, if the specific alternative structure is not represented then there should be no difference in looks to the target following alternative and no implicature primes.

If the specific alternative structure is used in deriving the implicature then repetition of this alternative is expected to boost any priming effect. In order to test this we also included a lexical overlap manipulation. In half of the trials the referent was repeated across prime and target trials. If the specific alternative is represented then lexical overlap between alternative primes and targets should boost priming (c.f. Cleland & Pickering, 2003; Pickering & Branigan, 1998; Pickering & Ferreira, 2006). Thus we expect more looks to the target, earlier when there is lexical overlap.

Method

Participants

Thirty participants were recruited from the Cardiff University population.

Design & Materials

Experimental items referred to the A and AB cards. A cards were always target trials and AB cards were always prime trials. The no-implicature primes were the same as the AB primes from Experiment 1. The alternative prime trials also described the AB card however the descriptions used a conjunction ("the card with the [A] and the [B]"). Experiment 2 demonstrated a priming effect following implicature primes relative to no implicature primes. Since Chapter 2 demonstrated equivalent priming from alternative and implicature primes we did not include implicature primes in this experiment.

Items were organised into 64 prime->target pairs. Pairs could be overlap or no-overlap. In overlap pairs the referent was repeated across the prime and target trials (a different picture was used). This meant that for no-implicature primes participants heard the same sentence in prime and target trials These trials were not analysed because they involved the use of the same audio file repeated with no intervening trials; the repetition of the audio file may have provided an early cue to participants about which card was the

target which was unrelated to the processing of an implicature. For alternative primes the [B] referent was repeated in the prime and target trials.

This resulted in 4 conditions: alt overlap, alt no overlap, no implicature overlap, and no implicature no overlap. Experimental pairs were counterbalanced so that each pair appeared in each condition, this resulted in 4 separate lists. The position of the correct card was rotated across the four positions in both prime and target trials so that the correct card appeared in each position an equal number of times. The correct card was in the same position in both prime and target for 25% of trials. Filler trials referred to the C and DE cards. There were 64 DE fillers and 64 C fillers, 32 DE fillers had a referent overlap with the C fillers.

At the start of the experiment there were 16 practice items (4 of each card type), 8 of which had overlapping referents. These items were indistinguishable from the main experiment. Consequently there were 32 (prime x target pairs) + 128 fillers + 16 practice items = 208 trials. Experimental pairs and filler items were presented randomly.

Audio descriptions were recorded by a female native British English speaker. She was given a script to read from and did not see the items. The procedure was the same as in Experiment 2 but the eye-tracker sampling rate was 300hz.

Results

Figure 9 shows the proportion of looks to the target card from 250 ms before referent onset to 1000ms after referent onset. Average referent offset was 534 ms after referent onset.

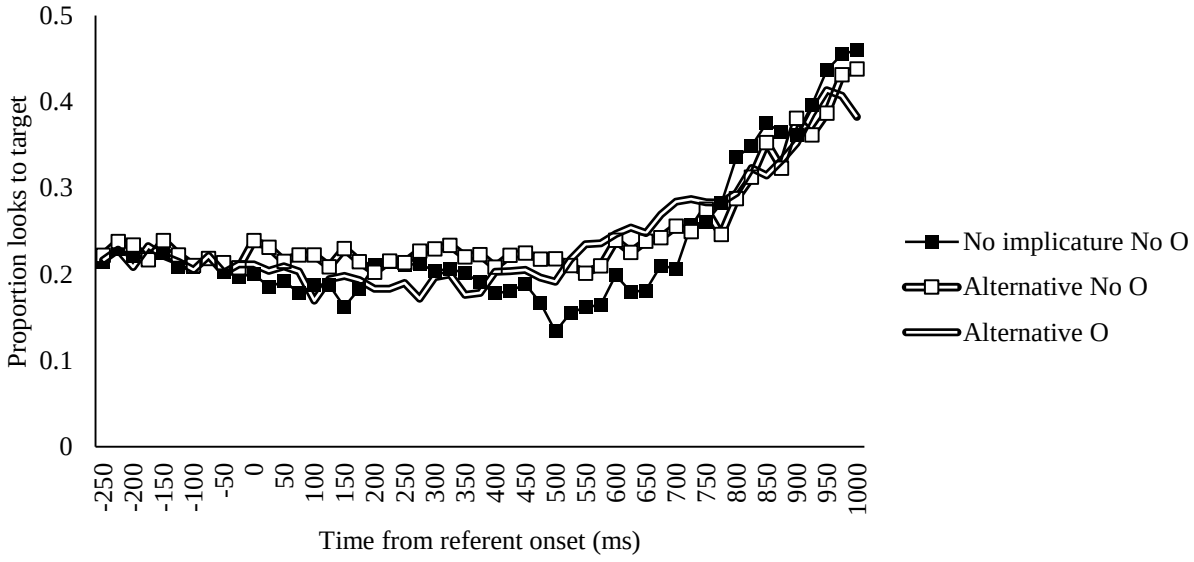

Figure 9. Proportion of looks to target from 250 ms before referent onset to 1000ms after onset. 0 ms is referent onset.

If a specific alternative is involved in deriving *ad hoc* implicatures then participants should be more likely to look to targets following the alternative prime than following the no implicature prime. Consequently, we conducted pairwise comparisons between the two conditions from referent onset to 1 second after referent onset. There was no significant difference in proportions of looks to the target following no implicature or alternative primes for participants or items (t_1 (29) = -1.31, p = .200, BF = 0.4; t_2 (63) = -1.28, p = .207, BF = 0.3). This is consistent with the representations not including a specific alternative structure. Further support for this conclusion comes from the comparison between overlap and no overlap trials; no difference was found (t_1 (29) = .29, p = .771, BF = 0.2; t_2 (63) = -.26, p = .797, BF = 0.1).

Discussion

There was no difference in looks to target following alternative and no implicature primes. There was also no effect of lexical overlap. These results are consistent with the exhaustive account where ad hoc implicatures are derived without reference to a specific set of alternatives. This is further strengthened by the failure to find an effect of lexical overlap.

General discussion

In the experiments presented we investigated how priming affects the processing of implicatures and tested between two accounts of *ad hoc* implicature. The first account, the *specific account*, states that *ad hoc* implicatures are derived by using specific alternatives as with scalar implicatures (Bott & Chemla, 2016; Hirschberg, 1981, Rooth, 1985; Stiller,

Goodman, & Frank, 2014). The second account, the *exhaustive account*, suggests that *ad hoc* implicatures are a type of exhaustive inference which do not need specific alternatives. Instead there is a general *anything else* alternative (Geurts, 2010; van Tiel & Schaeken, 2016). We anticipated facilitatory priming effects after deriving the implicature (strong primes, e.g. Bock, 1986; Bock & Griffin, 2000; Pickering & Ferreira, 2008). Based on the *specific account,* facilitatory processing was expected following alternative primes (see Chapter 2). The *exhaustive account* however, does not predict facilitatory priming following alternative primes.

The results of the three experiments presented here are consistent with the *exhaustive account*. Facilitatory effects were found following strong primes but not alternative primes. This was seen in Experiment 1 where reaction times following strong primes were much faster than following alternative primes. Following alternative primes the reaction times were equivalent to trials following weak primes. Experiment 3 also showed no difference in processing the implicature following weak or alternative primes whereas Experiment 2 demonstrated a priming effect following strong primes. An obvious concern is that the *exhaustive account* relies on the absence of an effect rather than the presence of an effect. However, to overcome this limitation we utilised the Bayes Factors (BF) analysis. The BF is the ratio of the likelihood of the experimental hypothesis explaining the data to the likelihood of the null hypothesis. In this case we were testing the *specific account* and the *exhaustive account*. The *specific* account predicted that we would find priming following alternative primes and that this priming would be boosted with lexical overlap. We failed to find any evidence of priming. We used Bayes Factors to interpret the nonsignificant findings (Dienes, 2011, 2014; Rouder, Speckman, Sun, Morey, & Iverson, 2009). The Bayes Factors calculated were < 0.33 which indicates 'substantial' evidence for the null hypothesis (Dienes, 2011, 2014); that there was no priming effect following alternative primes and there was not lexical boost to priming. Thus we interpret this as supporting the *exhaustive account*.

The results of this chapter are at odds with previous work. Chapter 2 showed that the alternative is important for ad hoc implicature derivation however the results of this chapter argue against this for ad hoc implicatures. It is difficult to reconcile these findings with those from Bott and Chemla (2016). Bott and Chemla demonstrated cross implicature priming; *ad hoc* implicatures primed scalar implicatures in numbers and quantifiers. They suggested this was the consequence of a shared mechanism that searches for the alternative but if *ad hoc* implicatures do not require an alternative in the same way that

numbers and quantifiers do then it is not clear what mechanism was responsible for the cross implicature priming.

There are several crucial differences with the experiments presented in this chapter and previous work on priming implicatures which may account for the differing results. Firstly, in both Bott and Chemla (2016) and Chapter 2, quantifiers and numerals were investigated in conjunction with *ad hoc* implicatures. The proportion of *ad hoc* implicatures derived was significantly lower than for quantifiers and numerals. One explanation is that participants learned a convention of how to respond to the *ad hoc* expressions based on their interpretations of the other expressions. However, this is unlikely since participants rarely changed their interpretation for *ad hoc* trials (Chapter 2 Figures 4 and 7). Another possibility is that the alternative for *ad hoc* expressions are more difficult to derive than the alternative for the other expressions (see Bott & Chemla, 2016, for a similar point). For *ad hoc* expressions, the alternative requires adding material to the sentence (e.g., the alternative to "There is an A," was, "There is an A and a D"[4]). Expansion could be more complex for the language processor than replacement. This mirrors Katzir (2007), who argues that there is a fundamental difference between alternatives formed from replacement and those formed by the addition of material. However, based on the results of the experiments this is unlikely. It is plausible that there were low rates of implicature derivation because *ad hoc* implicatures are a distinct category and involve different processes or mechanisms. Any differences may have been masked by the floor effects.

Secondly, the tasks in the experiments presented here differed from those in Chapter 2. The experiments of Chapter 2 and Bott and Chemla (2016) involved two distinct tasks. In prime trials participants were asked to decide which picture matched the sentence. In target trials participants were presented with one picture and then the option to choose a different picture if they thought there was a picture which would match the sentence better. This was intended to give participants the choice of accepting the weak interpretation of the sentence or to derive the implicature. However, the target trials do not necessarily require participants to calculate the implicature. This is odd because it is a different task from the prime trials; participants do not necessarily have to derive an implicature, they only have to decide that the picture they are provided with is not appropriate. In the present experiments participants did not have to make judgements about a "better picture".

[4] The alternative may also be "There is an A and nothing else." We return to this in Chapter 4.

Finally, the experiments presented in this chapter focused on processing time whereas previous experiments (Chapter 2, Bott & Chemla) used interpretation judgements. Sentence interpretation judgements provide no information about how that interpretation is reached. Instead they reflect the end product of online processing and conscious decision making. It is possible that the same interpretations are reached through different processes. One way to assess this would have been to include an implicature prime in Experiment 3. This is a a key limitation; based on the work of Chapter 2 we did not include an implicature prime for Experiment 3 because it had been seen that alternative primes resulted in the same level of priming as implicature primes. The results of this experiment demonstrate that offline findings do not always translate into online measures. Eye movements during comprehension provide a continuous measure of language processing (Tanenhaus et al, 1995). Since eye movements are linked to attentional processes, how a participant's gaze changes in response to stimuli can provide some insight into how that stimulus is being processed and an interpretation is reached. Consequently, offline measures do not necessarily map onto online processing. However, it must be noted that the calculation of looks to the target was as a proportion of looks to everything other than the target and this is still quite a crude measure. Overall, the experiments presented in this chapter provide further evidence of priming pragmatic enrichments along with an investigation into *ad hoc* implicatures.

Since priming effects demonstrate the presence of a particular type of representation (Branigan & Pickering, 2017) these results indicate pragmatic, or implicature specific, representations. The nature of these representations however, is less clear. The representations involved would be at the sentence level but based on the experiments presented here the representation for *ad hoc* implicatures would not include specific alternatives. Instead the representation would include a more general, *anything else,* alternative. This would be problematic for other types of implicatures which do require specific alternatives. However, as shown by van Tiel et al (2014) there is considerable variation across different types of implicatures. Consequently it is plausible that there are several related representations which are responsible for implicatures. For example the representation for quantifier implicatures could be [S & not(S')], where S refers to the basic unenriched sentence (e.g. Charlie ate some of the cakes) and S' to the informationally stronger sentence (e.g. Charlie ate all of the cakes). Whereas for ad hoc implicatures the representation could be [S & not(A)] where A refers to a general *anything else* alternative.

Summary

The aim of the experiments presented in this chapter was twofold. Firstly we wanted to investigate how priming affects the online processing of implicatures and secondly we wanted to test two explanations of how ad hoc implicatures are derived. The results of the experiments show that priming effects facilitate the processing of implicatures. Participants' reaction times are faster after being primed and they are quicker to identify a target requiring an implicature after having derived an implicature. The experiments also provide some insight into how ad hoc implicatures are derived. Unlike traditional accounts of implicature derivation ad hoc implicatures do not appear to involve negating a specific alternative. Instead there is a general *anything else* alternative.

Chapter 4: Structural alignment of pragmatic enrichment in dialogue.

Coordination in language is a wide-spread phenomenon whereby interlocutors align their language at many different levels. Over time, speakers and listeners adopt the same accents, lexical expressions, and even syntactic structures (Branigan, Pickering, & Cleland, 2000; Cleland, & Pickering, 2003; Garrod & Anderson, 1987; Giles & Powesland, 1975). This confers advantages in terms of the predictability of the exchange and ultimately the ease with which people can communicate. It is not clear, however, whether coordination applies to pragmatic enrichment in the same way as to others areas of language. Mechanistic accounts of enrichment are typically described from the listener's perspective, and without representations, and so fail to provide structures that support alignment. In this chapter I present a novel paradigm that investigates the production of enrichments and test whether enrichment alignment arises in dialogue.

Pragmatic enrichment takes many forms but some of the most extensively researched are Gricean implicatures (Grice, 1989). Consider the following:

(1) A: I hear Helen's husband is rich and intelligent.

B: Well, he's rich.

(2) John ate some of the cakes.

In (1) Speaker B *says* that Helen's husband is rich, but *implies* that he is not intelligent. In (2) the speaker *says* "some" but *implies* that John did not eat all of the cakes. The standard approach for how a listener derives a Gricean implicature assumes that the listener considers what the speaker could have said but didn't. The listener derives the implicature through the following steps: (i) reasoning about what B could have said instead. What are the alternatives? B could have said "he's rich and intelligent" (ii) reason about why B didn't say this alternative. The most likely explanation is that he doesn't believe this is true. (iii) B is likely to have an opinion about this alternative. (iv) combining (ii) and (iii) yields the implicature that B believes that *Helen's husband is rich but not intelligent*. (Table 1, adapted from Geurts, 2010, shows the reasoning process in more detail for (2)).

Reasoning	**Content**	**Direction**
	"John ate some of the cakes."	Speech.
A stronger statement could have been made (alternative). Why not?	John ate all of the cakes.	
Speaker must not believe that the stronger alternative is true.	¬BELIEVE(John ate all of the cakes)	
Speaker likely has an opinion about whether the alternative is true.	BELIEVE(John ate all of the cakes) ∨ BELIEVE(¬(John ate all of the cakes))	
	John ate some but not all of the cakes.	Conceptual understanding.

Table 1. Standard reasoning stages for Gricean implicatures. Note that the direction of information flow is from speech to conceptual understanding.

Since Grice's seminal lectures, researchers have analysed implicatures in linguistic pragmatics (e.g. Chierchia, 2004; Geurts, 2010; Sauerland, 2004, 2012; Schulz & van Rooij, 2006) and, more recently, in psychology (e.g. Bott & Noveck, 2004; Breheny, Ferguson & Katsos, 2013; Degen & Tanenhaus, 2015; Huang & Snedeker, 2009; Tomlinson, Bailey & Bott, 2013). Whilst there is now a wealth of research into Gricean implicatures, all of this work takes the listener's perspective. The focus has been on how individual listeners derive an inference[5] rather than how a speaker produces an implication or how interlocutors engaged in dialogue use implicatures. Consequently, little is known about the interaction between production and comprehension in pragmatic enrichment. This is in contrast to syntax and semantics where experiments often involve dialogue and production. The set of experiments presented in this chapter aim to readdress the imbalance by asking whether interlocutors become aligned in dialogue with respect to Gricean enrichment. Do speakers and listeners converge on when to enrich expressions?

Interlocutors typically become aligned across all levels of linguistic representation, which in turn facilitates communication (Pickering & Garrod, 2004). Alignment would be

[5] When discussing a listener I use the term inference since the listener must infer what the speaker means. When discussing a speaker I use the term implication because the speaker implies additional meaning.

beneficial for the listener because they could predict what the speaker is communicating more easily. In particular, since Gricean inferences are optional, the listener would not have to engage in reasoning about whether to derive the enrichment. Alignment would also be beneficial to the speaker. By knowing the form of expression that would be needed, the speaker would not have to choose between a range of formulations and determine which one the listener would understand. With respect to implicatures, knowing that the listener will correctly derive the inference minimises the risk of miscommunication.

The results from the previous chapters of this thesis (and Bott & Chemla, 2016) demonstrate that Gricean inferences can primed within an individual (within comprehension). A listener (reader) was more likely to derive a Gricean inference immediately after they had been obliged to derive an enrichment than after a literal expression. In other words, inferences can be primed. These findings, together with the potential benefit of alignment, argue in favour of enrichment alignment occurring between interlocutors.

However, existing explanations of Gricean enrichments do not provide structures that give rise to priming between a speaker and listener. This is because they take the perspective of the listener, and not the speaker (or they are not mechanistic accounts at all, as in Grice, 1989). Inferences are standardly explained as unidirectional processes, from speech to conceptual understanding (see Table 1), that do not work "in reverse." To see this, compare the implication process from the perspective of the listener and the speaker. For the listener, the sounds (or letters) are first transformed into words and grammar, and then mapped onto concepts. The listener then reasons about possible alternative inputs that they could have received from the speaker and about why they were not used. That is, inferring is the expansion of a message, and requires additional content to be added to the input. For the speaker, concepts are first transformed into words and grammar, and then, at some point before articulation, an implicature procedure intervenes and reduces the number of words in the utterance (so that the listener can then expand the message back to its original conception). The processes of inferring and implying operate in different directions and current models of inferring cannot straightforwardly be used to explain the interaction between implying and inferring.

A related problem is that classical theories of Gricean inference do not propose abstract representational frames that correspond to implicatures, in the same way that syntactic theories propose syntactic frames. Syntactic frames contain the combinatorial information for particular syntactic realisations. Combinatorial information defines how linguistic units combine to form expressions. For example the sentence *give a bone to the*

dog is a prepositional object construction and contains the combinatorial specification noun phrase and prepositional phrase. Alternatively, *give the dog a bone* is a direct object construction with a noun phrase and noun phrase combination. Double object sentences prime double object sentences and prepositional object sentences prime prepositional object sentences despite both constructions being semantically equivalent (Bock, 1986; Bock & Loebell, 1990). This priming effect has been attributed to the activation of syntactic frames; after comprehending a sentence which used a particular structure, the representation of that structure (the syntactic frame) has an activation advantage over other frames and thus is more likely to be repeated (Branigan & Pickering, 2017). Priming is found both in the presence and absence of lexical overlap. Since priming is found independently of lexical repetition this suggests that these representations are linked to but abstract from the lexical elements (e.g. Pickering & Branigan, 1998; Traxler, Tooley, & Pickering, 2014).

Unlike syntax, Gricean inferences are not typically explained in terms of representations. Most authors agree that implicatures have a range of properties that distinguish them from other components of meaning. For example, Inferences are highly context dependent and thought to arise through reasoning processes (as outlined above), rather than the retrieval of linguistic elements. Consequently describing inferences in terms of static representations would not make sense. Furthermore, in order to derive an inference alternative constructions must be considered. This is not necessarily the case with standard comprehension; listeners do not typically have to infer content in addition to their input. Furthermore, implicatures are optional. Listeners do not have to derive an inference in order make a comprehensible sentence. Other features of language are not optional in this manner. Finally, taking a Gricean perspective, implicatures must occur at the sentence level rather than being sentence components. Overall, if implicatures are governed by shared representations then these representations are likely to be distinct from those that are assumed by researchers of syntax and semantics (see Branigan & Pickering, 2017).

The following experiments investigated pragmatic alignment between speaker and listener. The literature reviewed in the introduction suggests that alignment would be beneficial for communicators but current theories of pragmatic enrichment do not provide the necessary structures to support it. Although the previous chapter demonstrated priming of inferences in comprehension, this effect could be explained by priming of comprehension-specific processes and does not demonstrate evidence of representations shared by comprehension and production. We test this using a confederate-scripting

priming paradigm (adapted from Branigan, Pickering, & Cleland, 2000). If interlocutors become aligned with respect to enrichment then it should be possible to prime the production of implicatures via their comprehension.

Experiment overview

We present four experiments investigating alignment and implicature production. The experiments used a confederate scripting priming paradigm in which a participant and a confederate took turns describing and identifying a referent card from a set of four cards. These cards consisted of rectangles containing either one or two images (see Figure 1). Cards were displayed on two separate screens (one for the participant and one for the confederate), and neither party could see the other's screen. The referent card was identified to the speaker (but not the listener) by being embedded in a bold square. The task for the speaker was to communicate to the listener which of the cards was the referent card.

The configuration of the images in the display were the same on each trial. Figure 1 shows the configuration (left panel) and an example trial (right panel). Crucial to the study was the duplication of one object, [A], across cards, so that the A card and the AB card shared the same object, [A] e.g. the pencil in Fig.1. This meant that without further enrichment, an unmodified single object description involving [A], e.g., "The card with the pencil," was ambiguous between the [A] card and the [AB] card. However, the ambiguity could be resolved if the listener derived a Gricean inference, e.g. *because the speaker did not say the card with the pencil and the book, they must mean the card with pencil only*. Of course, instead of the speaker obliging the listener to make an inference, the speaker could instead disambiguate the referent by using a modifier, e.g., "The card with *just* a pencil."

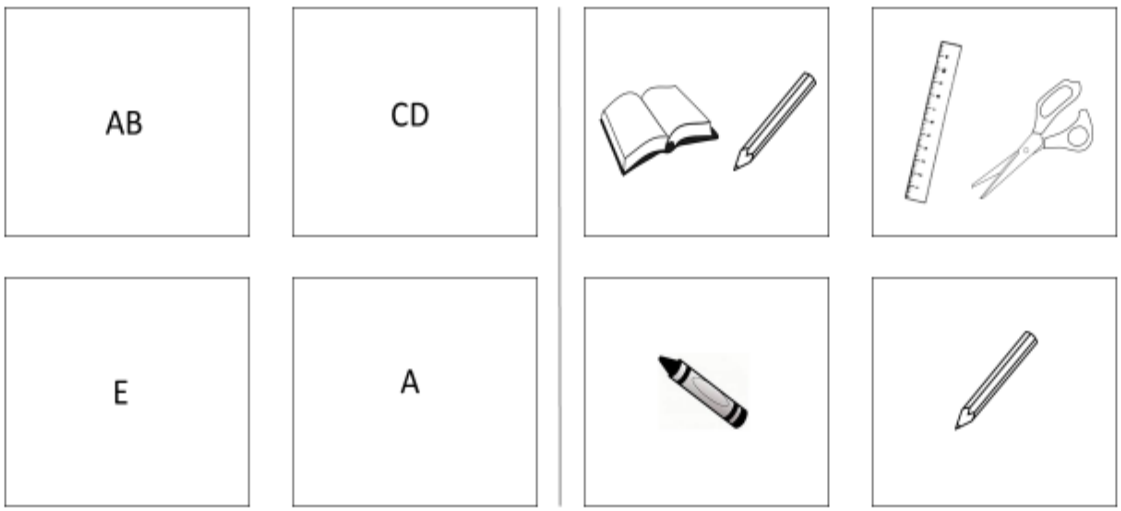

Figure 1. Left panel shows object configuration. Right panel shows an example trial.

Thus, from the speaker's perspective, they could choose either an unmodified single object utterance and expect the listener to derive an inference, or a modifier that was more explicit. Speakers similarly had a choice of constructions when the [AB] card was the referent[6]. The speaker could choose between using an unmodified single object utterance where they refer to the unique B item on the card e.g. "The card with the book." This would involve cancelling, or defeasing a Gricean inference ("the card with the book," does not mean *the card with book only* in this context). Or a conjunction where they name both items on the card, e.g. "The card with the book and the pencil."

If interlocutors become aligned on when to enrich a sentence then participants should produce a description that was sensitive to the form used by the confederate. When the confederate used an inference, the participants could also use an inference, and when the confederate used a modifier, the participant could also use a modifier.

Experiment 1

Experiment 1 investigated whether interlocutors show enrichment alignment. Alignment was assessed by manipulating the trial sequence. The confederate and participant took turns to be the speaker and listener and each described [A] and [AB] cards (and fillers). Prime trials were always described by the confederate and target trials were described by the participant. Whether the participant (as speaker) chose an unmodified single object utterance or a modifier (or a conjunction) was the dependent measure.

The confederate always described the experimental ([A] and [AB]) cards with an unmodified single object utterance ("The card with a pencil") so that to correctly identify the [A] card, the participant had to derive an inference, and to identify the [AB] card, they had to cancel an inference. In subsequent trials, the participant chose how to describe the referent. Alignment predicts that participants would use more unmodified single object utterances to describe [A] cards after deriving an inference (after an [A] card) than after cancelling one (after an [AB] card). Consequently, an interaction is expected between type of confederate (prime) trial and type of participant (target) trial, with rate of unmodified single object utterances as the dependent measure.

[6] Referring to the [AB] card with an unmodified single object utterance was always sufficient to disambiguate this card e.g. "The card with the book" refers to an item that appears on only one card and thus disambiguates the card.

Method

Participants

Thirty-five participants from the Cardiff University community were recruited and received course credit for their participation.

Materials and Counterbalancing

There were five objects in each display, organized according to Figure 1. The five objects were different on every trial. The locations of the card types [A, AB, C, DE] were rotated across trials so that each card type appeared equally often in the four possible display positions.

Confederate and participant alternated roles throughout the experiment. There were four experimental prime-target sequences [A->A; AB->A; A->AB and AB->AB]. In order to boost the priming effect there were two primes, of the same type, before a target. Thus the confederate always described two cards (e.g. A->A) before the participant then took their turn. To prevent any discrepancy between the confederate's and the participant's behaviour the participant also described two cards. However, only the first description was of interest. The two primes were always of the same type [A->A or AB->AB] and targets were either [A or AB]. There were four examples of each prime target combination (16 triplets in total). In addition there were 8 [A], 6 [AB], and 2 [CD] "extra" cards which the participant described after describing a target.

Each experimental sequence was separated by four filler items (to preserve the sequence of turn alternation the confederate described two and the participant then described two). The confederate described [AB] fillers using a conjunction. The [CD] fillers were described using either a conjunction or a simple noun phrase and the [E] fillers were described with a simple noun phrase. There were 16 sets of 4 fillers. The confederate described 7 [AB] fillers, 13 [CD] fillers (7 conjunction and 6 simple noun phrase), and 12 [E] fillers (three included the modifier *just*). The participant described 2 [AB], 9 [CD], 14 [E], and 7 [A] fillers. The filler trials served several functions. They prevented participants from becoming biased towards the [AB] and [A] cards by referring to the other cards in the display and they highlighted to the participant the different constructions that could be used to describe a card.

An additional 8 practice quadruplets were presented at the start of the experiment to allow participants to get used to the experimental procedure. The practice items referred to all of the cards and they were indistinguishable from the main experiment. We did not analyse these trials. Consequently there were: 16 x (double prime + target + extra)

+ 16 x (filler quad) + 8 x (practice quad) = 160 trials in total. Presentation order was in one of two lists. One order was the reverse of the other.

Procedure

The confederate was a female native-English speaking student from the Cardiff University student population. The participant and confederate were sat at opposite sides of a table facing a computer screen. They could not see the other person's screen (see Fig. 2). The confederate and participant were told: "You will be playing a game where you take turns describing and identifying cards. The same set of cards will be displayed on both computer screens. If you see one with a bold border it is your turn to describe. To make a guess about which card your partner was describing press one of the four keys corresponding to the position of the card on the screen. Do not speak [to your partner] except to describe the card". Participants were not allowed to describe the position of the card on the screen but, if they needed their partner to, they could ask for their partner to repeat their description.

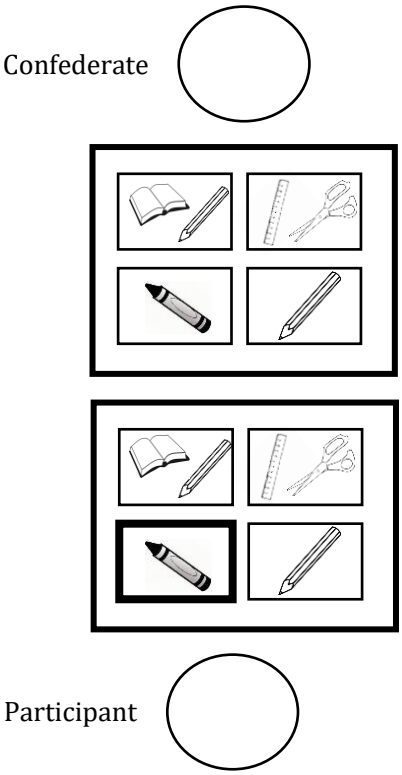

Figure 2. Experiment set up. The card in bold is the card to be described. The speaker in this case is the participant.

Throughout the instruction stage the experimenter treated the confederate like a participant: they collected a consent form, demonstrated which keys to press to indicate their choice of card, and checked if they had any questions.

Results

Analysis procedure

Two responses out of the 560 produced were excluded due to an experimenter error. The remaining 558 utterances were coded with respect to whether they were unmodified single object utterances, e.g. "The card with a pencil," or the alternative utterance type. For [A] card trials, the alternative was to use a modifier with the object, e.g. "The card with *only* a pencil" (i.e. to be explicit). For [AB] cards, the alternative was to describe both objects, e.g. "The card with a pencil and a ruler." The dependent variable throughout was the proportion of unmodified single object utterances. Data underwent a logit transformation and were analysed using ANOVA.

For non-significant comparisons we report the Bayes Factors (Dienes, 2011, 2014; Rouder, Speckman, Sun, Morey, & Iverson, 2009). All analyses used the default JZS prior

(0.707). The JZS prior is a non-informative objective prior that minimises assumptions regarding expected effect sizes (Rouder et al., 2009). All Bayes Factors (BF) were calculated using JASP (JASP Team, 2016). Bayes factors > 3 suggest 'substantial' evidence for the alternative hypothesis and Bayes factors < 0.33 indicate 'substantial' evidence for the null hypothesis (Dienes, 2011, 2014).

Analysis

To ensure that participants were paying attention to the confederate's descriptions participants key press responses to prime trials were checked. Participants selected the correct card 98% of the time, confirming that they were paying attention to the confederate.

Overall participants' utterances were not sensitive to the form used by the confederate, that is, participants did not demonstrate enrichment alignment (see Figure 3). Prime type and target type were included in a repeated measures ANOVA as within participants factors. There was no effect of prime (F (1, 34) = 2.40, p = .131, BF = 0.23) but there was a main effect of target (F (1, 34) = 32.62, p < .001). Participants produced a higher proportion of unmodified single object utterances to [A] target cards than to [AB] target cards regardless of the prime. There was no interaction (F (1, 34) = .007, p = .932, BF = 0.24).

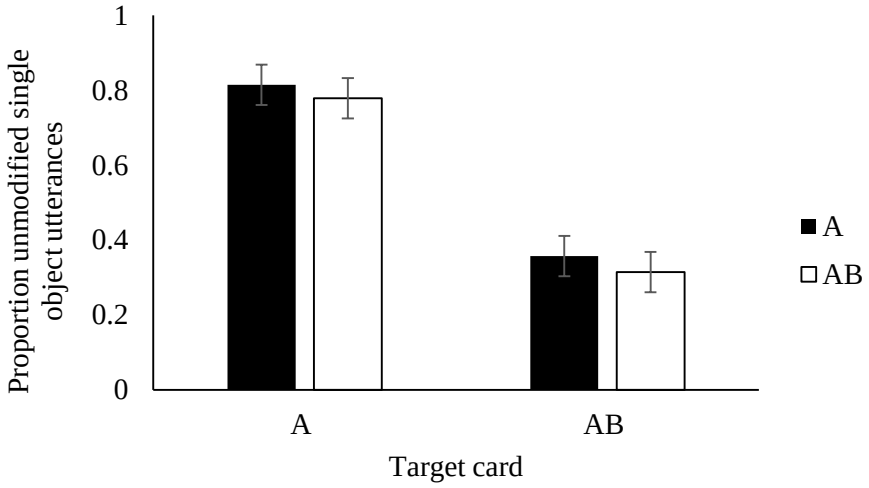

Figure 3. Proportion of unmodified single object utterances to targets. Black bars correspond to [A] prime cards and white bars correspond to [AB] prime cards. Error bars show standard error.

Discussion

Experiment 1 did not find evidence of alignment. Key press responses indicated that participants were correctly deriving the inference when they needed to, but this did not influence their subsequent utterance.

One explanation for this result is that the comprehension and production processes involved in enrichment do not overlap to the same degree as they do for other types linguistic structures, such as those used in syntactic processing. Pragmatic alignment between interlocutors is perhaps not as useful as syntactic alignment. Another plausible explanation relates to the speaker's inconsistency in the filler trials. In the filler trials the confederate used a mixture of simple noun phrases, modified noun phrases, and conjunctions. This was done in an attempt to notify the participant to the range of possible constructions that could be used to describe the cards. However, this may have affected the participants' ability to align with the confederate. Alignment arises through non-conscious automatic priming of linguistic structures (Pickering & Garrod, 2004; 2009) and results in interlocutors using common coding during production and comprehension. Consequently members of a dialogue are able to make predictions about their partner and ultimately align their mental representations. If a speaker is not consistent then a listener will not be able to align successfully because different structures will be activated across the interaction and this will impede their ability to make predictions about their partner (Shintel & Keysar, 2007; Graham, Sedivy, & Khu, 2014). Since the confederate's descriptions in Experiment 1 were not consistent then multiple different representations would be activated and thus none would have elevated activation levels. Consequently the participants would appear insensitive to the priming manipulation.

This is seen most clearly in participants' descriptions of the [AB] cards. In prime trials the confederate always described the [AB] card using an unmodified single object utterance ("It's the card with an A"). It was only in the filler trials that the confederate used a conjunction ("It's the card with an A and a B"). Despite this the participants overwhelmingly preferred to use a conjunction. This is especially interesting when you consider that an unmodified single object utterance was always sufficient to disambiguate the [AB] card. This explanation is further supported when you also consider participants' descriptions of [A] cards. Across the experiment the [A] cards were mostly described by the confederate with an unmodified noun phrase, only four instances used a modifier. Analogously participants' descriptions of [A] cards were predominantly unmodified noun phrases despite the fact that this description was ambiguous and therefore not sufficient to disambiguate the referent card. Furthermore, Grodner and Sedivy (2011) found that listeners were less likely to derive an inference when their interlocutor was judged as an unreliable speaker. The lack of consistency in describing [AB] cards may have marked the interlocutor as an unreliable speaker, at least where [AB] cards were concerned. Consequently, it is plausible that the lack of a priming effect was a consequence of the

confederate's inconsistent descriptions of double item cards preventing the participant from successfully aligning (see also Jaeger & Snider, 2012).

The second experiment aims to address this issue by introducing a between participants manipulation where the confederate's descriptions are consistent either by including a modifier to describe [A] cards or not.

Experiment 2

In Experiment 1 participants did not align with the confederate. One explanation is that confederate inconsistency affected the participants' ability to align. Experiment 2 tested this by removing the conjunctions used in filler items, thereby removing the inconsistency, and by including a between participant manipulation of conversational style. Thus Experiment 2 investigated two different types of priming, local and global.

Local priming was the within participants manipulation of the trial sequence as described in Experiment 1 and involved the confederate using an implication on some trials and cancelling the implication on others. As in Experiment 1 there were four possible experimental prime-target sequences [A->A, AB->A; A->AB; and AB->AB] where the confederate always described the prime card.

Global priming relates to a between participants manipulation of the confederate's conversational style. The global priming manipulation considers participants aligning instead with the confederate's overall conversational style. Conversational style was manipulated on the [A] cards. In the *explicit* condition, the confederate included modifiers, e.g. *just*, as in, "The card with *just* the pencil", and in the *implicit* condition, they did not, as in "The card with the pencil". In both conditions the [AB] card was always referred to by the confederate with a simple noun phrase and the referent was always the B item on the card e.g. "The card with the book." In subsequent trials, the participant chose how to describe the referent. To describe the [A] card, they could use an unmodified noun phrase, just as the confederate did, or they could use a modifier, such as "just" or "only" ("The card with just a pencil"). To describe the [AB] card, they could use an unmodified noun phrase, or they could use a conjunction and describe the A and B objects ("The card with the book and the pencil").

If participants show enrichment alignment then we expect to find global and local priming effects. We expect participants to produce more unmodified descriptions in the *implicit* condition than the explicit condition. These are global effects. We expect to find local priming effects in the *implicit* condition but not the *explicit* condition. This is because in the *implicit* condition there were no implicature trials; all trial sequences predicted low

implicature activation levels. Thus there were no theoretical reasons why participants should prefer to use an implicature in A->A sequences than in an AB->A sequences, say, or more in A->AB than in AB->AB sequences.

In the *implicit* condition participants should produce higher rates of unmodified descriptions for A targets in [A->A] sequences than [AB->A] sequences because in the A trials the confederate uses an implication whereas in AB trials the confederate cancels any implication (there is no card which corresponds to "The card with the [B] and nothing else"). The opposite is predicted for AB targets, participants should produce lower rates of unmodified descriptions for [A -> AB] sequences than [AB -> AB] trials. Following AB prime trials using an unmodified description is acceptable whereas following an A prime this would indicate the need for an implicature. Consequently an interaction is predicted for the *implicit* condition between type of confederate (prime) trial and type of participant (target) trial, with rate of unmodified descriptions as the dependent measure.

Method

Participants

Thirty-five participants from the Cardiff University community were recruited and received either course credit or payment.

Design and hypothesis

Participants were randomly assigned to either the implicit condition (N = 17) or the explicit condition (N = 18). The difference between the conditions was the style adopted by the confederate. In the explicit condition, the confederate always used a modified single object utterance to describe the [A] card, e.g. "the card with *just* the pencil," but in the implicit condition they always used an unmodified single object utterance, "the card with the pencil." Thus in the explicit condition participants never derived an inference but in the implicit condition participants needed to derive an inference to identify the [A] card referent. All other aspects of the design were the same as in Experiment 1.

Materials

Since the use of two primes in Experiment 1 did not have an effect single primes were used in Experiment 2. Experimental items used the same structure as in Experiment 1 and most of the same items were reused. In the explicit condition [A] cards were described using one of four modifiers: *only, just, on its own, by itself*. Each modifier was used 4 times across the experiment with an equal number appearing the first and second half of the experiment.

Experimental pairs were separated by filler pairs. Filler items differed from Experiment 1 in that they only referred to the [CD] and [E] cards and were always described, by the confederate, using a single object utterance. An additional 8 practice pairs were included at the start of the experiment to allow participants to get used to the experimental procedure. These were a mixture of [A], [AB], [CD], and [E] cards. Thus there were 32 x (prime + target) + 32 x (filler pair) + 8 x (practice pair) = 144 trials. Presentation order was in one of two lists. One order was the reverse of the other.

Results

The same analysis procedure as in Experiment 1 was used. We excluded 22 out of 1120 utterances because of an error in a picture. To ensure that participants were paying attention to the confederate's descriptions key press responses to prime trials were checked. Participants selected the correct card 98% of the time. Therefore we can be confident that they were paying attention to the confederate.

Local priming

Each condition was tested separately. Figure 4 shows the results for the *explicit* condition. Using a two factor repeated measures ANOVA, for the explicit condition there were no main effects and no interaction (*F's* (1, 17) < 1.91, *p's* > .185, BF's < .27). In the *implicit* condition we found no main effect of prime (F (1, 16) = 1.43, p = .249, BF = .30, 95% CI = -.52 - .15) nor target (F (1, 16) = 1.76, p = .203, BF = 1.31, 95% CI = -.32 – 1.40). Crucially, however, there was an interaction between prime and target (F (1, 16) = 9.99, p = .006), whereby the unmodified single object prime raised the rate of unmodified single object utterances on A trials but lowered them for AB trials (see Figure 5). Pairwise comparisons showed that this effect was observable on the AB trials but not on the A trials (t (16) = 2.53, p = .022; t (16) = 1.52, p = .148, BF = .65).

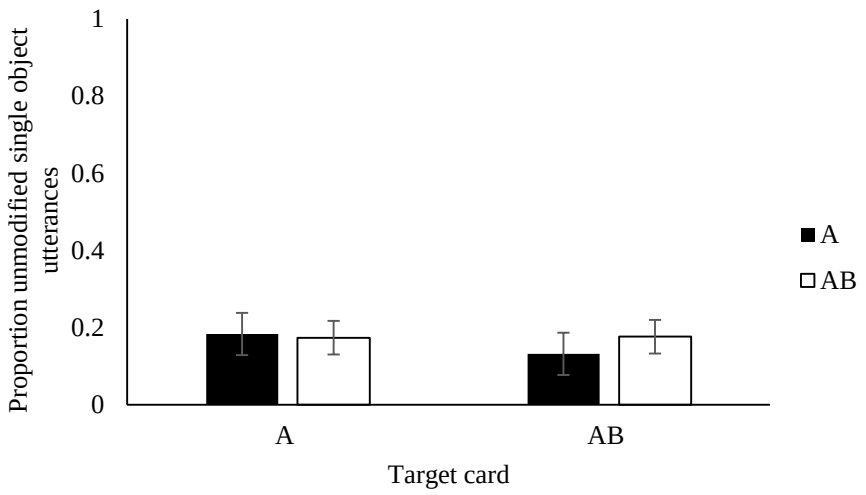

Figure 4. Proportion of unmodified single object utterances to targets in the explicit condition. Black bars correspond to [A] prime cards and white bars correspond to [AB] prime cards. Error bars show standard error.

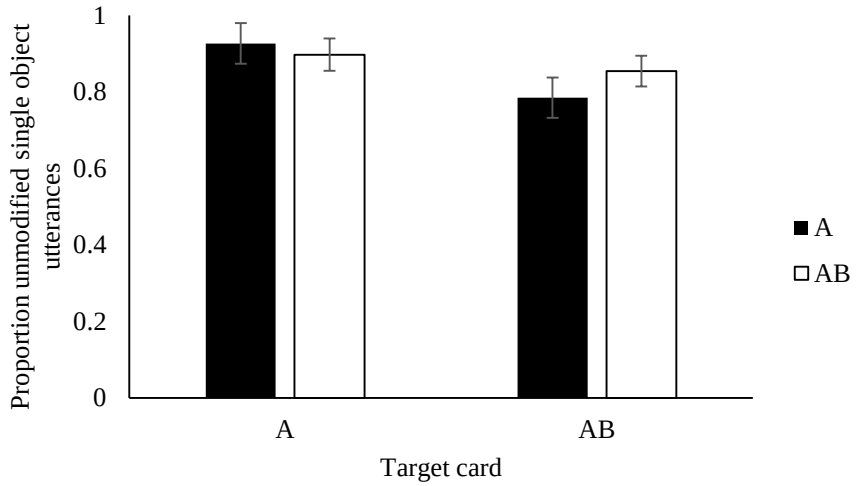

Figure 5. Proportion of unmodified single object utterances to targets in the implicit condition. Black bars correspond to [A] prime cards and white bars correspond to [AB] prime cards. Error bars show standard error.

Data from the local priming provided evidence that deriving inferences as a listener influenced the use of implications as a speaker, unlike in Experiment 1. This is in line with the predictions of enrichment alignment.

Global priming

Implicit and explicit utterances were also compared independently of trial order. Participants in the explicit condition produced a smaller proportion of unmodified utterances on the [A] card trials than those in the implicit condition, $M = 0.18$ *vs* $M = 0.91$

(F (1, 31) = 108.50, p < .001, 95% CI = 4.17-4.20). Thus, participants were sensitive to the structures used by the confederate. Surprisingly, however, there were also differences on the [AB] cards (which were described with a single object utterance in both conditions). Here, participants had the choice between using expressions referring to the (B) object alone, or naming the (A) and the (B) in a conjunctive sentence. Participants in the explicit condition used significantly fewer single object utterances than those in the implicit condition, M = 0.15 vs M = 0.82, (F (1, 31) = 58.21, p < .001, 95% CI = -.27 - .50).

Note that the direction of the latter effect is the opposite to what elevating implicature activation levels might predict. If implicature mechanisms were more strongly activated in the implicit condition, an utterance of the form, "The card with a [B]" would strongly (and misleadingly) imply a card with a B and nothing else. Participants in the implicit condition should therefore have used more conjunctions than those in the explicit condition so as to avoid potentially misleading the listener. This effect therefore suggests that processes in addition to implicature mechanisms were being primed with the global manipulation.

One explanation for the effect on the A card was that lexical material (modifiers) were primed in the explicit condition. For example, after hearing "The card with only an [A]", the modifier "only" could become particularly salient and influence the choice about whether to use an implicature or a modified expression. This was tested by examining the modifiers used by the participant as a function of the modifiers used by the confederate. If the priming effect were lexically based, participants should use the same modifier on trial N as the confederate used in trial N-1. Figure 6 shows the results for the explicit condition (modified responses were too low to be meaningful in the implicit condition). For each modifier there were a large proportion of responses that did not use the same modifier as the confederate. For example, for "only", 60% of the responses used a different modifier while 18% used the same modifier (the remainder used an unmodified expression). The proportion of trials in which the same modifier was used was sufficiently small that we were able to analyse the data after removing these trials (4.5%). When we did this, participants were still more likely to use unmodified utterances when the confederate was also implicit, (F (1, 31) = 98.00, p < .001, 95% CI = 4.01 – 6.09). Thus, the priming effect cannot be entirely due to lexical priming.

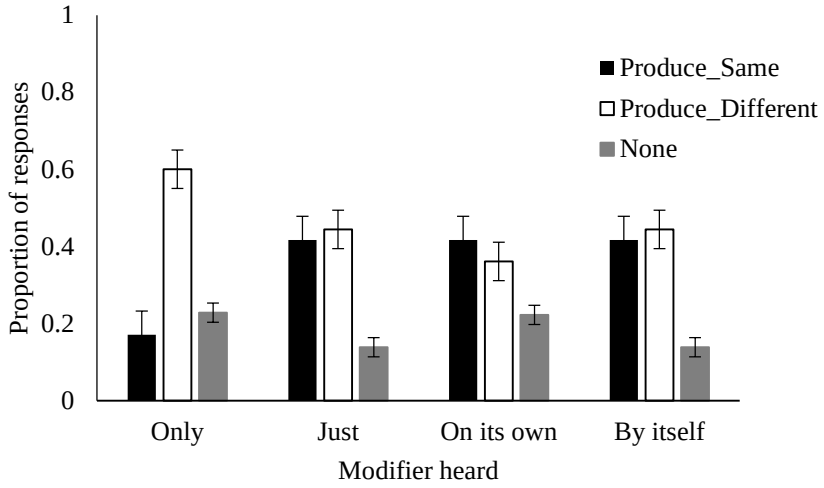

Figure 6. Proportion of participant utterances using no modifier or using the same or different modifier to the one heard. Error bars show standard error.

Discussion

Experiment 2 investigated enrichment alignment through two different manipulations. The first, global, manipulated the form of the confederate's descriptions of the [A] cards. In the implicit condition the confederate used unmodified simple noun phrases and in the explicit condition the confederate used a modified simple noun phrase. Descriptions of the [AB] cards were kept constant across both conditions. Participants in the implicit condition produced significantly more unmodified single object utterances than those in the explicit condition. This pattern was seen for both [A] and [AB] target cards. The second, local, manipulated the trial-by-trial sequence. No effect was found in the explicit condition since no trials required an inference. In the implicit condition however, participants were sensitive to the utterance used by the confederate and demonstrated enrichment alignment. After having made an inference participants were more likely to then produce an implicature. The results suggest that there are representations or processes corresponding to implicatures that can be activated and deactivated during conversation. After comprehending an inference the representations involved had an activation advantage over other representations that were not used. Consequently these implicature representations were more likely to be used in subsequent speech production. After cancelling an inference, the implicature representations' activation was suppressed thereby reducing the likelihood of them being used for subsequent production.

The comparison of implicit to explicit utterances revealed large alignment effects. However, it is not clear what kind of alignment occurred. While alignment of Gricean

processes or representations explains the effect on the [A] cards (the modifiers in the explicit condition might suppress the Gricean representations), it predicts the reverse effect on the [AB] cards. If inference mechanisms were suppressed generally in the explicit condition, there should have been more single object utterances than in the implicit condition, not fewer. It could be that in the global effect reflects participants aligning with the confederate with respect to *conciseness*. When the confederate used short expressions, so did the participant, and when the confederate used more complete, but longer expressions (i.e. by including the modifier), so did the participant. Note that this explanation does not apply to the local priming effect because the direction of the effect was in the opposite direction.

Experiment 2 used a confederate as the interlocutor. However, we have no way of knowing whether participants believed our deception. Our results could therefore be a consequence of participants believing that the conversational partner was an experimenter. In Experiment 3 we tested this by manipulating whether the partner was presented as an experimenter or another participant.

Experiment 3

Experiment 3 had two aims. The first was to replicate the alignment effects observed in Experiment 2 and the second was to investigate how the social status of the confederate affected alignment. In one condition participants were informed that their partner was an experimenter whereas in the other condition the confederate was treated like another participant.

There is reason to believe that an individual's perception of their interlocutor influences their utterances. Behavioural and linguistic imitation, or mimicry, is seen when interacting with someone of a higher status and is often linked to the desire to be liked by that person (e.g. van Baaren, Holland, Kawakami, & van Knippenberg, 2004; Bandura & Kupers, 1964; Branigan, Pickering, Pearson, & McLean, 2010; Lakin, Chartrand, & Arkin, 2008; McGuigan, 2013). There is also evidence that mimicry is used for in group affilitation; individuals demonstrate greater imitation to their in-group (e.g. Bourgeois & Hess, 2008; Welkowitz, Feldstein, Finkelstein, & Aylesworth, 1972; Yabar, Johnston, Miles, & Peace 2006). The degree of alignment however, is modulated by social factors (Weatherholtz, Campbell-Kibler, & Jaeger, 2014).

Consequently, manipulating the status of the confederate could affect the strength of alignment observed. One the one hand, if participants believe their partner to be an experimenter this may lead to greater alignment since the experimenter is in a position of authority and in this context could be considered to be of higher social status of the

confederate. By aligning with the experimenter the participant signals similarity with the experimenter which could serve to enhance success in the task (e.g. Giles & Powesland, 1975; Smith, Brown, Strong, & Rencher, 1975). On the other hand though there may be greater alignment when the participant believes their partner is another participant because they are similar and are part of the same group. Thus, participants may perceive their partner as more likeable and demonstrate greater alignment (Balcetis & Dale, 2005; Hwang & Chun, 2018). Alternatively there may be no effect of this manipulation. Branigan et al (2003) investigated alignment in human-computer interaction and found that participants displayed similar levels of alignment when interacting with a human as when interacting with a computer. Thus it is possible that manipulating the role of the confederate will not influence the level of alignment.

Orthogonal predictions can be reached about the overall levels of implicit language use. Participants might choose to use more implications overall in the experimenter condition. Since the experimenter would generally be in a position of knowledge, there would be little risk of miscommunication by using implications. Alternatively, participants might use fewer implications because if the partner were the experimenter, participants might feel they have to be particularly informative and precise in their responses.

The basic design was exactly the same as Experiment 2. The only difference was that one group of participants were told that the partner was an experimenter and in the other group they were not. In the latter group, there was an experimenter and a confederate, whereas in the former group one experimenter played the role of both experimenter and conversational partner.

Method

Participants

Fifty participants from the Cardiff University community were recruited and received either course credit or payment.

Design and Materials

The materials and design were the same as in Experiment 2 apart from the addition of a between participant confederate manipulation.

The confederate took the role of either a participant or an experimenter. When the confederate undertook the role of participant the true participant was unaware of their partner's involvement in the experiment. As in the previous experiments reported in this chapter, the participant was unaware that their partner was a confederate. However, when the confederate took the role of experimenter the participant was aware that their

partner was not a participant. The experimenter informed the participant that they would be playing a communication game together and instructed the participant of their task.

Results

Ten participants were excluded due to a problem with the microphone. The data from the remaining forty participants were analysed.

Confederate role

Numerically, participants produced more implicit descriptions when they knew the confederate was the experimenter compared to when they thought the confederate was another participant (see Fig. 7). Despite the numerical difference this was not statistically significant (F (1, 36) = 1.13, p =.296, BF = 0.39, 95% CI = -1.28 – .40), nor was there was an interaction between interlocutor role and conversational style (F (1, 36) = .13, p = .73, BF = 0.3).

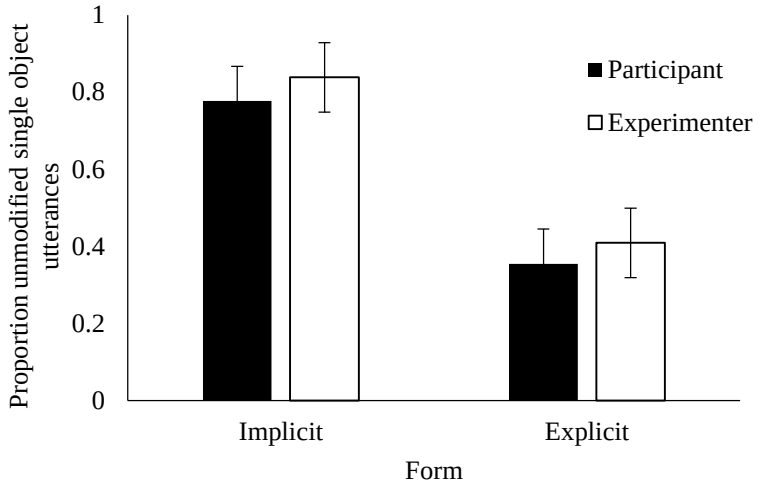

Figure 7. Proportion of unmodified single object utterances to targets. Black bars correspond to the participant condition and white bars correspond to the experimenter condition. Error bars show standard error.

Local priming

Collapsed across the implicit and explicit groups the main effects of Experiment 2 were replicated (see Fig. 8). There was no effect of prime (F (1, 32) = .016, p = .90, BF = 0.17) or target (F (1, 32) = 3.58, p =.068, BF = 6.78). However, there was an interaction between prime type and target (F (1, 32) = 6.64, p =.015). Following an [A] card prime participants descriptions of [A] card targets were more implicit but when the target was an [AB] card descriptions were more explicit. We examined the interaction with pairwise comparisons and found this effect was observable on the AB targets but not the A targets (t (39) = 2.06, p = .046; t (39) = 1.52, p = .136, BF = .49).

Looking at the implicit group alone there was no effect of prime, target and the interaction was nearing significant (F (1, 18) = .567, p = .461, BF = .03; F (1, 18) = .613, p = .444, BF = .47; F (1, 18) = 4.10, p = .058, BF = .50).

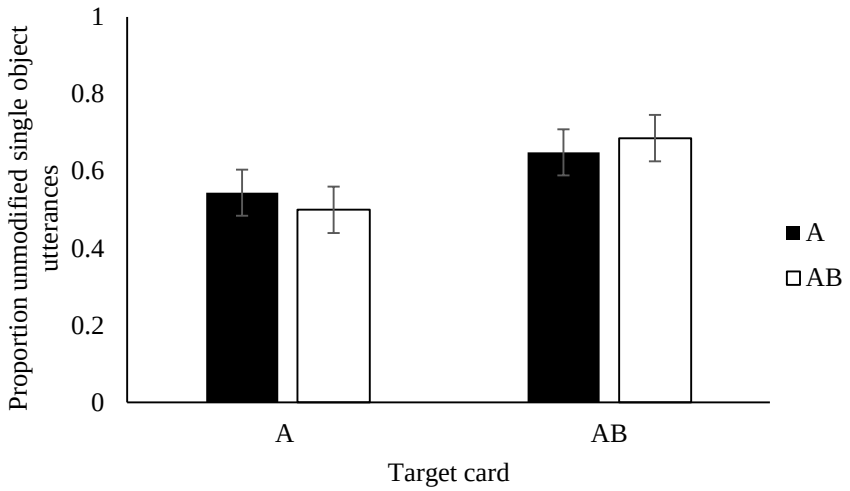

Figure 8. Proportion of unmodified single object utterances to targets. Black bars correspond to [A] prime cards and white bars correspond to [AB] prime cards. Error bars show standard error.

The general pattern of results was the same when taking each partner role separately. However, there was no significant interaction when the partner was a participant (F (1, 16) = 3.01, p=.10, BF = 0.5) or when the partner was an experimenter (F (1, 16) = 4.18, p=.058, BF = 0.4). The Bayes Factors give no reason to suggest that these nonsignificant results were anything else but a lack of power.

Global priming

Participants in the implicit condition produced more implicit utterances than those in the explicit condition (F (1, 36) = 45.72, p < .001, 95% CI = 1.97 – 3.65). On the [A] card trials participants in the implicit condition produced a greater proportion of unmodified single object utterances, M = 0.84 *vs* M = 0.21 (F (1, 36) =74.64, p < .001, 95% CI = 3.08 – 5.00). Thus the production choices of the participant were influenced by the confederate. This pattern was also observed for the [AB] cards. Participants in the implicit condition used significantly fewer unmodified single object utterances than those in the explicit condition, M = 0.78 *vs* M = 0.56, (F (1, 36) = 5.06, p = .031, 95% CI = .15 – 3.01) (participants who didn't use single object utterances used conjunctions involving both objects).

Participants' use of modifiers was analysed as in Experiment 2 to ensure that the global priming results couldn't be accounted for by the repetition of lexical material. If the

priming effect was lexically based then participants should use the same modifier as the confederate used on the immediately preceding trial. As in Experiment 2 there were a large proportion of responses that did not use the same modifier as the confederate (see Fig. 9). The proportion of trials in which the same modifier was used was sufficiently small that we were able to analyse the data after removing these trials (4.6%). When we did this participants were still more likely to use unmodified conditions when the confederate was also implicit (F (1,32) = 62.31, p <.001, 95% CI = 2.81 – 4.76).

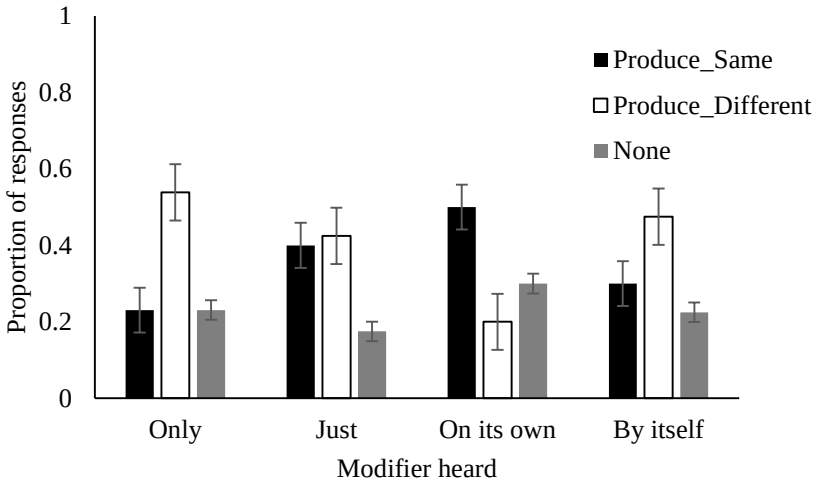

Figure 9. Proportion of responses using the same, different, or no modifier. Error bars show standard error.

Discussion

The main findings from Experiment 2 were replicated: Participants were more likely to produce implicit constructions when their interlocutor was using implicit constructions than when they were using explicit constructions. These effects were shown for local and global priming manipulations.

There was no influence of the social status of the conversational partner. There were no significant main effects nor interactions of the partner manipulation. However, Bayes Factors indicated that the experiment lacked the necessary sensitivity to support the null hypothesis in this respect. We therefore leave the question about the role of social status in priming to further research. Importantly, global priming effects occurred regardless of the partner role, and local priming effects showed similar patterns in both conditions but were narrowly nonsignificant. Therefore, the priming effects observed in Experiment 2 were not due to particular strategies adopted by participants disbelieving that the partner was another participant. Instead participants were showing enrichment alignment.

Participants in Experiments 2 and 3 displayed enrichment alignment. They were more likely to produce implications after comprehending an implication. These results differ to those of Experiment 1 where participants did not show alignment. We suggested that this was a consequence of the confederate's descriptions in filler trials being inconsistent. The inconsistency lies in the informativity of the description. The filler descriptions of double item cards, [AB] or [CD], used a mixture of simple noun phrases and conjunctions. In experimental trials, [AB] cards were always described using a simple noun phrase, which was sufficient for disambiguating the referent. Despite this, participants preferred to use conjunctions to describe [AB] cards. Conversely the majority of participants' descriptions of [A] cards were simple noun phrases and thus ambiguous without deriving an implicature. That is, participants were not susceptible to the local priming effect; they did not align with respect to enrichment. In Experiment 2 and 3 the confederate's descriptions were consistent throughout the experiment and participants displayed enrichment alignment along with alignment on conversational style. However, conversational style was manipulated between-participants.

Experiment 4 manipulated the conversational style within participants by altering the confederate's descriptions of [A] cards; half of the descriptions used simple noun phrases and the other half used modified noun phrases. Altering the conversational style at a local level provides a way of testing how interlocutor in consistency affects enrichment alignment. If inconsistency interferes with enrichment alignment then participants should be less susceptible to the trial-by-trial manipulation (local effect in the previous experiments).

Experiment 4

Method

Participants

Thirty-two Cardiff University undergraduate students participated for either payment or course credit.

Materials and Design

The items from Experiment 2 were used. [A] card descriptions were split into modified and unmodified descriptions such that there were 8 instances of each. The same modifiers as in experiment 2 were used and each appeared twice throughout the experiment; once in each half. The 8 modified [A] cards were swapped across two lists, these lists were then reversed giving a total of 4 counterbalancing lists. Participants were randomly assigned to one of the lists. All other details remained the same.

Results

Each participant produced 32 target responses. Of the 1024 responses 46 were excluded due to experimenter error. To ensure that participants were paying attention to the confederate's descriptions we looked at key press responses to prime trials. Participants selected the correct card 95% of the time hence they were paying attention to the confederate. The same analysis procedure from the previous experiments was followed. Figure 10 shows participants responses to each target type following each prime. We assessed the modifier effect (A and modified A) primes separately to the local priming effect (on A and AB primes).

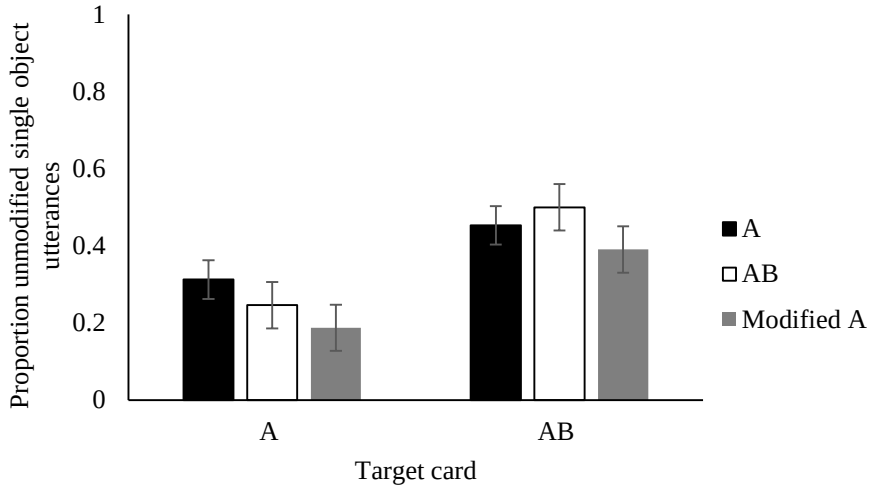

Figure 10. Proportion of unmodified single object utterances to targets. Black bars correspond to [A] prime cards and white bars correspond to [AB] prime cards. Grey bars correspond to [A] prime cards that were described with a modifier. Error bars show standard error.

Modifier effect

To assess the effect of the modifier a 2x2 ANOVA was run with prime type (A, Modified A) and target type (A and AB) as within participant factors. A main effect of prime was found (F (1, 28) = 5.41, p = .028). The effect of target was not significant (F (1, 28) = 3.00, p = .094, BF = 5.31) and there was no interaction (F (1, 28) = .39, p = .680, BF = 0.27). After hearing a modifier participants were less likely to produce an unmodified single object utterance but this was only the case for the [A] target cards (t (31) = 2.11, p = .043; t (31) = 1.13, p = .265, BF = 1.32).

Local priming

Enrichment alignment was assessed by comparing responses following [A] and [AB] primes. A 2x2 ANOVA with prime (A and AB) and target (A and AB) as within participant factors was run. As in Experiments 2 and 3 there were no effects of prime (F (1, 28) = .003,

p = .954, BF = .19) or target (F (1, 28) = 3.30, p = .080, BF = 11.52). Unlike the previous experiments however, there was also no interaction (F (1, 28) = .86, p = .358, BF = 0.314).

Discussion

Experiment 4 investigated the effect of speaker inconsistency on enrichment alignment. A within participant manipulation was used where the confederate's descriptions of [A] cards either included or omitted a modifier. This was predicted to disrupt the participant's ability to successfully align with the confederate. By inconsistently using implications the confederate impeded the priming of the participant's implicature representations, thereby reducing the activation of these representations and thus decreasing the likelihood of their use. The results of Experiment 4 support this.

Overall Experiment 4 appears to offer some support to the hypothesis that individuals do become aligned with respect to enrichment but that this alignment is sensitive to the consistency of their interlocutor.

General Discussion

The experiments presented in this chapter investigated the structural alignment of pragmatic enrichment. Taken together, they demonstrate that interlocutors become aligned on enrichment and that the extent of alignment is affected by interlocutor consistency. It is important to note that experiments investigating social factors typically have larger sample sizes than those of the experiments presented here. In some of the experiments presented above (particularly Experiment 3) there is indication that there is low power (Bayesian analysis) and thus the conclusions drawn from these experiments require further investigation. Despite this, evidence for two different types of priming was found: local and global. Local priming was the main test of enrichment alignment and was investigated by manipulating the trial sequence. Participants' use of implications was influenced by whether or not the confederate had used an implicature in the preceding trial. Global priming on the other hand reflected a different type of priming where participants aligned with the confederate's overall conversational style. We discuss these results in more detail below.

Local priming

Participants' use of implicatures was influenced on a trial-by-trial basis depending on whether or not the confederate had used an implicature in the previous trial. There was an interaction between prime and target. For [A] target trials, after making an inference participants were more likely to produce an unmodified noun phrase. Whereas for [AB] target trials, after making an inference participants were less likely to use an unmodified noun phrase. In other words, if the confederate had used an implicature in the previous

trial participants were more likely to use an implicature to describe an [A] target but were more likely to use a conjunction to describe an [AB] target. This can be accounted for by shared representations between comprehension and production. After making an inference (comprehending), the representations involved retained activation so that when it was the participant's turn to describe a card, they were more likely to reuse the shared representations and thus, in the case of an [A] target, to produce an implicature.

The case is more complicated for [AB] cards. Recall that [AB] cards contained two items, one of which was unique to the card and one of which was shared with another card. Thus a sufficient description needed only to refer to the single unique referent (B image) since that was unambiguous. Alternatively, participants could have used a conjunction and named both referents. Therefore, participants' descriptions of [AB] cards never truly used implicatures. Despite this, whether or not the participant had made an inference did influence their subsequent description of [AB] cards. After making an inference participants were more likely to use a conjunction than refer to the single item. This too can be explained in terms of shared representations. After making an inference, describing the [AB] card using the single unique referent would be misleading since the implication, *the card with the [B] and nothing else,* would not identify any of the cards. Describing both items on the card avoids this problem. That participants' descriptions of [AB] cards were influenced by whether or not they had made an inference is especially interesting considering that the confederate only ever used a single referent in their descriptions.

These results can be explained by a shared representation as follows. The implicature representation is a sentence level representation [S $\wedge$ $\neg$ S′] where S refers to the basic unenriched sentence and S' to the informationally stronger alternative. Consider an [A] card prime. The confederate's description "the card with the [A]" corresponds to S and the informationally stronger alternative, S′ , is "the card with the [A] and the [B]." In order to identify the [A] card the participant must derive the implicature "the card with the [A] *and not the card with the [A] and the [B]."* Thus the [S $\wedge$ $\neg$ S′] representation will retain some activation when it is then the participant's turn to describe a card and hence is more likely to be reused.

Global priming

Now consider the results from the global priming. Participants in the implicit condition produced more unmodified single object utterances than those in the explicit condition. This is consistent with there being shared representations between comprehension and production. However this alone cannot account for the results.

Consider the [AB] cards again. If implicature representations were more strongly activated in the implicit condition then the use of the single referent description would be misleading due to the implicature. Consequently there should have been more conjunctions used to describe the [AB] card in the implicit condition and fewer in the explicit condition. Interestingly the opposite pattern was seen; in the implicit condition there were fewer conjunction descriptions of [AB] and more in the explicit condition. This effect therefore suggests that processes in addition to implicature mechanisms were being primed with the global manipulation.

It is not clear what these processes are. It could be that in the implicit condition participants were being primed to be concise, or to speak efficiently, whereas in the explicit condition participants had no such constraint. Efficiency has been proposed as an explanation for why people produce implicatures (Levinson, 2000). Using implicatures could be considered as speaking efficiently. Compared to speech preparation processes articulation is very slow which causes a bottleneck (Levinson, 2000; Wheeldon & Levelt, 1995). The effect of the bottleneck however, can be minimized by reducing the amounts of material to be articulated (Grice, 1989; Levinson, 2000). Whilst this does not account for the local priming effects, since efficiency was not changed within conditions, it could account for the global priming effects.

More broadly, the global priming effects are likely to relate to audience design. It is well established that speakers often tailor their utterances to suit the addressee (e.g. Brown-Schmidt, Yoon & Ryskin, 2015; Keysar, Barr, Balin, Brauner, 2000). For example in referential communication games where a speaker interacts with two independent interlocutors the speaker will adjust their choice of referent based on their past experience with the particular addressee (Garrod & Doherty, 1994; Horton & Gerrig, 2002, 2005). Similarly a speakers choice to use modifiers to describe an object is influenced by whether their partner can see a contrastive item (e.g. using “big glass” when the addressee can see two glasses but omitting the modifier if the addressee can only see one of the two glasses; Brown-Schmidt & Konopka, 2011; Engelhardt, Bailey, & Ferreira, 2006; Horton & Keysar, 1996). In the case of the experiments presented in this chapter audience design may account for the global priming effects.

In the implicit condition of Experiments 2 and 3, based on the local priming, it was expected that participants would use more conjunctions to describe [AB] cards than in the explicit condition. Instead the opposite patterns was found. There were more conjunction descriptions in the explicit condition. We suggest that participants were tailoring their descriptions based on the overall conversational style. As discussed above it could be

based on efficiency. In the implicit condition the confederate used unmodified single object utterances to describe [A] and [AB] cards which were short (and therefore efficient descriptions) whereas in the explicit condition the confederate used modifiers to describe [A] cards which may be considered less efficient (from a speaker's perspective).

Whilst efficiency, and audience design, can account for the global priming effect they cannot account for the local priming effect since these results were in the opposite direction to the predictions of an efficiency account.

Interlocutor inconsistency

When the confederate was inconsistent in their descriptions this reduced the participants' ability to align; after deriving an inference participants were no more likely to produce an implicature than if they had not derived an inference. Alignment relies on priming whereby a structure retains residual activation after being used and is thus more easily used on a subsequent occasion. Inconsistency may affect this by activating multiple different structures and therefore preventing one structure from gaining an advantage over another (if priming occurs cumulatively over the course of the experiment, e.g. Kaschak, Kutta, & Coyle, 2014). This explanation is inconsistent with work on syntax which sees not only priming immediately after encountering a structure, but also priming effects which last for multiple intervening trials which use different structures (e.g. Bock & Griffin, 2000; Segaert, Wheeldon, & Hagoort, 2016).

Instead, interlocutor inconsistency is more likely to affect the participant's ability to tailor their utterance to their partner. Successful audience design relies on consistency (much in the same way that priming does) in order to be able to make predictions about the addressee (Graham, Sedivy, & Khu, 2014; Jaeger & Snider, 2012; Shintel & Keysar, 2007). The interlocutor inconsistency in Experiments 1 and 4 are likely to affect the participant's evaluation of their partner's pragmatic ability[7]. In Experiment 1 the confederate described single item cards ([A] and [E]) using an unmodified single object utterance most of the time thus the participant can be confident that the confederate will correctly derive the implicature when the [A] card is the target. In Experiment 1 the inconsistency arose on the double item cards ([AB] and [CD]); on some trials the confederate would use an unmodified single object utterance and in others they would use the conjunction. The confederate consistently described [A] cards using a single object utterance and this indicated the use of an implicature. Using a single object utterance to describe an [AB] card however did not indicate the use of an implicature. Instead, an

[7] I am not claiming that this is a conscious evaluation of pragmatic ability.

implicature interpretation would have to be cancelled if it were derived. However, because the confederate described these cards inconsistently it is possible that the participant could not be sure that using a single object utterance would allow the confederate to identify the card and thus used conjunctions irrespective of the structure the confederate had used.

Summary

The aim of the experiments presented in this chapter was to investigate the interaction between the production and comprehension of implicatures and see whether interlocutors become aligned based on pragmatic enrichment. The results of the experiments demonstrate that interlocutors do become aligned on when to enrich a sentence. However, the extent of alignment is affected by interlocutor consistency. We suggest that the locus of alignment is an implicature specific representation that is shared between the production and comprehension systems.

Chapter 5: Conclusions

The experiments presented in this thesis made use of structural priming to investigate the nature of pragmatic enrichments. Overall this thesis makes several important contributions to our understanding of pragmatic enrichments. Chapter 2 demonstrated that the salience of the alternative is vital for the derivation of scalar implicatures and that adults are sensitive to alternative salience. In Chapter 3 we focused on ad hoc implicatures and found that for ad hoc implicature derivation rather than generate contextually based alternatives there is a general *anything else* alternative that is used. The final chapter found that interlocutors' use of implicatures becomes aligned but the extent of alignment is affected by interlocutor consistency.

Chapter 2 compared two models of implicature derivation. The first, the *combination* mode, states that implicature derivation involves the distinct stages of identifying appropriate alternatives and then negating these alternatives. In this model the identification of alternatives and their subsequent use are two separate stages in the processing of implicatures. The second model, the *salience* model, states that the derivation of an implicature is contingent upon the salience of the alternative alone. That is, this model does not posit the involvement of a separate usage mechanism; the usage mechanism is applied automatically providing the alternative is sufficiently salient. Existing theories of implicature derivation are not explicit about this distinction however they can be broadly mapped onto these models. The evidence from Chapter 2 favours a *salience* model; we did not find evidence of an independent usage mechanism. This addresses a question posed by Bott and Chemla (2016).

Bott and Chemla (2016) demonstrated within and between expression priming of scalar implicatures. They suggested that the priming effects could be accounted for by either priming a mechanism that searches for the alternative or a usage mechanism that negates the alternative. Based on Chapter 2 the priming effects in Bott and Chemla are likely due to priming the search for alternatives rather than a usage mechanism. Whilst Bott and Chemla talk about mechanisms, their findings are not inconsistent with priming a general implicature representation (as discussed below). Of course, the work in Chapter 2 only looked at within expression priming and thus cannot necessarily speak to between expression priming. However, it would be interesting to see whether between expression priming is observed when the prime is the alternative.

Chapter 3 investigated *ad hoc* implicatures. Typically research into implicatures focuses on a limited range of categories, predominantly quantifiers and disjunctions (see van Tiel et al, 2014). Contrary to the uniformity assumption recent work has demonstrated that that findings from a particular category cannot be generalised to other categories (Doran et al, 2009; 2012;

van Tiel et al, 2014). Thus it is important to investigate a range of implicature categories. By investigating *ad hoc* implicatures the work of this chapter demonstrates the need to examine a range of expressions with a range of techniques in order to understand implicatures more fully. The results of Experiment 3 in this chapter are at odds with the findings of Chapter 2 and this is most likely due to the different tasks used across the experiments.

Ad hoc implicatures are distinct from other scalar implicatures because they are determined entirely by the context of the discourse; there is no lexicalised scale from which to draw alternatives from. The work of Chapter 3 investigated whether deriving *ad hoc* implicatures involved calculating a contextually based scale of alternatives or whether there was a general purpose alternative. The results were consistent with a general purpose alternative (i.e. *anything else*) as suggested by Geurts (2010).

This is further supported when considering the developmental trajectory of implicature derivation. Children often struggle with implicatures that arise from quantifiers whereas the same difficulties are not seen for *ad hoc* implicatures or number implicatures (e.g. Gualmini et al, 2001; Huang & Snedeker, 2009; Noveck, 2001; Papafragou & Musolino, 2003; Stiller, Goodman, & Frank, 2014). This difference has been attributed to difficulty in generating appropriate alternatives for quantifiers. *Ad hoc* and number implicatures do not have the same difficulty. For numbers the alternatives are clearly relevant because when children are learning numbers they learn them in a scale such that the relation between numbers is clear. In the case of *ad hoc* implicatures, if the speaker did not say anything else they likely did not mean anything else thus the general *anything else* alternative is also easily accessible.

The finding that there is a general purpose alternative rather than a specific contextual is interesting because in Chapter 2 we found priming of *ad hoc* implicatures from an alternative prime. This suggested that the *ad hoc* implicature was derived using a contextually based alternative structure. However, that is not what was found in Chapter 3. The most likely explanation for this relates to the different methodologies and tasks across the two experiments. In Chapter 2 an offline measure, choice proportions, was used whereas in Chapter 3 an online measure was used. Furthermore the experiments in Chapter 2 used a hidden box paradigm. This meant that the task across prime and target trials was slightly different; in prime trials participants had to evaluate two pictures based on a sentence whereas in target trials participants were only provided with one picture to evaluate. If they thought that picture did not match then they selected the Better Picture option (hidden box). Thus target trials require participants to evaluate the picture sentence combination and postulate what a better picture could be. In Chapter 3 however there was no Better Picture option thus there was less ambiguity in how a participant could respond. One suggestion is that in Chapter 2 participants

learned how to respond to the *ad hoc* trials based on their responses to the some and number trials. An interesting way to try and reconcile these different findings would be to explicitly use a general purpose alternative (*and nothing else*) and see whether there is a priming effect.

Chapter 4 took a novel approach to investigating implicatures by focusing on the speaker. Most work on implicatures focuses on how a listener derives an implicature (e.g. Bott & Noveck, 2004; Breheny, Ferguson, & Katsos, 2013, Geurts, 2010; Sauerland, 2004; Tomlinson, Bailey, & Bott, 2013). These are the first experiments to investigate implicatures from a speaker's perspective. We found that interlocutors become aligned in their use of implicatures. That is, the production of implicatures can be primed; participants were more likely to produce implicatures when their partner was also producing implicatures.

Participants use of implicatures was affected by speaker consistency; when their partner was inconsistent in their use of implicatures participants were less likely to produce implicatures. This is consistent with work by Grodner and Sedivy (2011) who found that listeners were less likely to derive an implicature when their partner was judged as unreliable. We suggested this was a result of audience design (e.g. Brown-Schmidt, Yoon, & Ryskin, 2015; Garrod & Doherty, 1994; Horton & Gerrig, 2002; Keysar, Barr, Balin, & Brauner, 2000). When the participant's partner was inconsistent in their use of implicatures this suggested that they may not be able to recognise if they needed to cancel an implicature thus participants were less likely to produce implicatures. This suggests that the production of implicatures cannot be accounted for entirely through priming. This is similar to the findings from Haywood, Pickering, and Branigan (2005). They found that participants could be primed to produce an ambiguous or unambiguous syntactic form. However, when the visual context was ambiguous participants were more likely to use a disambiguated utterance. This showed that priming effects are sensitive to the communicative context. This is further supported by other work finding social modulation of alignment and priming (Balcetis & Dale, 2005; Hwang & Chun, 208; Weatherholtz, Campbell-Kibler, & Jaeger, 2014). The social modulation of priming effects is important to bear in mind, particularly for experiments in pragmatics in which the social context the language is used is paramount.

Traditionally structural priming has been used to uncover syntactic representations however, the findings of this thesis demonstrated that structural priming can also be used to provide insights into how pragmatics could be integrated into a representational language system.

Pragmatic theories are traditionally expressed in terms of processes such as domain general reasoning procedures whereas structural priming results are explained in terms of representations. Thus one explanation for the priming results found in this thesis is that we

were priming the processes underpinning pragmatic enrichment. Whilst the findings of Chapters 2 and 3 could be explained as priming processes specific to enrichment this could not explain the results of Chapter 4. Chapters 2 and 3 found comprehension-comprehension priming but Chapter 4 found comprehension-production priming. Implicatures are typically described as unidirectional processes from speech to conceptual understanding consequently, the processes used in comprehending implicatures would not be the same as those producing implicatures. Thus in Chapter 4 we suggested that there are abstract representations that are shared between production and comprehension which are responsible for pragmatic priming.

The representations responsible for pragmatic priming must be different to those involved in syntax and semantics. The representations used to generate scalar implicatures must take *alternatives* as part of their input. This is supported by Chapter 2 which showed that the alternative primed implicature derivation at the same rate as previously deriving an implicature. This does not apply to the representations involved in syntax and semantics. Secondly, implicatures are optional thus the implicature representations must also be optional (or defeasible). For example, if the speaker is not deemed to have sufficient knowledge to have used the stronger term then the implicature representation would have been blocked. The results of Chapter 4 lend support to this; when the interlocutor was inconsistent in their use of implicatures participants were less likely to align.

One possibility for the representations involved in pragmatic enrichment is that they are sentence level representations,[$S \wedge \neg S'$], where S refers to the basic, unenriched sentence, and S' to the informationally stronger alternative (e.g., *all* in the case of *some*). Whether the same representations are involved for different categories of enrichment is an open question. It is possible that different categories of enrichment have specific representations (such as enrichments from quantifiers vs *ad hoc* enrichments). We have suggested representations rather than processes because processes must be directional and it is not clear how the priming of processes can account for the findings of Chapter 4 since the priming effect was seen across modalities.

Priming from comprehension to production is traditionally accounted for through the existence of shared representations (c.f. Branigan & Pickering, 2017; Branigan, Pickering, & Cleland, 2000). Whilst it makes sense to talk about static syntactic representations such as verb phrases the same cannot be said for pragmatics. Pragmatic meaning is highly context dependent and arises not via static representations but instead through reasoning mechanisms. It is possible that the priming effects seen in this thesis are attributable to bidirectional processes. The use of a process in one direction would increase the likelihood of the same process being reused at a later stage.

Further work is needed for a fuller understanding of what is responsible for the priming effect. Whether the priming effect is due to implicature specific representations or pragmatic reasoning processes it is still not clear. This thesis however, provides a strong demonstration that structural priming can be extended beyond its traditional application to syntax and semantics and can be used to provide an insight into many aspects of pragmatic enrichment.

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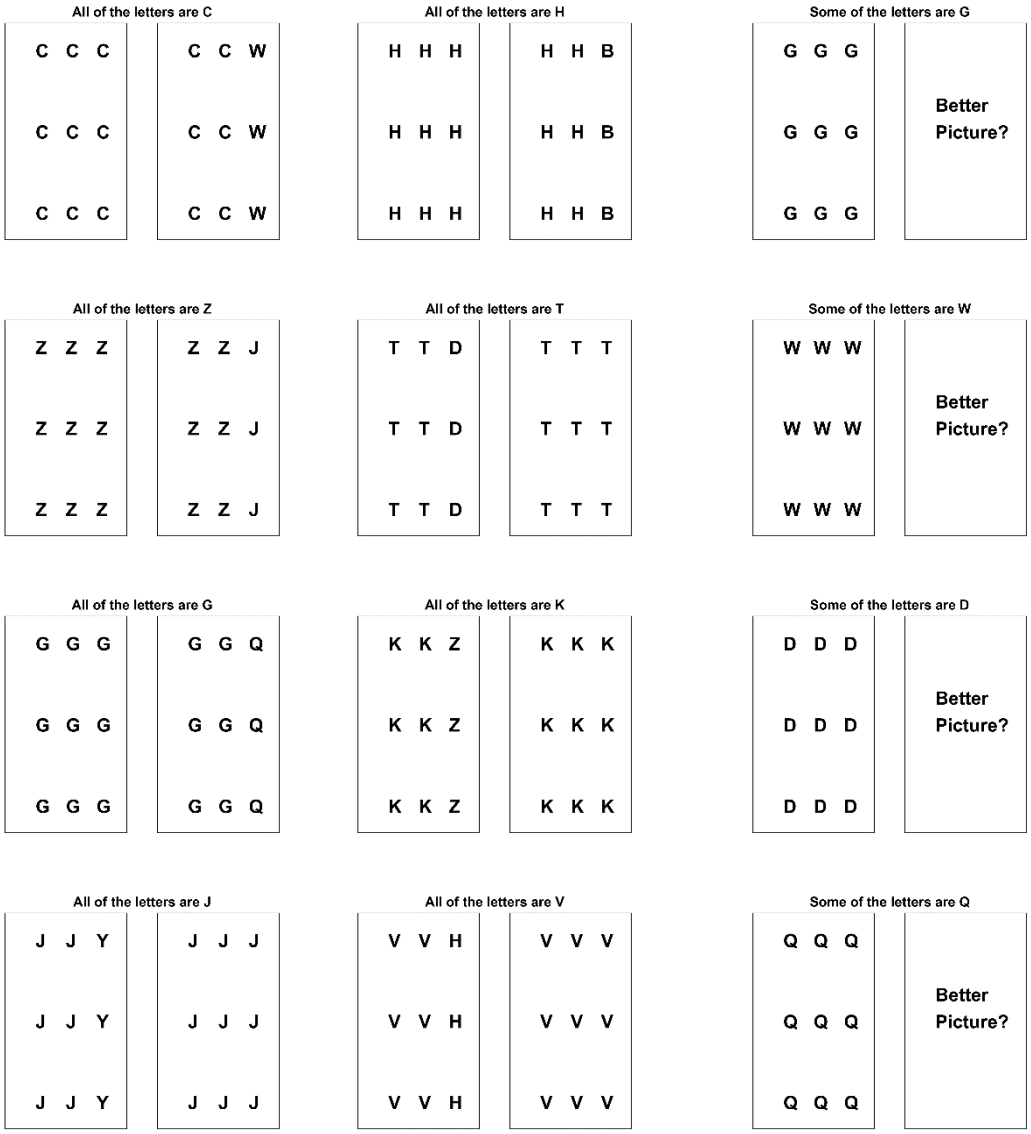
Appendix 1: Chapter 2 Stimuli

Experiment 1

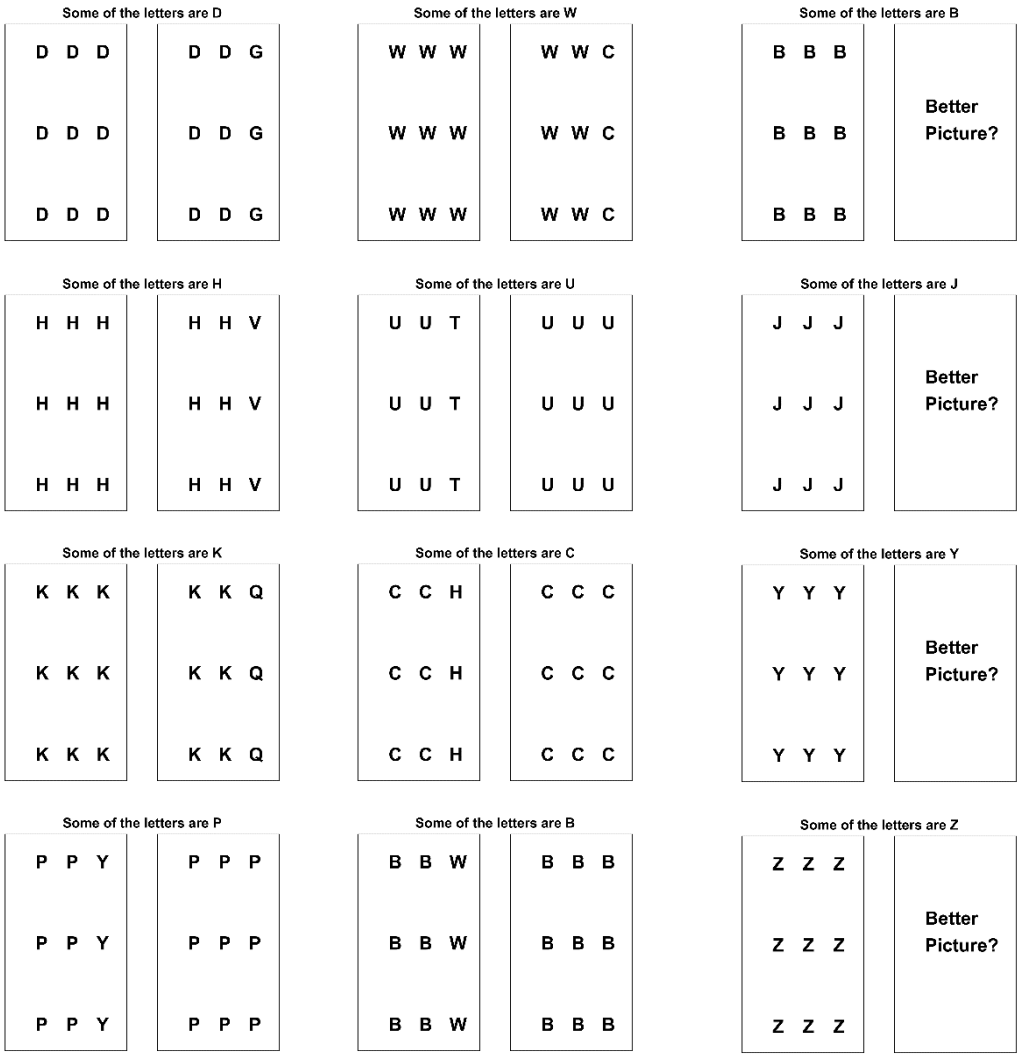
Quantifiers

Alternative Prime	Target

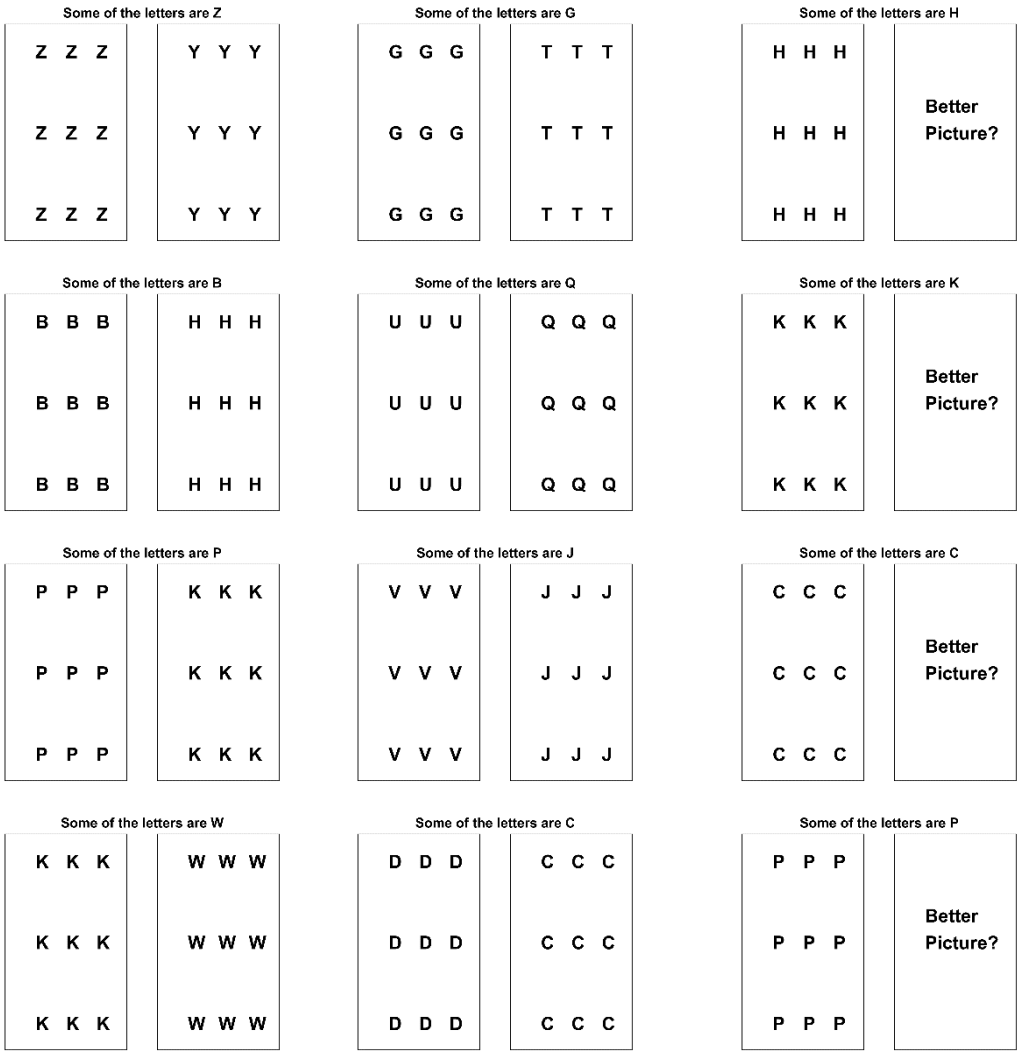


Appendix 1

Strong prime	Target

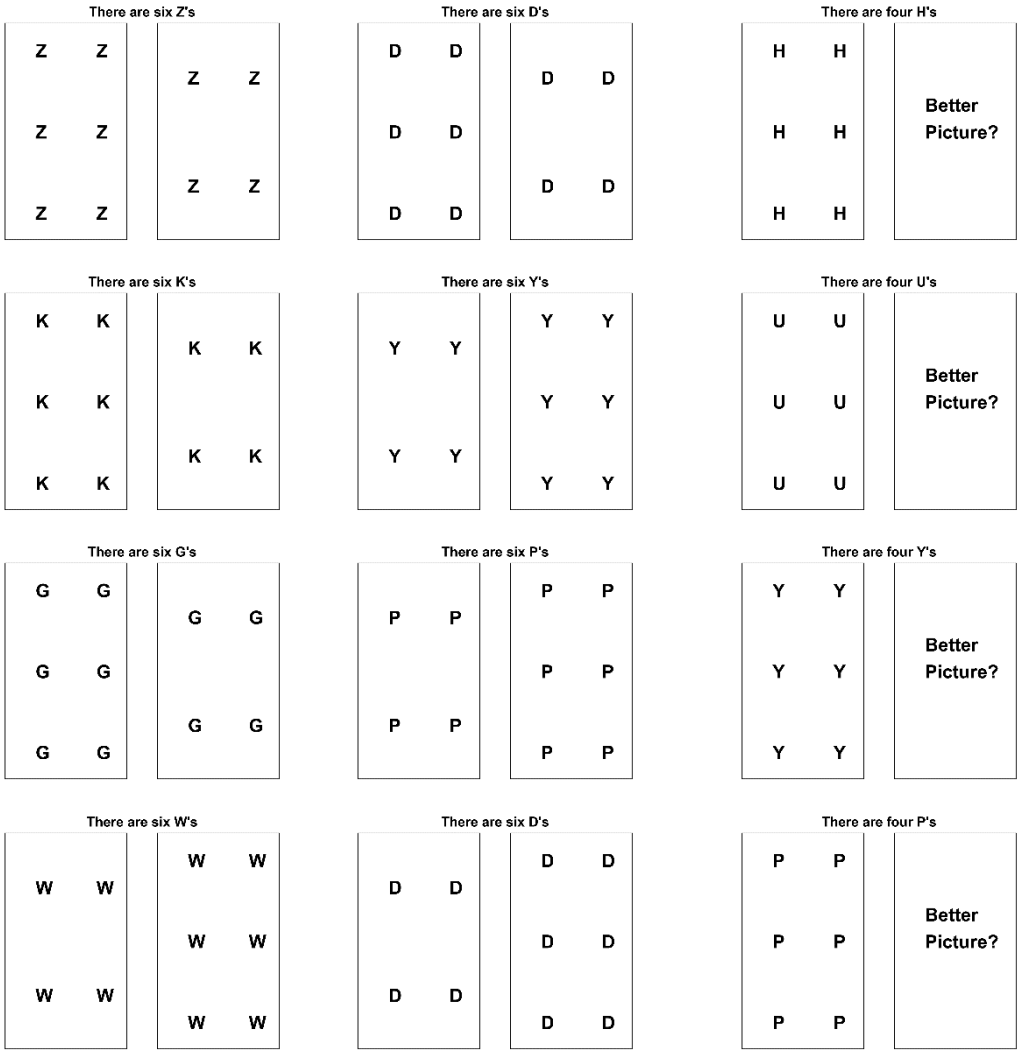


Weak prime	Target

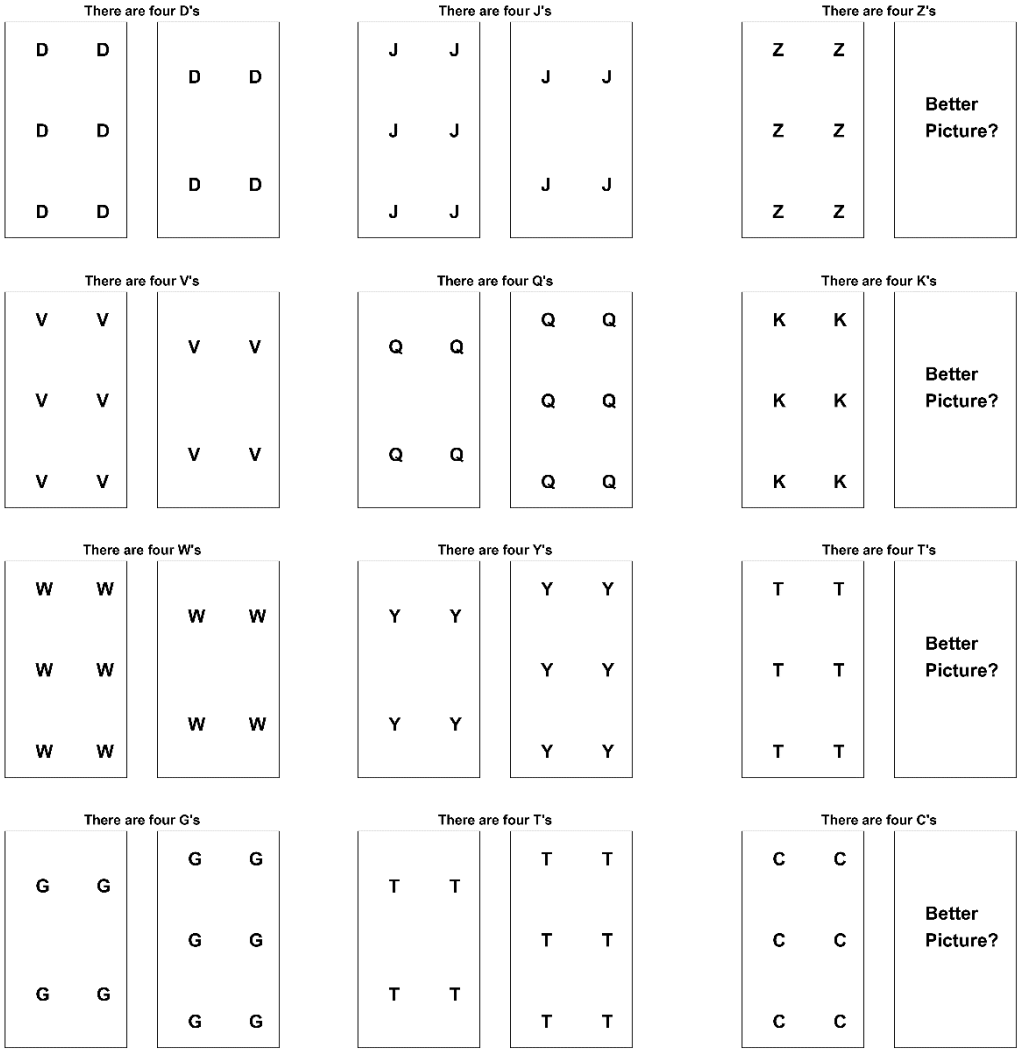


Numbers

Alternative prime	Target

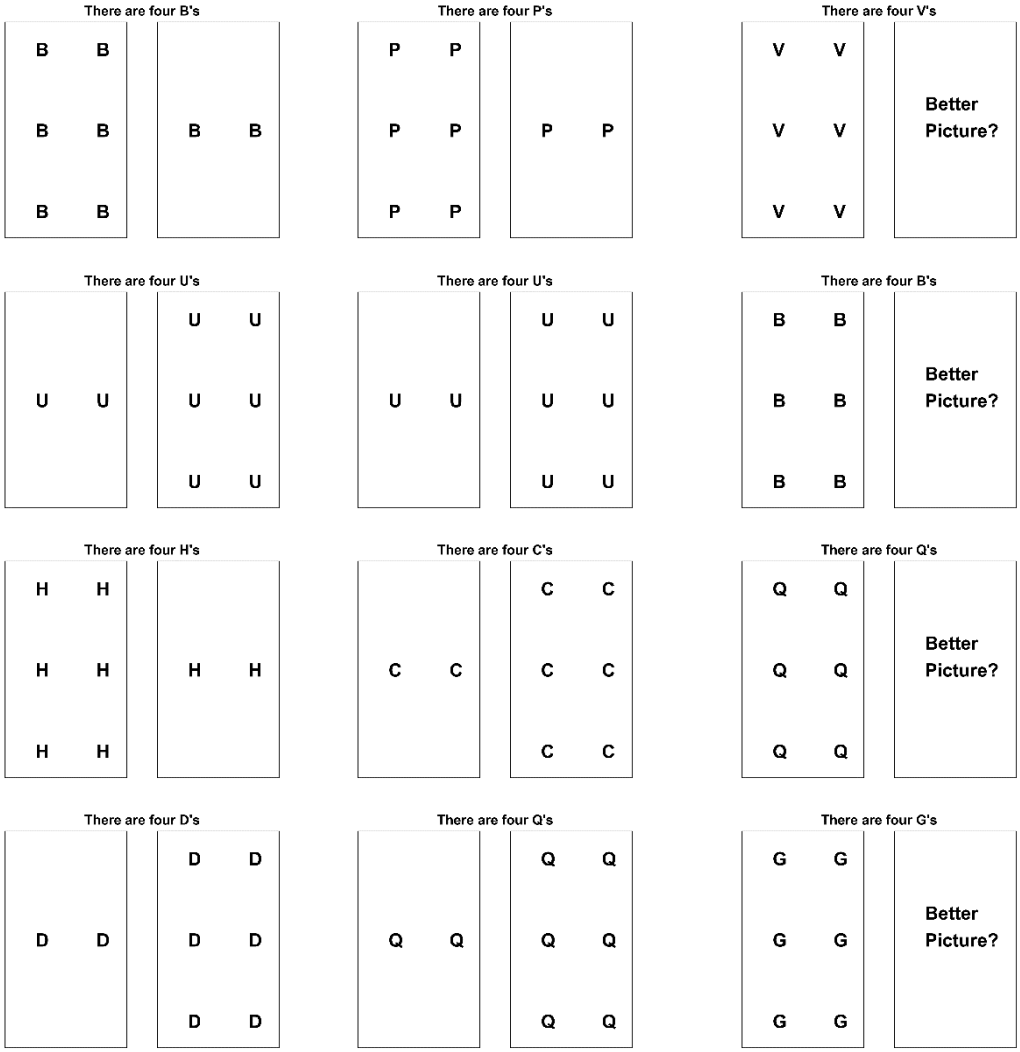


Strong prime	Target



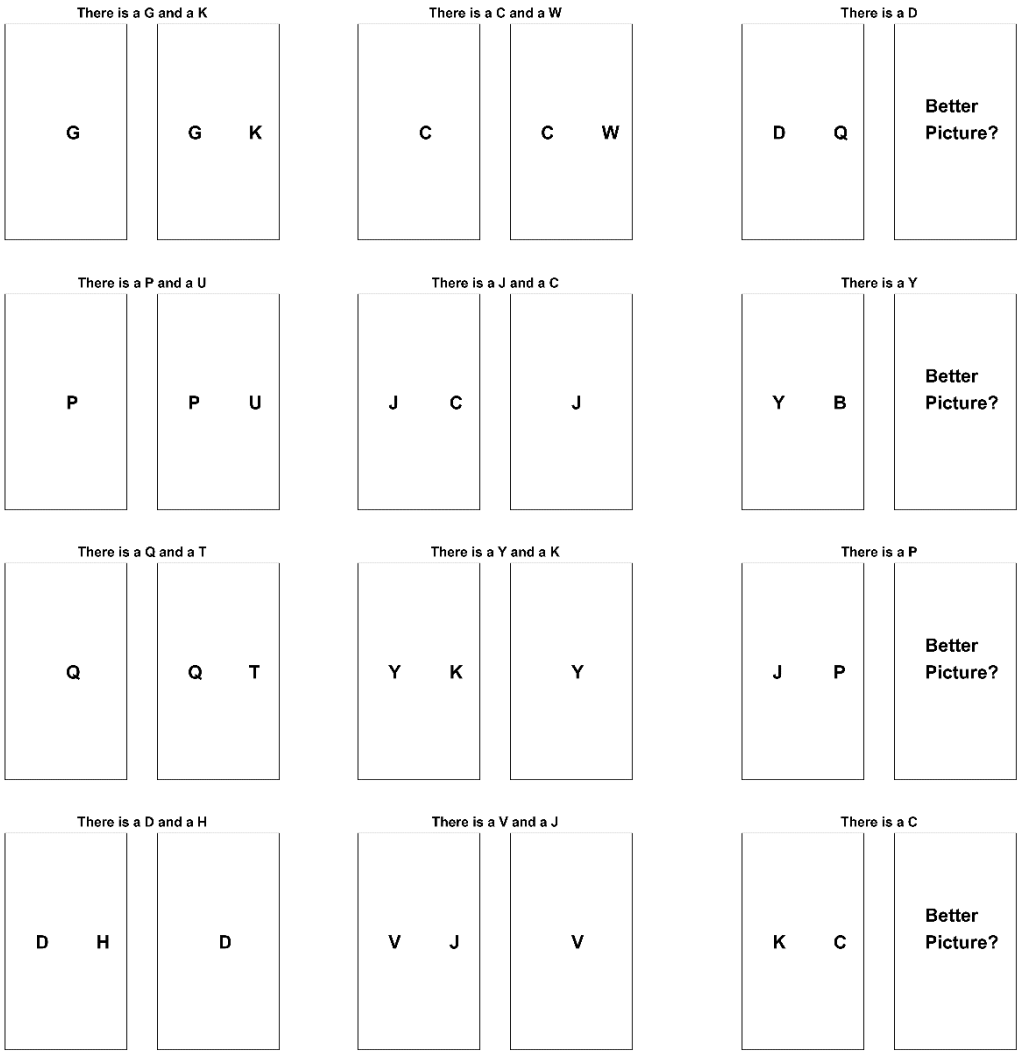
Appendix 1

Weak prime	Target



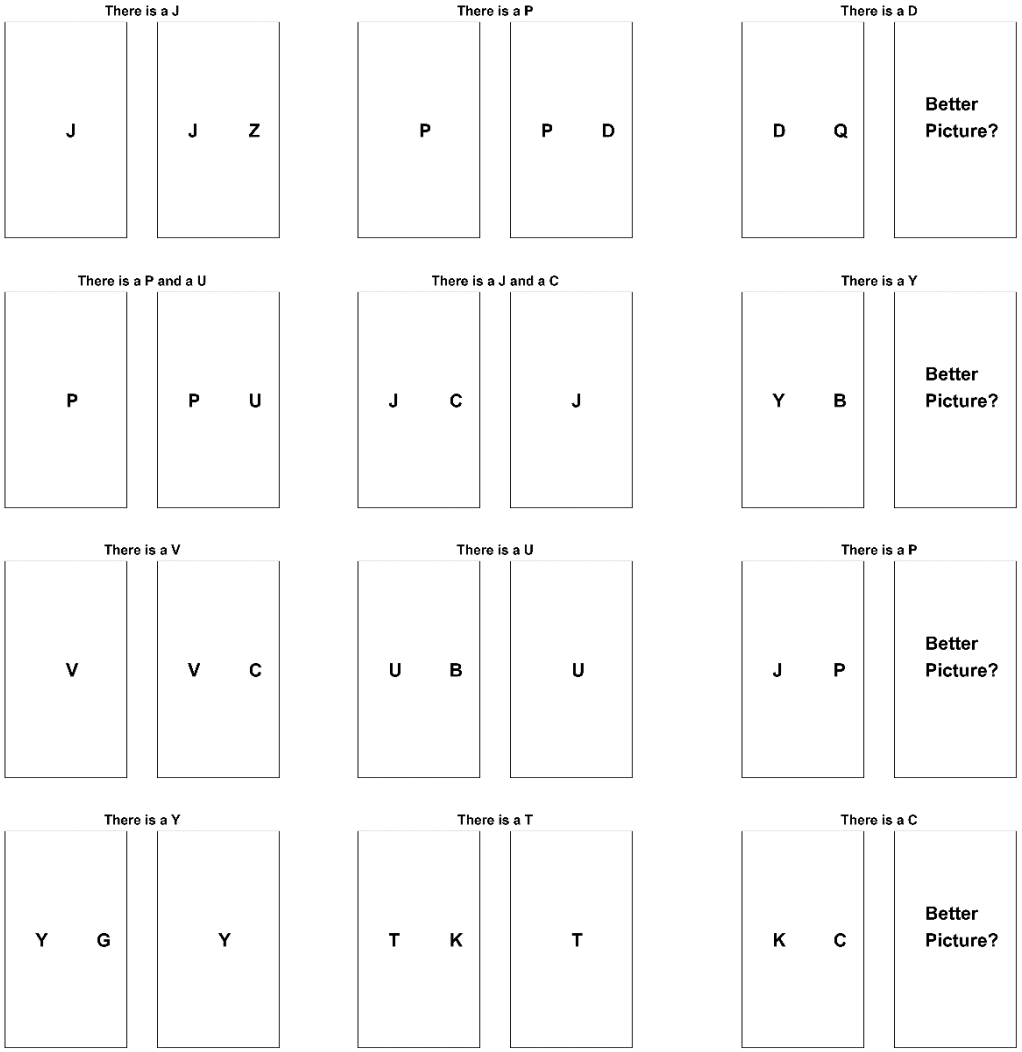
Ad Hoc

Alternative prime	Target

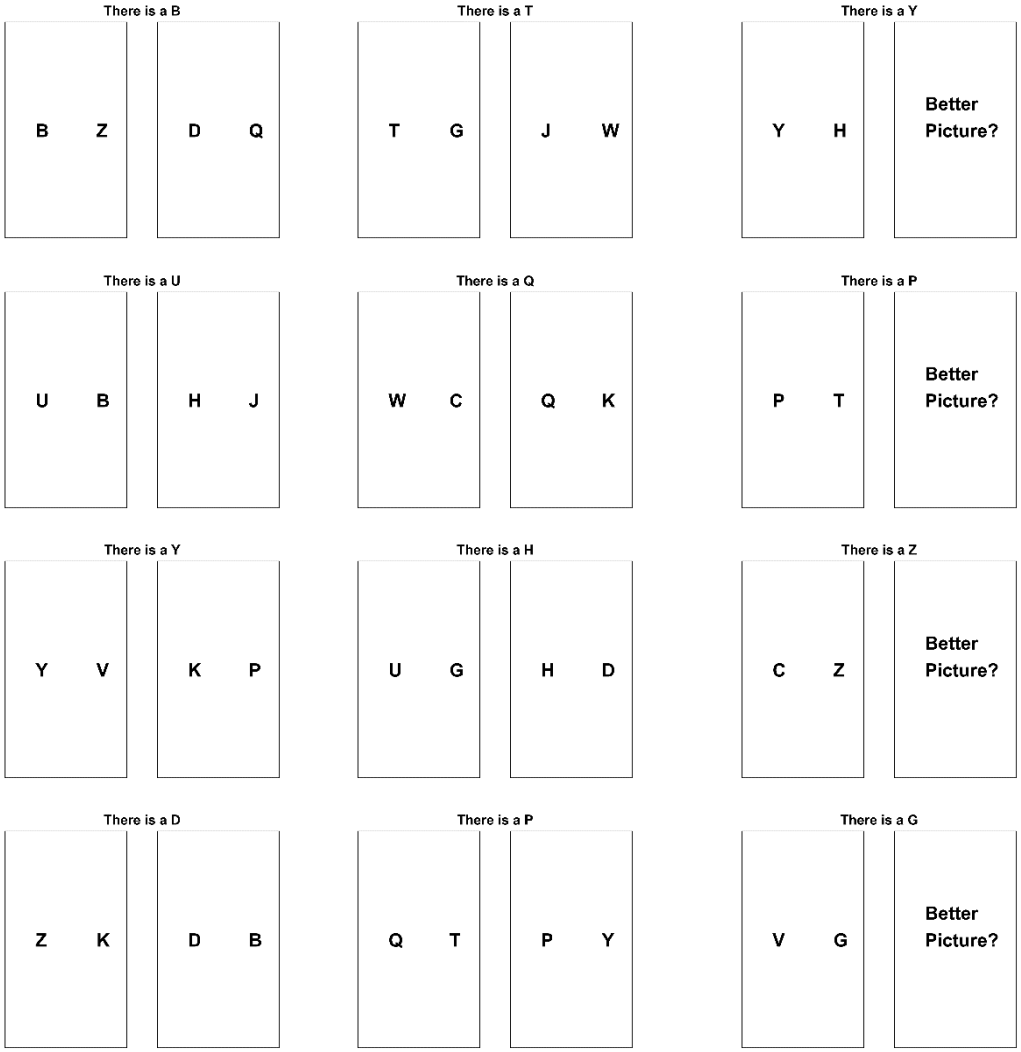


Appendix 1

Strong prime	Target



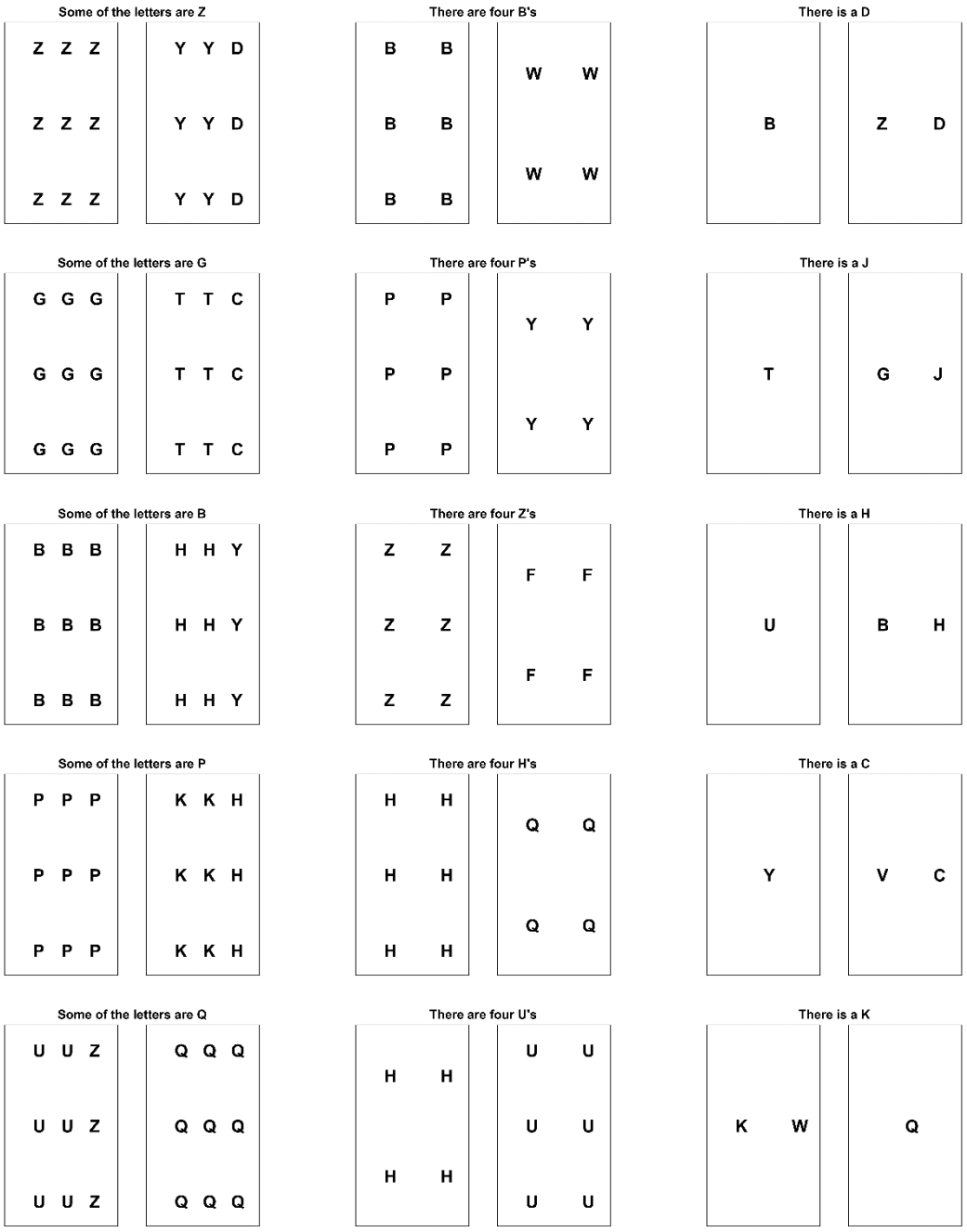
Weak prime	Target

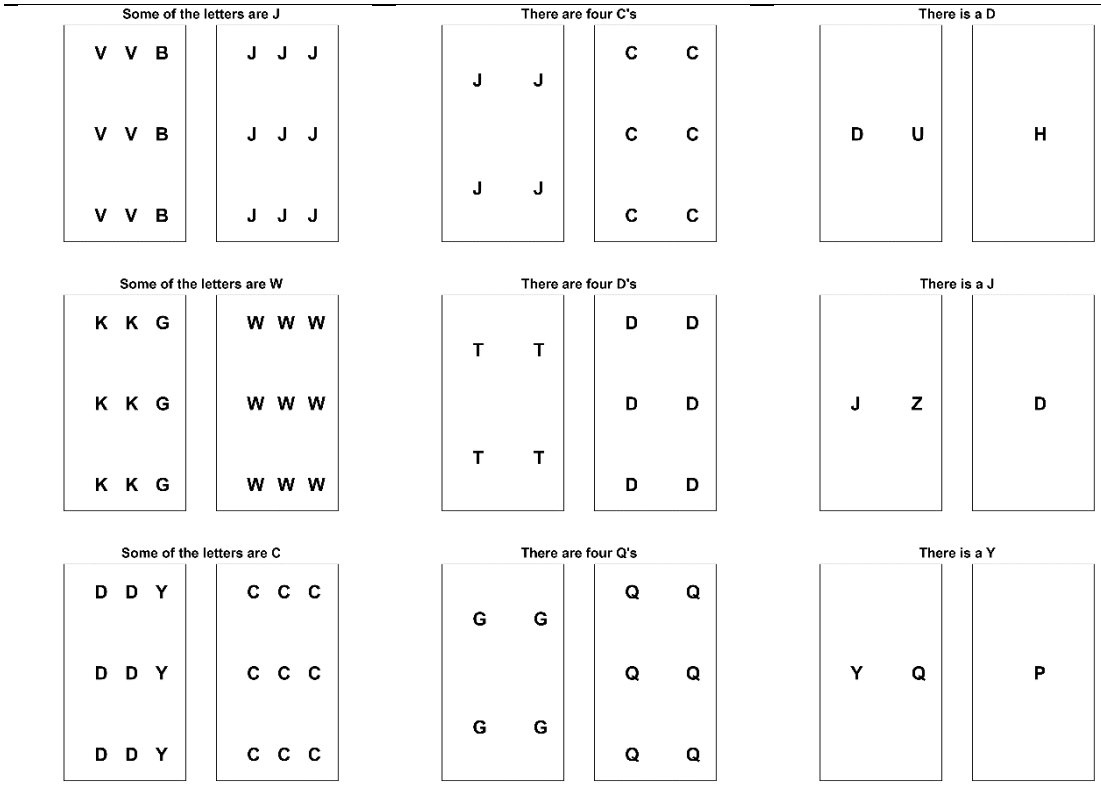


Experiment 2

Weak primes

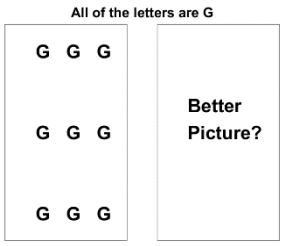
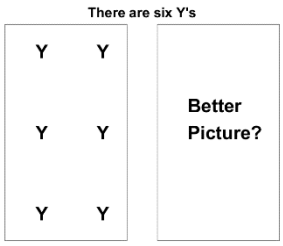
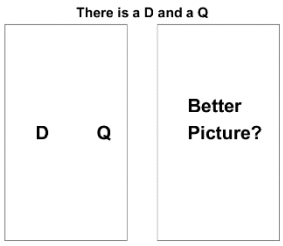
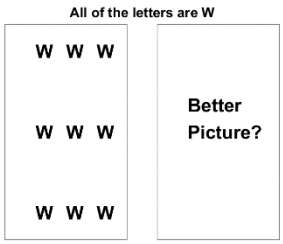
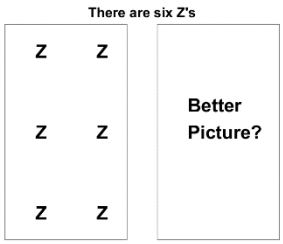
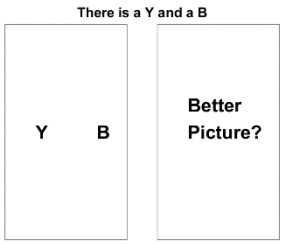
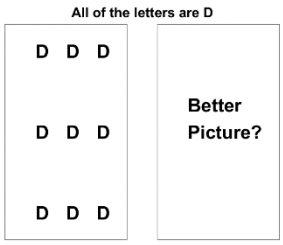
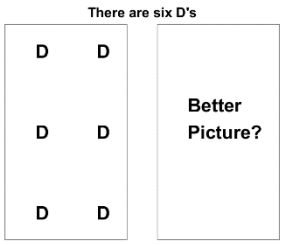
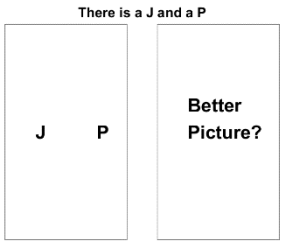
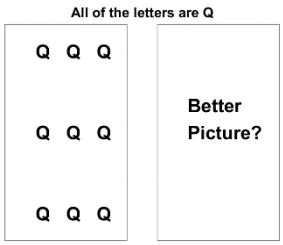
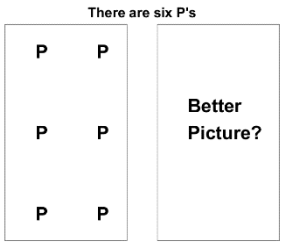
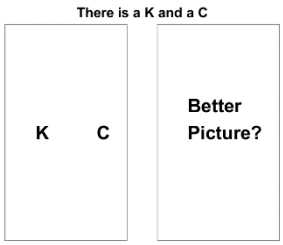
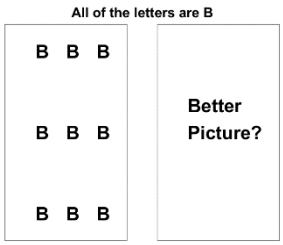
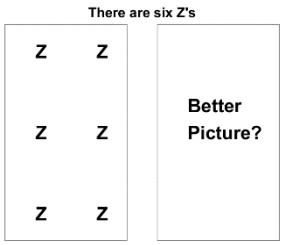
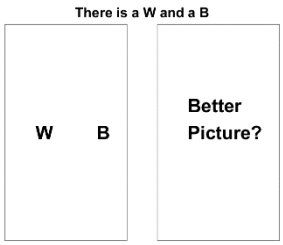
Quantifiers	Number	*Ad Hoc*

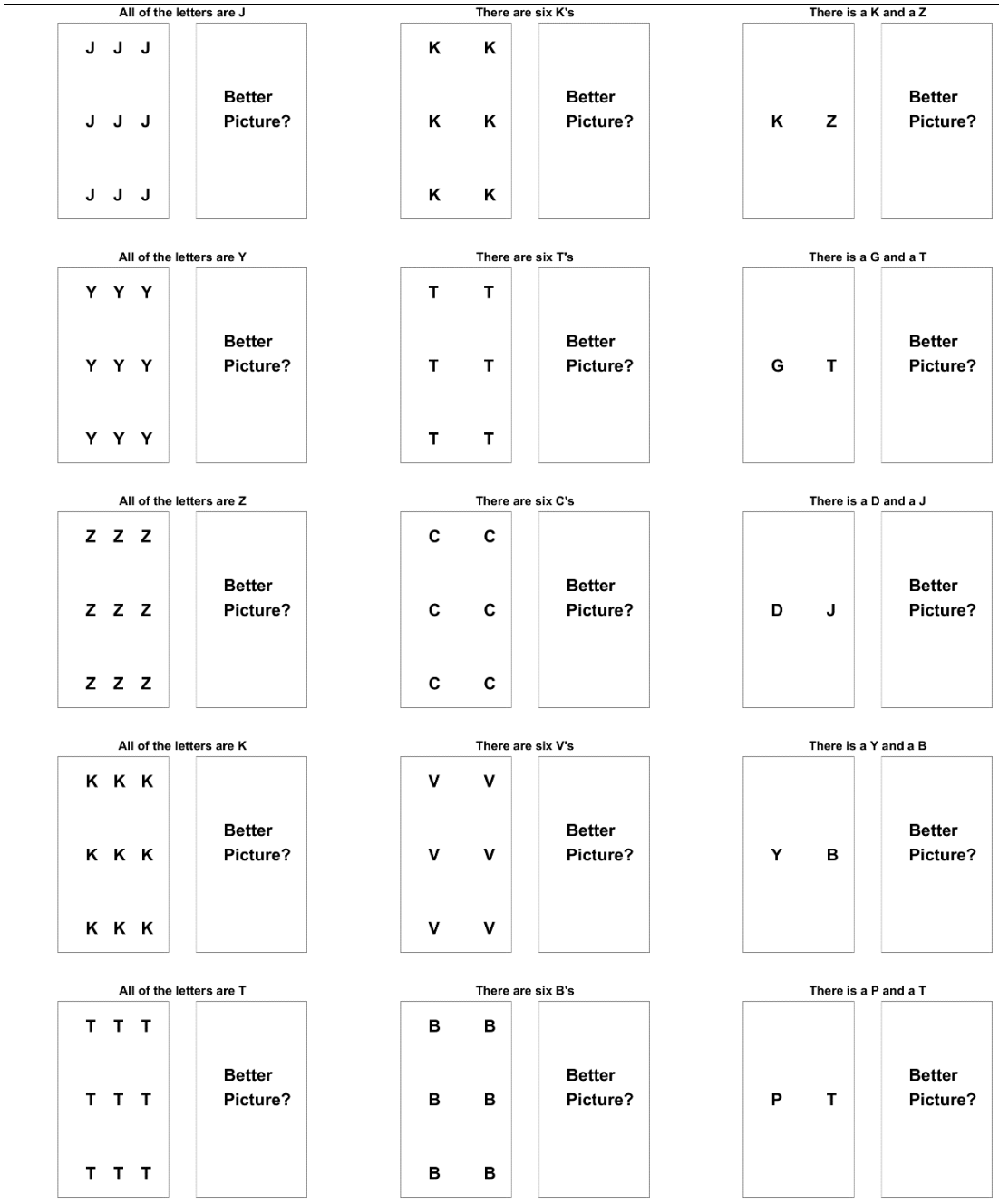


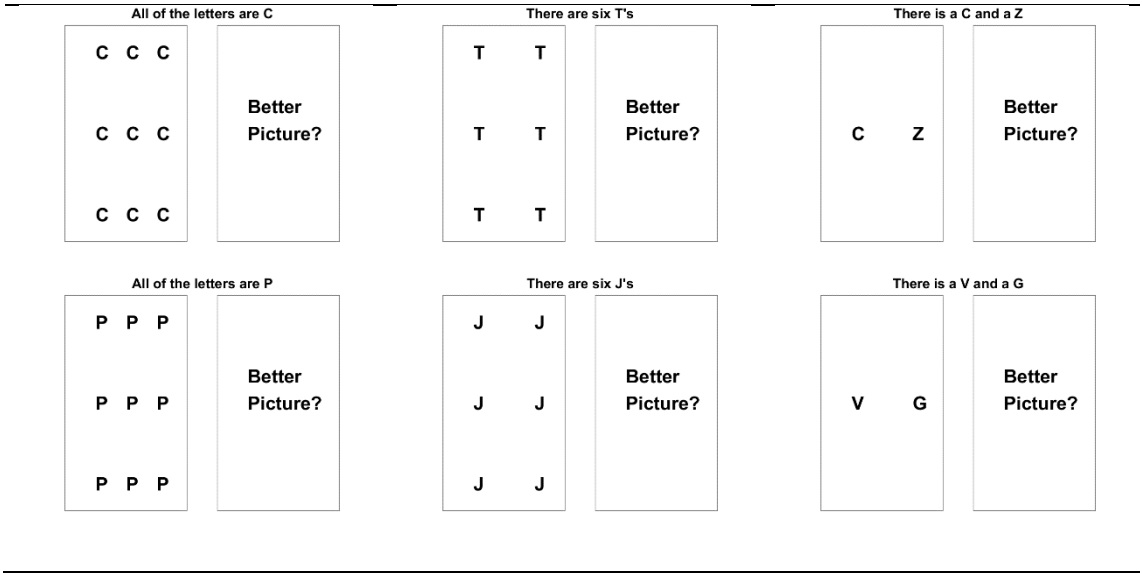

Some of the letters are J
V V B
V V B
V V B
J J J
J J J
J J J
There are four C's
J J
J J
C C
C C
C C
There is a D
D U
H
Some of the letters are W
K K G
K K G
K K G
W W W
W W W
W W W
There are four D's
T T
T T
D D
D D
D D
There is a J
J Z
D
Some of the letters are C
D D Y
D D Y
D D Y
C C C
C C C
C C C
There are four Q's
G G
G G
Q Q
Q Q
Q Q
There is a Y
Y Q
P

Experiment 3

Targets

Quantifiers	**Number**	***Ad Hoc***
		
		
		
		
		


All of the letters are J
J J J
J J J
J J J
Better Picture?
There are six K's
K K
K K
K K
Better Picture?
There is a K and a Z
K Z
Better Picture?
All of the letters are Y
Y Y Y
Y Y Y
Y Y Y
Better Picture?
There are six T's
T T
T T
T T
Better Picture?
There is a G and a T
G T
Better Picture?
All of the letters are Z
Z Z Z
Z Z Z
Z Z Z
Better Picture?
There are six C's
C C
C C
C C
Better Picture?
There is a D and a J
D J
Better Picture?
All of the letters are K
K K K
K K K
K K K
Better Picture?
There are six V's
V V
V V
V V
Better Picture?
There is a Y and a B
Y B
Better Picture?
All of the letters are T
T T T
T T T
T T T
Better Picture?
There are six B's
B B
B B
B B
Better Picture?
There is a P and a T
P T
Better Picture?

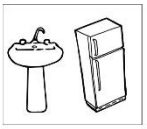
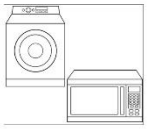
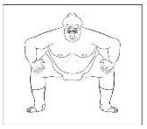
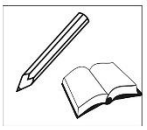
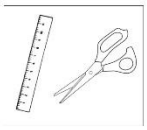
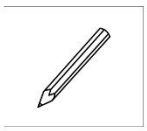
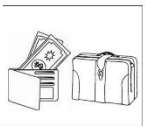
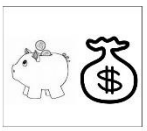
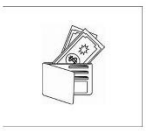
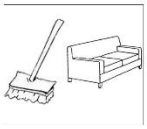
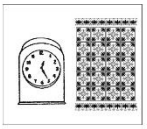
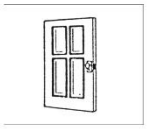
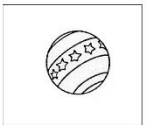

All of the letters are C
C C C
C C C
C C C
Better Picture?
There are six T's
T T
T T
T T
Better Picture?
There is a C and a Z
C Z
Better Picture?
All of the letters are P
P P P
P P P
P P P
Better Picture?
There are six J's
J J
J J
J J
Better Picture?
There is a V and a G
V G
Better Picture?

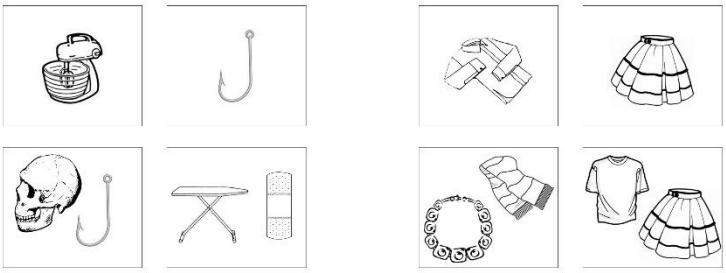
Appendix 2: Chapter 3 Stimuli

Experiment 1

Primes used in this experiment were the same as those used in the *ad hoc* conditions of Chapter 2. The targets were identical to the primes. See appendix 1 for examples.

Experiment 2

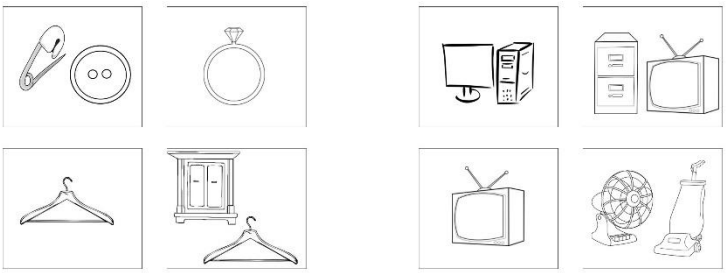
Prime	Target	Referent
   	   	Strong prime: The microwave Weak prime: The washing machine Target: The snowboarder
   	   	Strong prime: The pencil Weak prime: The book Target: The wallet
   	   	Strong prime: The broom Weak prime: The sofa Target: The baseball bat



Strong prime: The hook

Weak prime: The skull

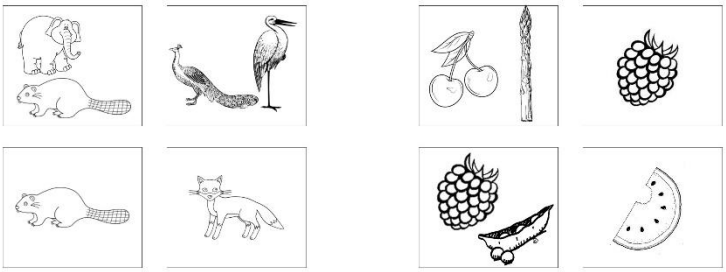
Target: The skirt



Strong prime: The coathanger

Weak prime: The wardrobe

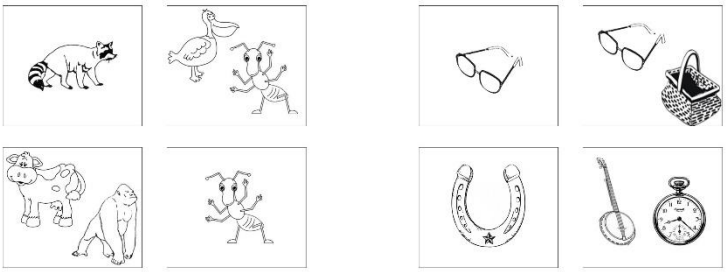
Target: The tv



Strong prime: The beaver

Weak prime: The elephant

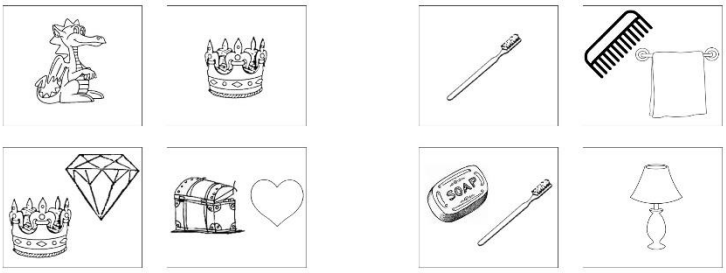
Target: The raspberry



Strong prime: The ant

Weak prime: The pelican

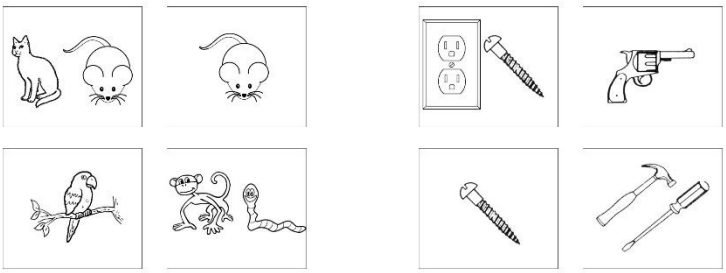
Target: The glasses



Strong prime: The crown

Weak prime: The diamond

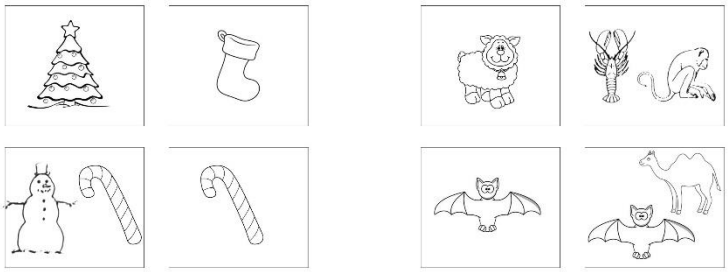
Target: The toothbrush



Strong prime: The mouse

Weak prime: The cat

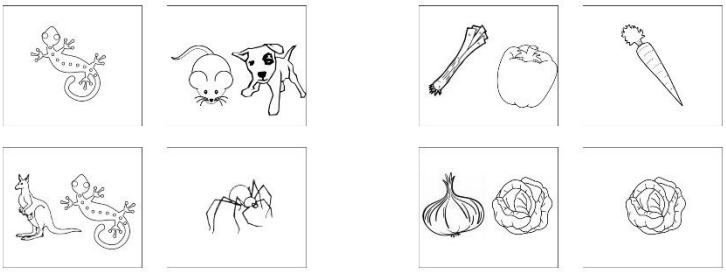
Target: The screw



Strong prime: The candy cane

Weak prime: The snowman

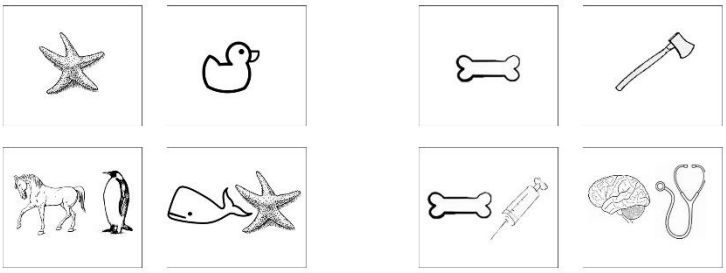
Target: The bat



Strong prime: The gecko

Weak prime: The kangaroo

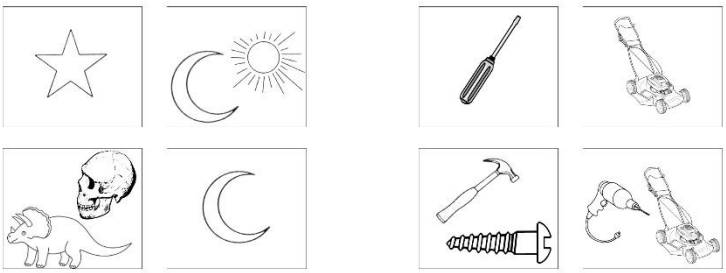
Target: The cabbage



Strong prime: The starfish

Weak prime: The whale

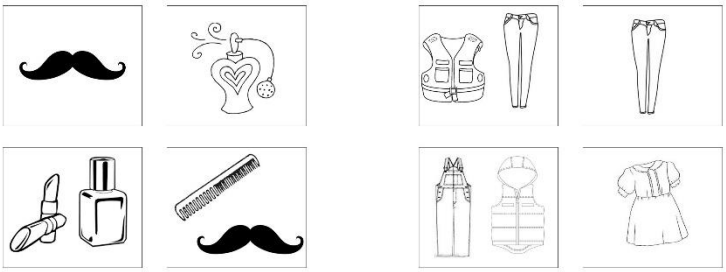
Target: The bone



Strong prime: The moon

Weak prime: The sun

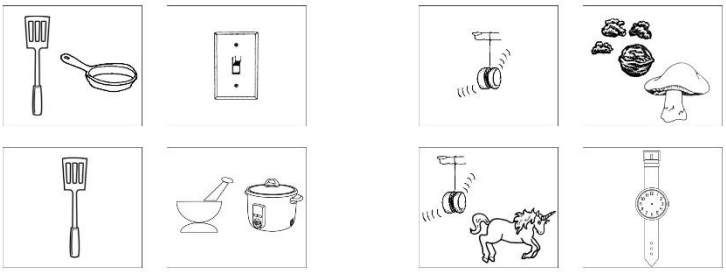
Target: The lawnmower



Strong prime: The moustache

Weak prime: The comb

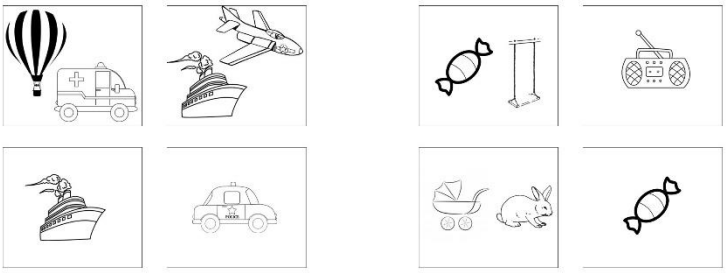
Target: The jeans



Strong prime: The spatula

Weak prime: The frying pan

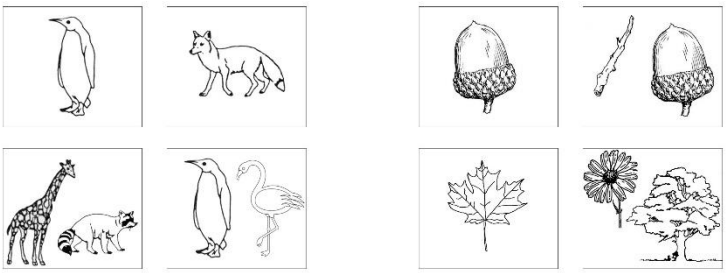
Target: The yoyo



Strong prime: The ship

Weak prime: The aeroplane

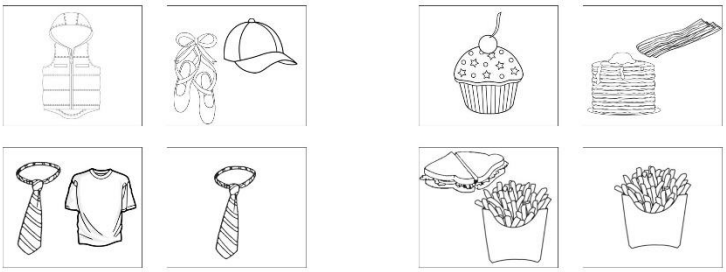
Target: The sweet



Strong prime: The penguin

Weak prime: The flamingo

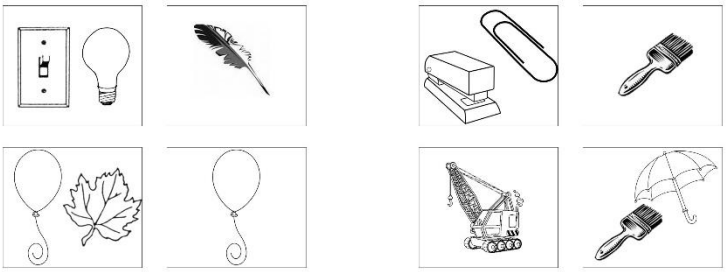
Target: The acorn



Strong prime: The tie

Weak prime: The t-shirt

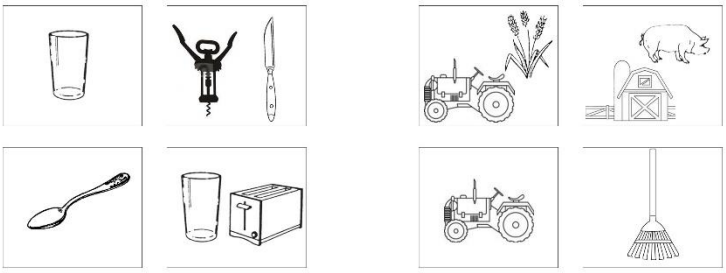
Target: The chips



Strong prime: The balloon

Weak prime: The leaf

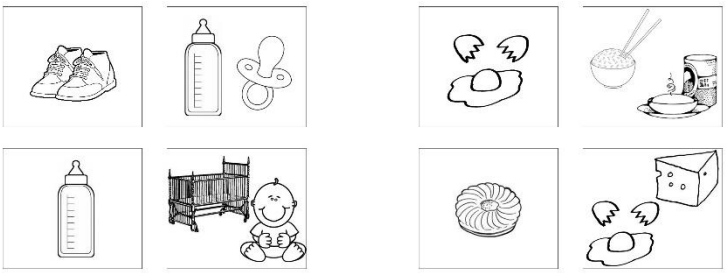
Target: The paintbrush



Strong prime: The glass

Weak prime: The toaster

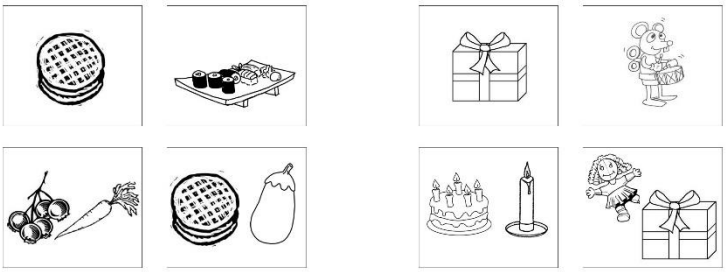
Target: The tractor



Strong prime: The bottle

Weak prime: The dummy

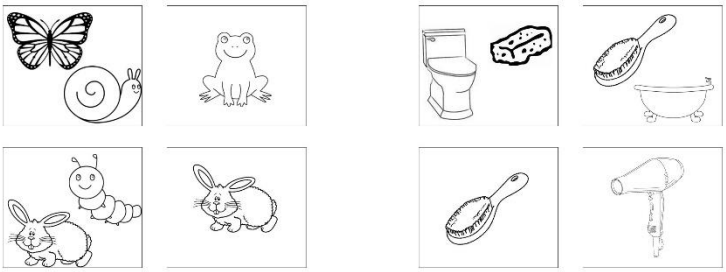
Target: The egg



Strong prime: The waffles

Weak prime: The aubergine

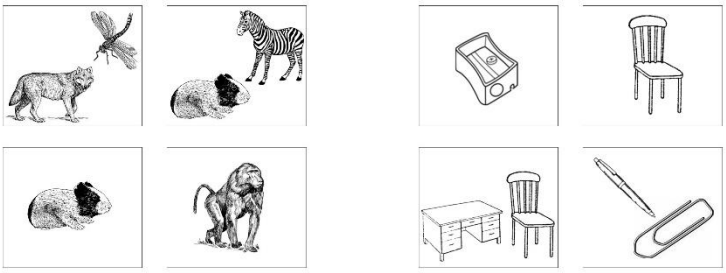
Target: The present



Strong prime: The rabbit

Weak prime: The caterpillar

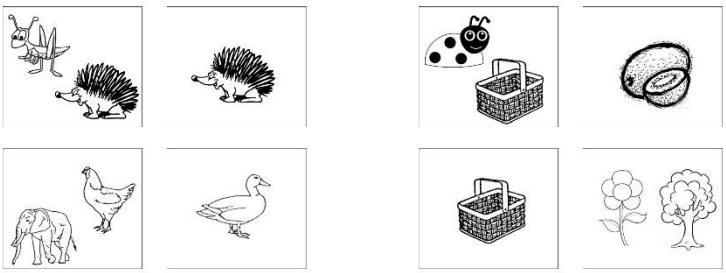
Target: The hairbrush



Strong prime: The guinea pig

Weak prime: The zebra

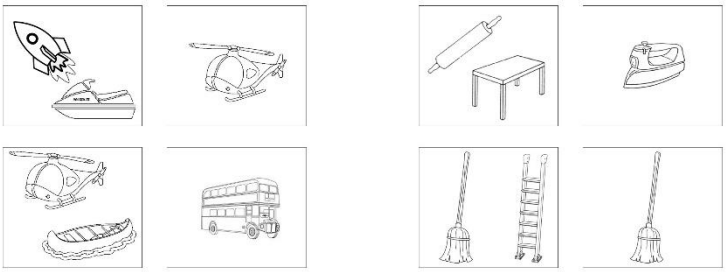
Target: The chair



Strong prime: The hedgehog

Weak prime: The cricket

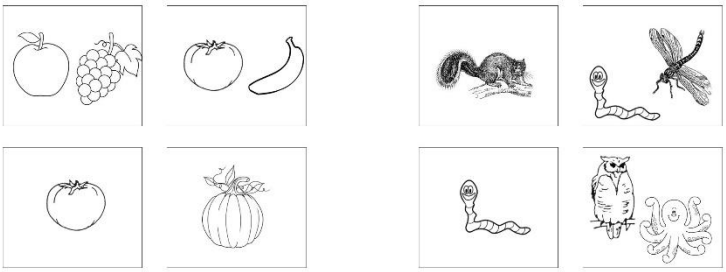
Target: The basket



Strong prime: The helicopter

Weak prime: The canoe

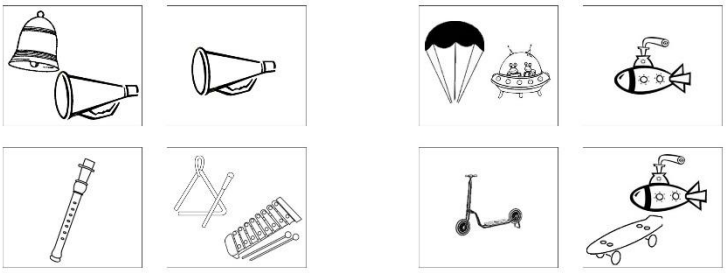
Target: The mop



Strong prime: The tomato

Weak prime: The banana

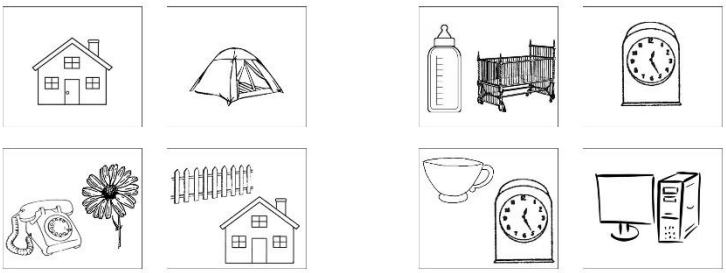
Target: The worm



Strong prime: The megaphone

Weak prime: The bell

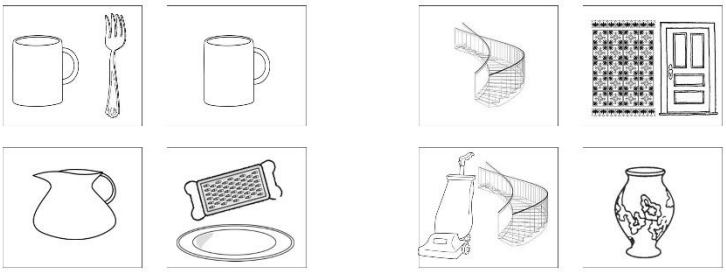
Target: The submarine



Strong prime: The house

Weak prime: The fence

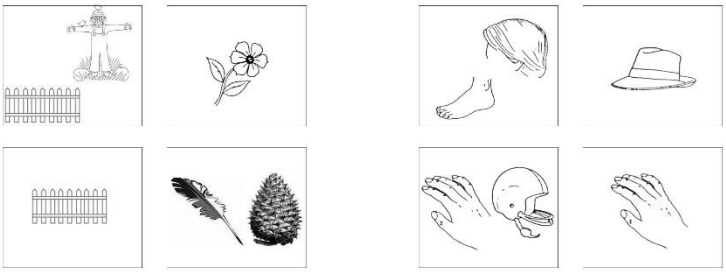
Target: The clock



Strong prime: The mug

Weak prime: The fork

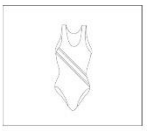
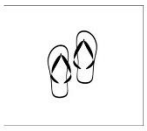
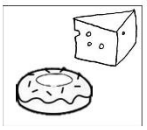
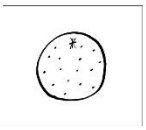
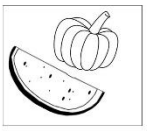
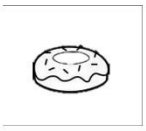
Target: The staircase



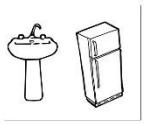
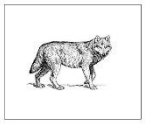
Strong prime: The fence

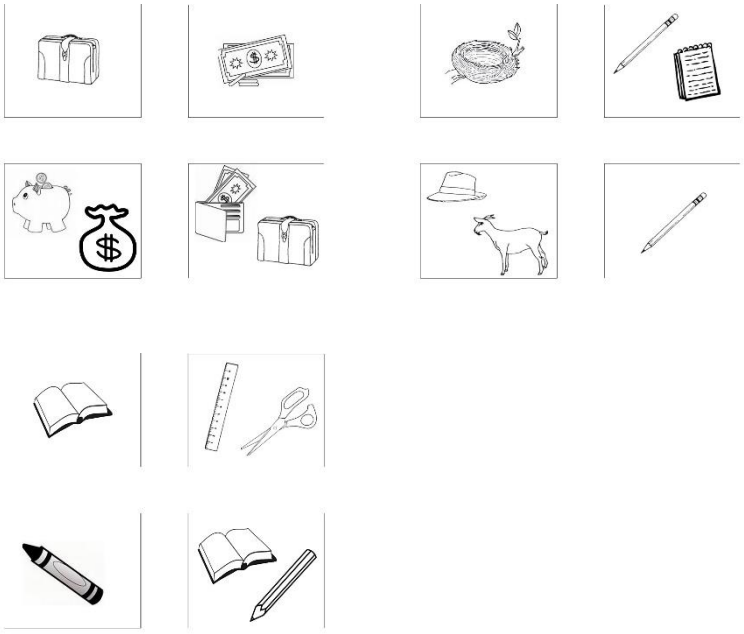
Weak prime: The scarecrow

Target: The hand

   	   	Strong prime: The flip-flops Weak prime: The scuba mask Target: The doughnut

Experiment 3

Prime	**Target**	**Referent**
       	   	<u>No overlap prime</u> Weak: The snowboarder Alt: The snowboarder and the footballer <u>Overlap prime</u> Weak: The microwave Alt: The microwave and the washing machine <u>Target</u> The microwave



<u>No overlap prime</u>

Weak: The wallet

Alt: The wallet and the suitcase

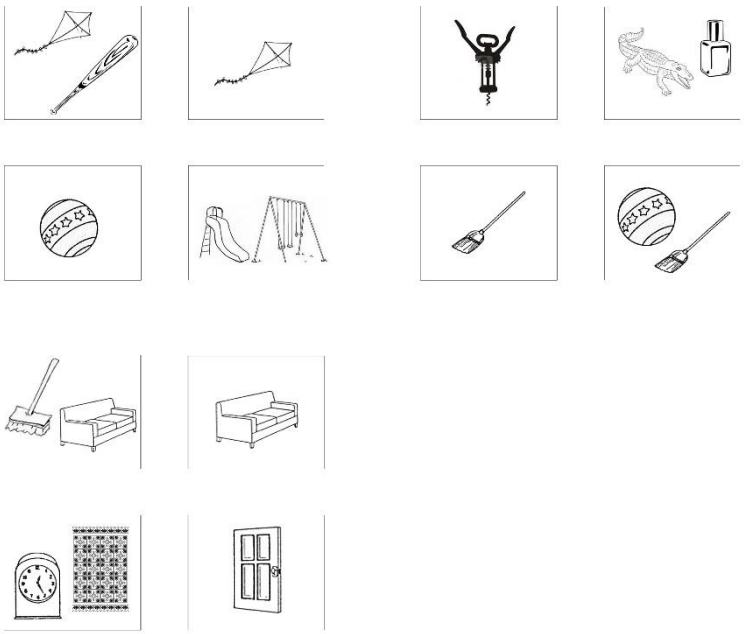
<u>Overlap prime</u>

Weak: The pencil

Alt: The pencil and the book

<u>Target</u>

The pencil



<u>No overlap prime</u>

Weak: The baseball bat

Alt: The baseball bat and the kite

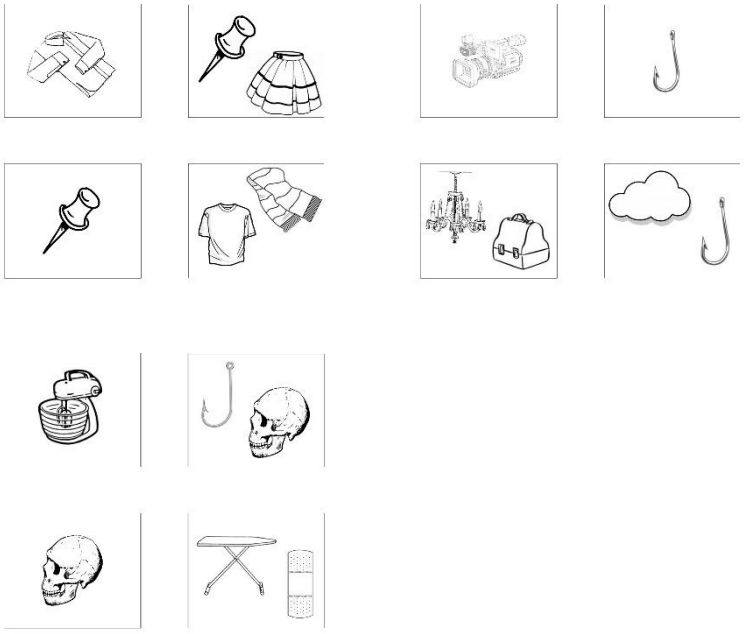
<u>Overlap prime</u>

Weak: The broom

Alt: The broom and the sofa

<u>Target</u>

The broom



<u>No overlap prime</u>

Weak: The skirt

Alt: The skirt and the pin

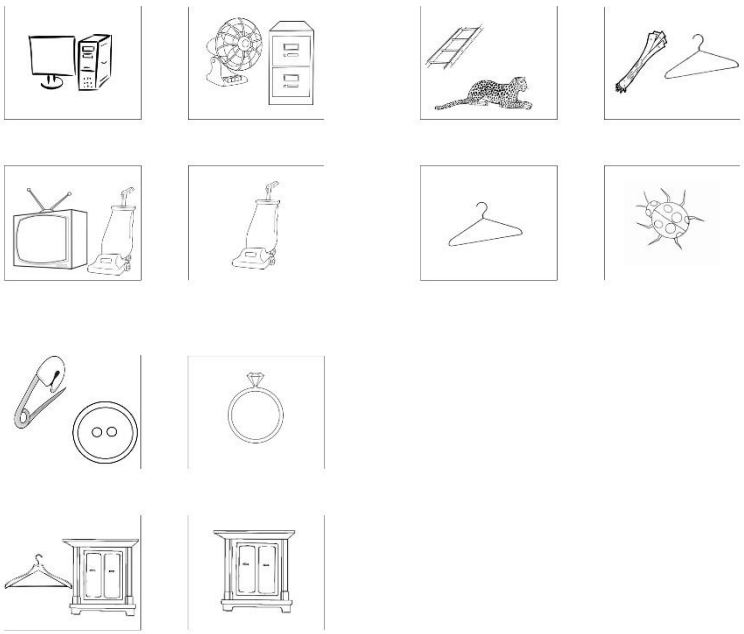
<u>Overlap prime</u>

Weak: The hook

Alt: The hook and the skull

<u>Target</u>

The hook



<u>No overlap prime</u>

Weak: The TV

Alt: The TV and the vacuum

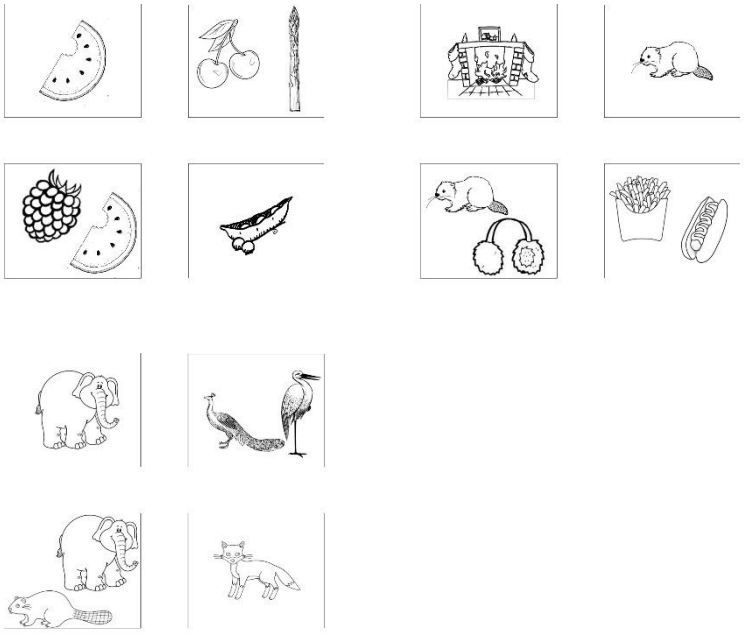
<u>Overlap prime</u>

Weak: The coat hanger

Alt: The coat hanger and the wardrobe

<u>Target</u>

The coat hanger



<u>No overlap prime</u>

Weak: The raspberry

Alt: The raspberry and the melon

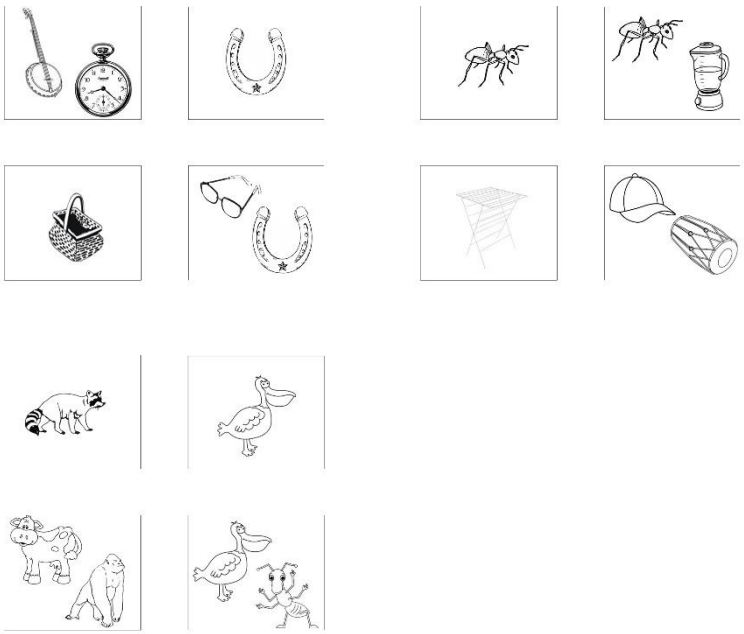
<u>Overlap prime</u>

Weak: The beaver

Alt: The beaver and the elephant

<u>Target</u>

The beaver



<u>No overlap prime</u>

Weak: The glasses

Alt: The glasses and the horseshoe

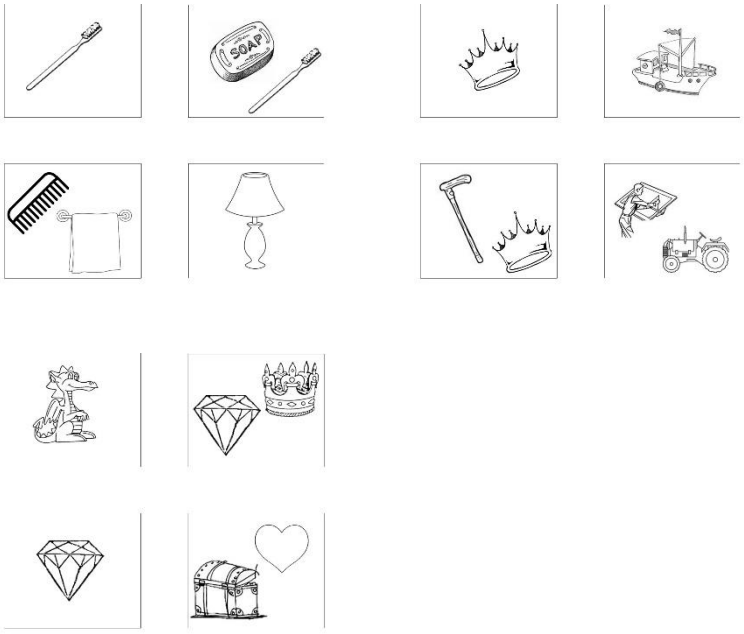
<u>Overlap prime</u>

Weak: The ant

Alt: The pelican and the ant

<u>Target</u>

The ant



No overlap prime

Weak: The soap

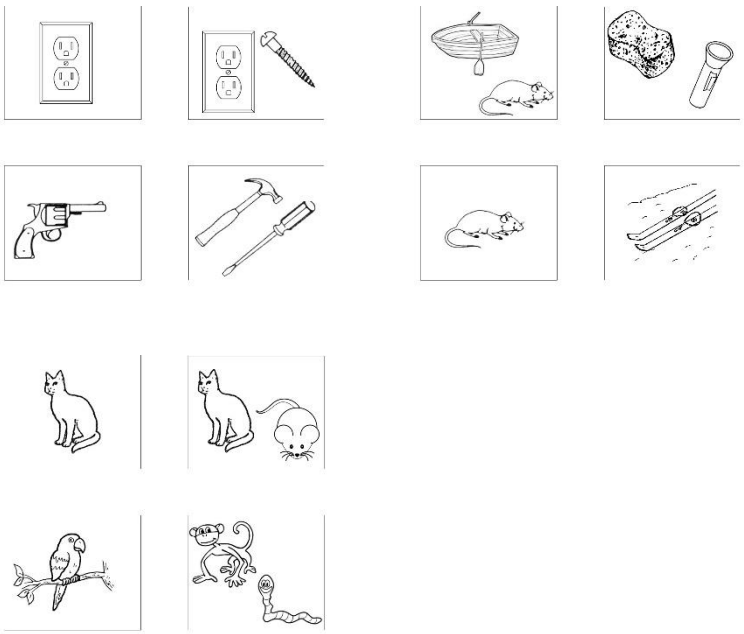
Alt: The toothbrush and the soap

Overlap prime

Weak: The diamond and the crown

Target

The crown



No overlap prime

Weak: The screw

Alt: The screw and the socket

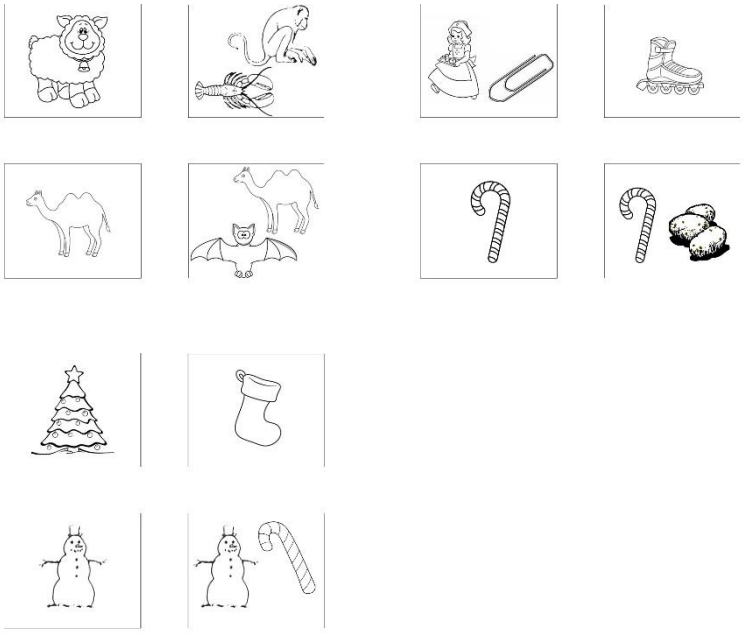
Overlap prime

Weak: The mouse

Alt: The mouse and the cat

Target

The mouse



No overlap prime

Weak: The bat

Alt: The bat and the camel

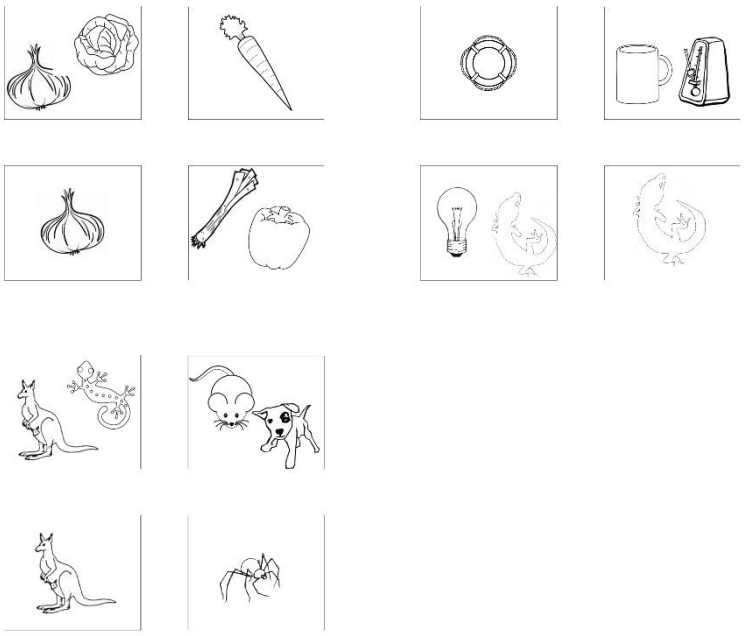
Overlap prime

Weak: The candy cane

Alt: The snowman and the candy cane

Target

The candy cane



No overlap prime

Weak: The cabbage

Alt: The garlic and the cabbage

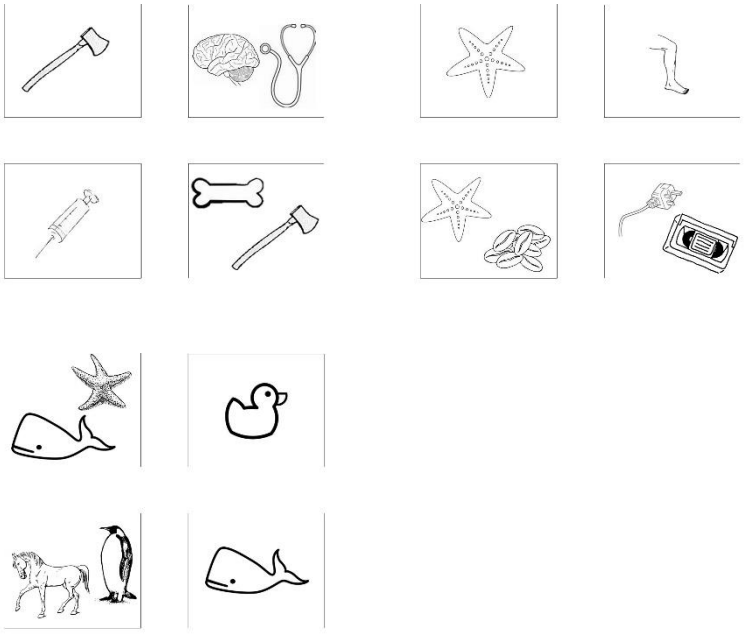
Overlap prime

Weak: The gecko

Alt: The kangaroo and the gecko

Target

The gecko



No overlap prime

Weak: The bone

Alt: The bone and the axe

Overlap prime

Weak: The starfish

Alt: The whale and the starfish

Target

The starfish

No overlap prime

Weak: The lawnmower

Alt: The lawnmower and the drill

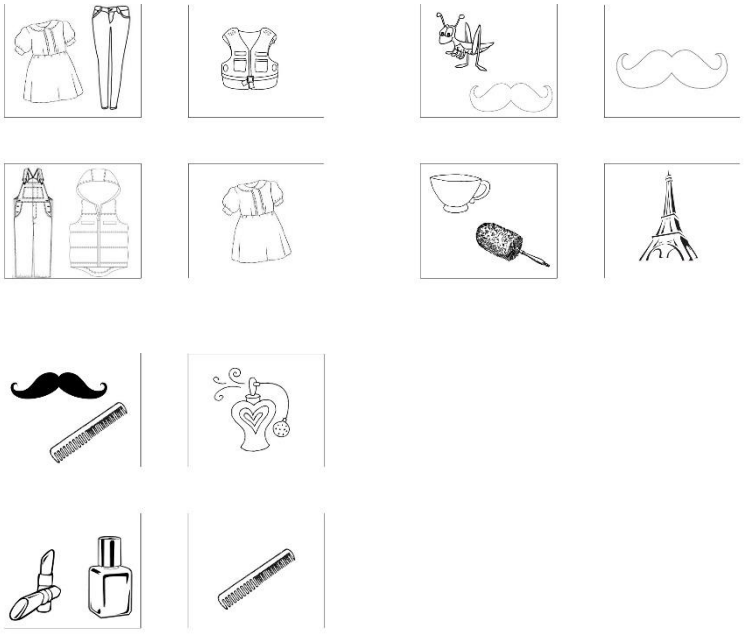
Overlap prime

Weak: The moon

Alt: The sun and the moon

Target

The moon



<u>No overlap prime</u>

Weak: The jeans

Alt: The jeans and the dress

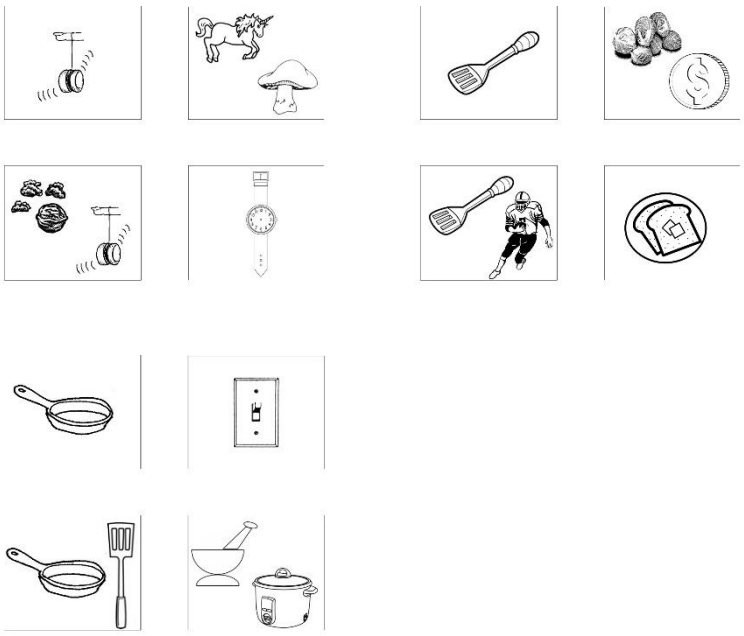
<u>Overlap prime</u>

Weak: The moustache

Alt: The comb and the moustache

<u>Target</u>

The moustache



<u>No overlap prime</u>

Weak: The nuts

Alt: The yoyo and the nuts

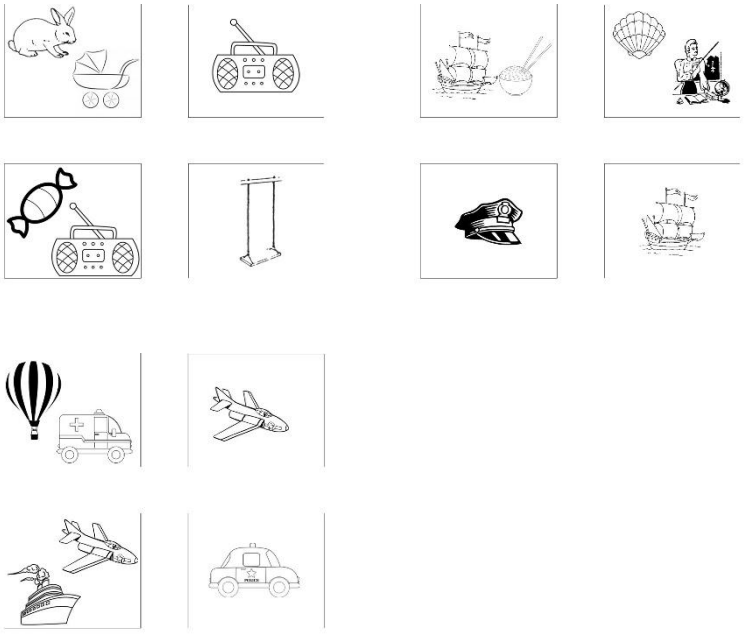
<u>Overlap prime</u>

Weak: The spatula

Alt: The frying pan and the spatula

<u>Target</u>

The spatula



<u>No overlap prime</u>

Weak: The sweet

Alt: The radio and the sweet

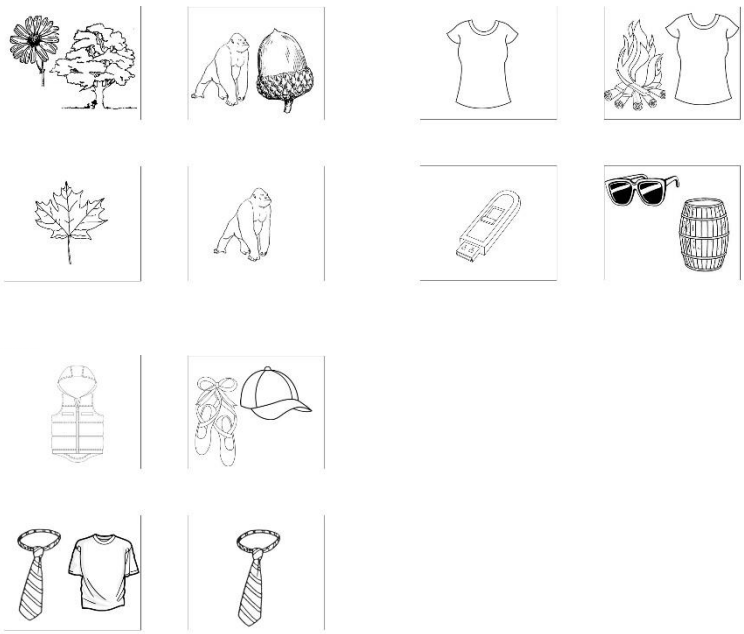
<u>Overlap prime</u>

Weak: The ship

Alt: The aeroplane and the ship

<u>Target</u>

The ship



<u>No overlap prime</u>

Weak: The acorn

Alt: The acorn and the gorilla

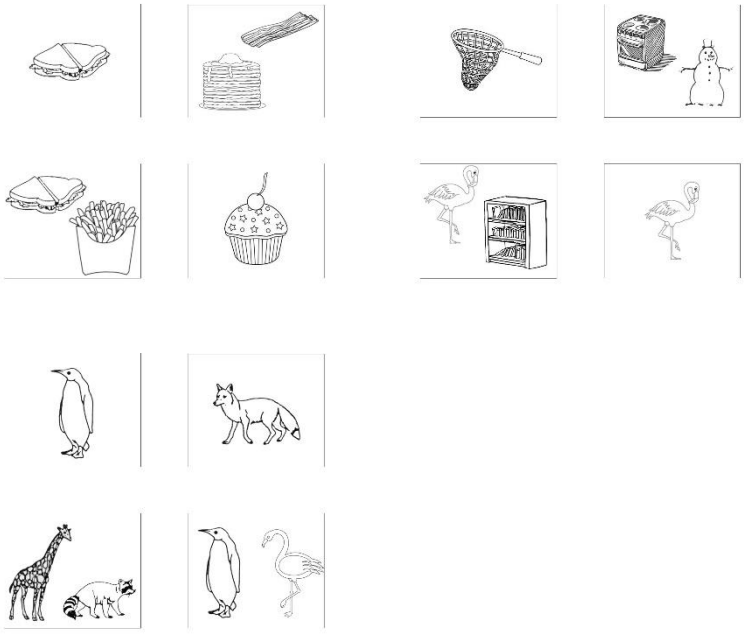
<u>Overlap prime</u>

Weak: The t-shirt

Alt: The t-shirt and the tie

<u>Target</u>

The t-shirt



No overlap prime

Weak: The chips

Alt: The chips and sandwich

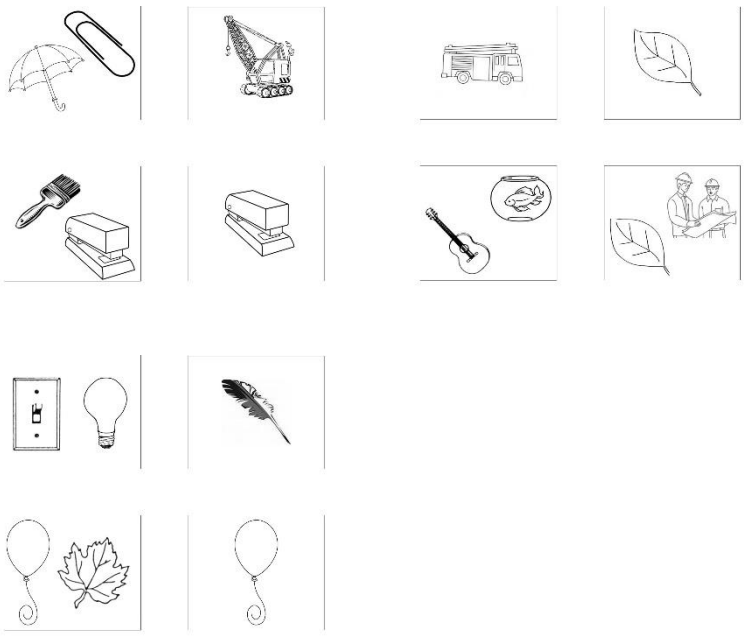
Overlap prime

Weak: The flamingo

Alt: The flamingo and the penguin

Target

The flamingo



No overlap prime

Weak: The paintbrush

Alt: The paintbrush and the stapler

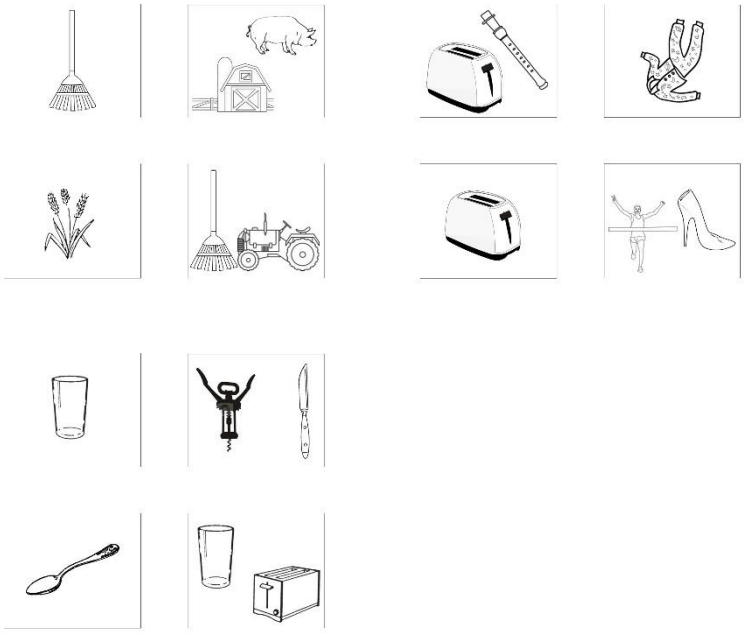
Overlap prime

Weak: The leaf

Alt: The leaf and the balloon

Target

The leaf



<u>No overlap prime</u>

Weak: The tractor

Alt: The tractor and the rake

<u>Overlap prime</u>

Weak: The toaster

Alt: The toaster and the glass

<u>Target</u>

The toaster

<u>No overlap prime</u>

Weak: The egg

Alt: The egg and the soup

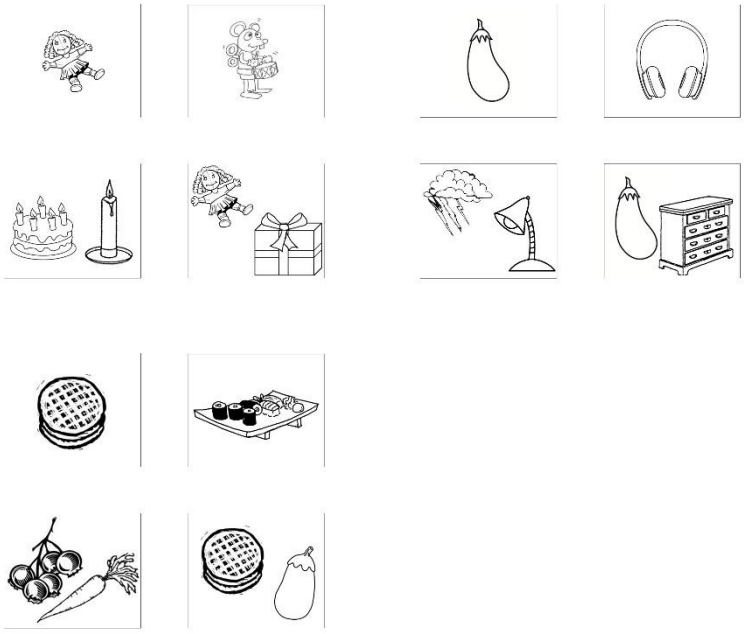
<u>Overlap prime</u>

Weak: The dummy

Alt: The dummy and the bottle

<u>Target</u>

The dummy



<u>No overlap prime</u>

Weak: The present

Alt: The doll and the present

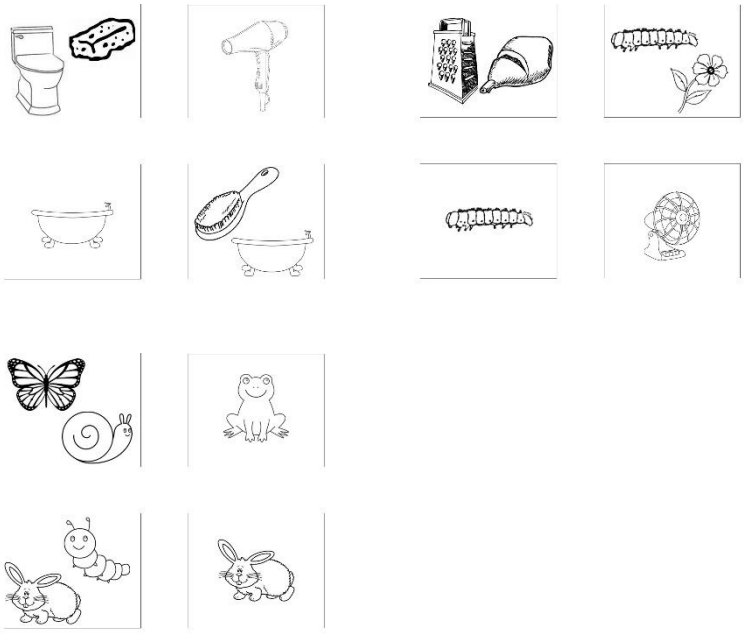
<u>Overlap prime</u>

Weak: The aubergine

Alt: The aubergine and the waffles

<u>Target</u>

The aubergine



<u>No overlap prime</u>

Weak: The hairbrush

Alt: The hairbrush and the bath

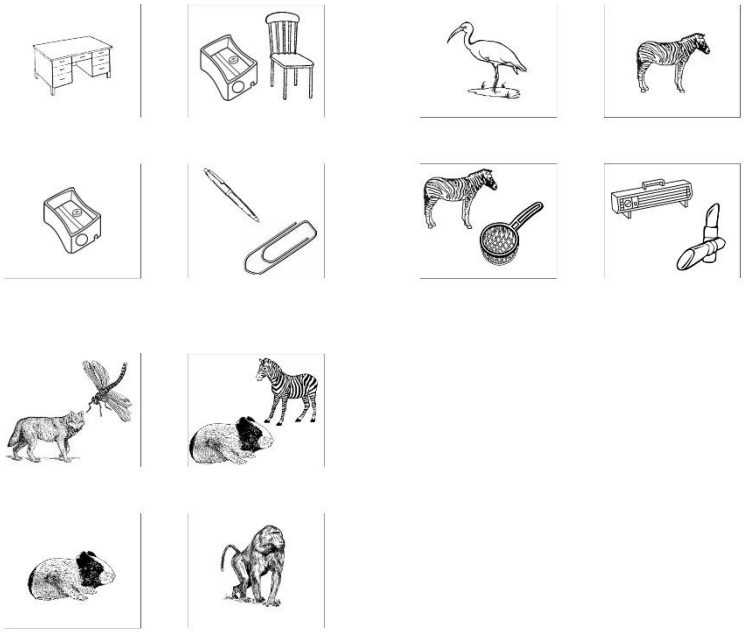
<u>Overlap prime</u>

Weak: The caterpillar

Alt: The caterpillar and the rabbit

<u>Target</u>

The caterpillar



<u>No overlap prime</u>

Weak: The chair

Alt: The chair and the sharpener

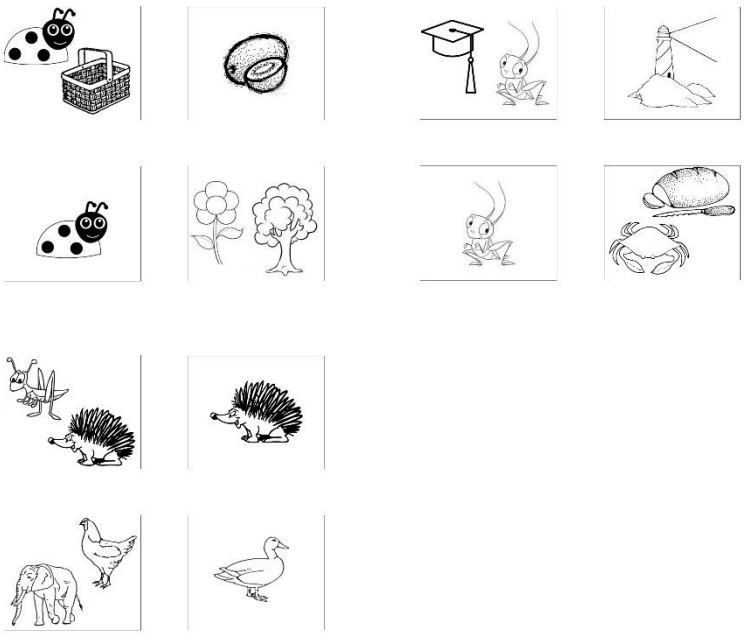
<u>Overlap prime</u>

Weak: The zebra

Alt: The zebra and the guinea pig

<u>Target</u>

The zebra



<u>No overlap prime</u>

Weak: The basket

Alt: The basket and the ladybird

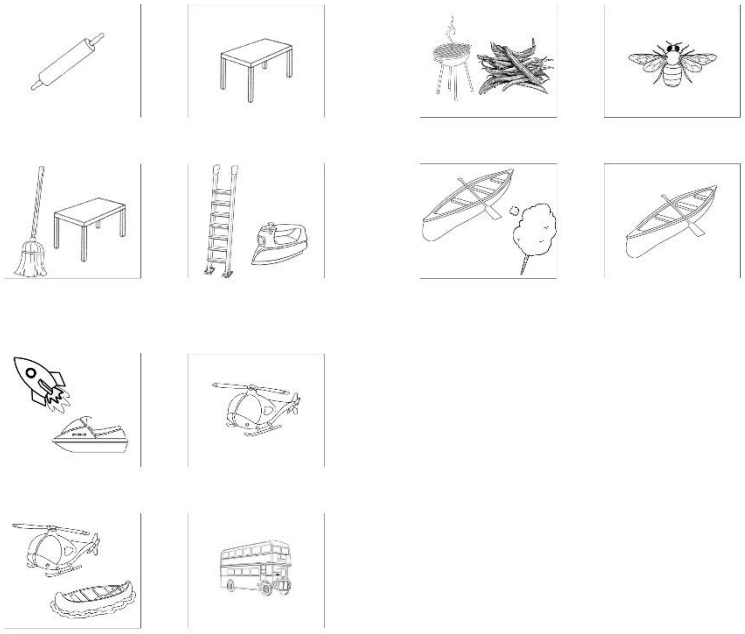
<u>Overlap prime</u>

Weak: The cricket

Alt: The hedgehog and the cricket

<u>Target</u>

The cricket



<u>No overlap prime</u>

Weak: The mop

Alt: The mop and the table

<u>Overlap prime</u>

Weak: The canoe

Alt: The helicopter and the canoe

<u>Target</u>

The canoe

<u>No overlap prime</u>

Weak: The worm

Alt: The squirrel and the worm

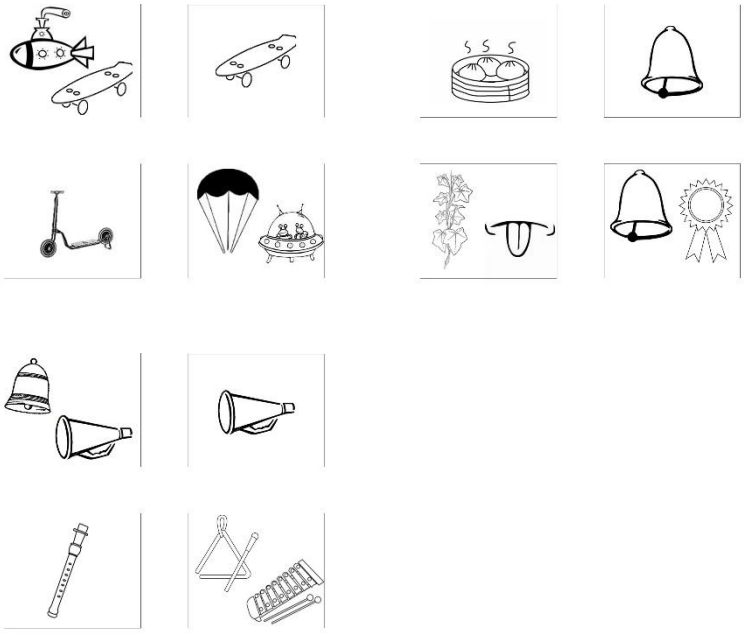
<u>Overlap prime</u>

Weak: The banana

Alt: The tomato and the banana

<u>Target</u>

The banana



<u>No overlap prime</u>

Weak: The submarine

Alt: The submarine and skateboard

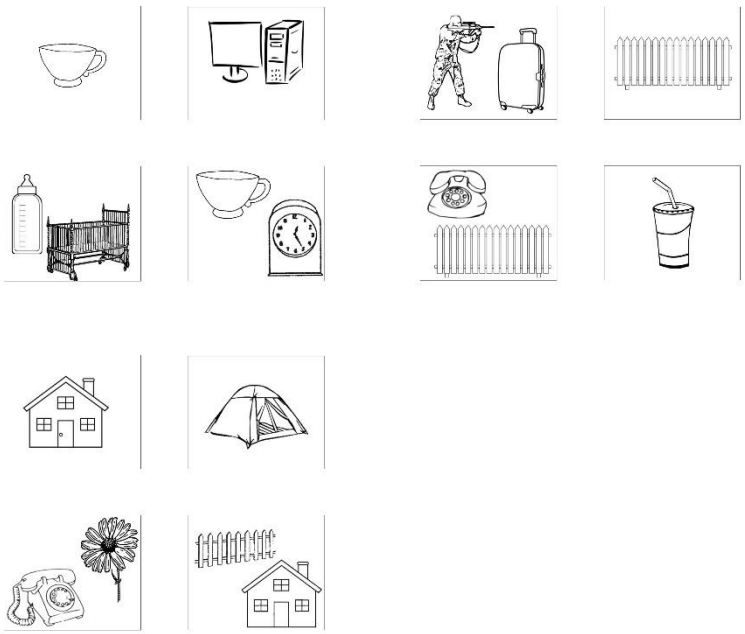
<u>Overlap prime</u>

Weak: The bell

Alt: The megaphone and the bell

<u>Target</u>

The bell



<u>No overlap prime</u>

Weak: The clock

Alt: The clock and the cup

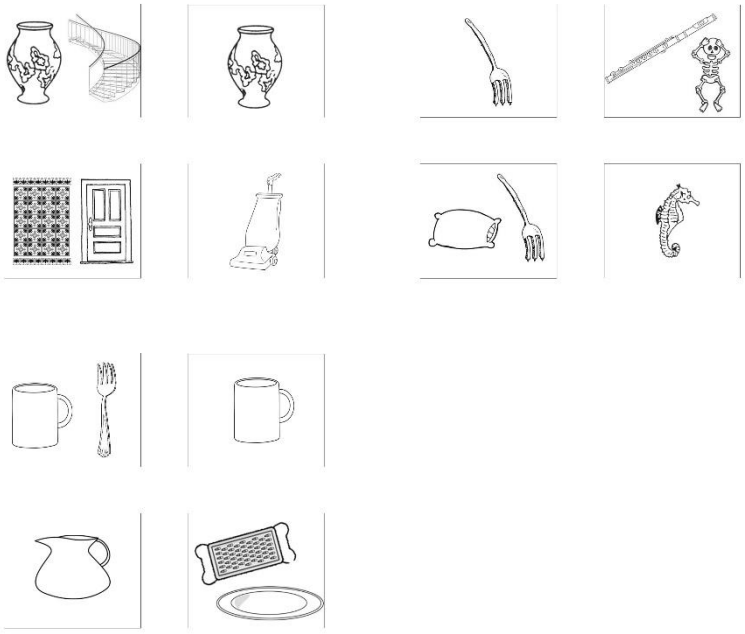
<u>Overlap prime</u>

Weak: The fence

Alt: The house and the fence

<u>Target</u>

The fence



<u>No overlap prime</u>

Weak: The staircase

Alt: The staircase and the vase

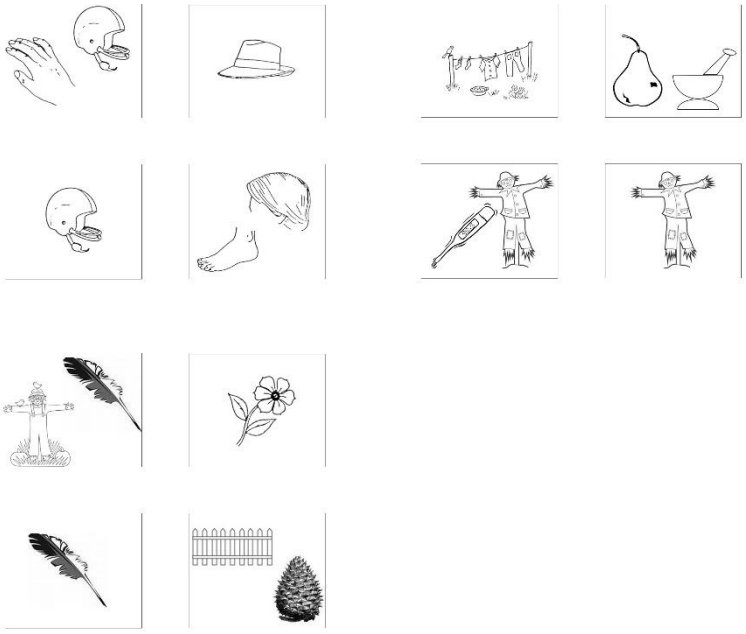
<u>Overlap prime</u>

Weak: The fork

Alt: The cup and the fork

<u>Target</u>

The fork



<u>No overlap prime</u>

Weak: The hand

Alt: The hand and the helmet

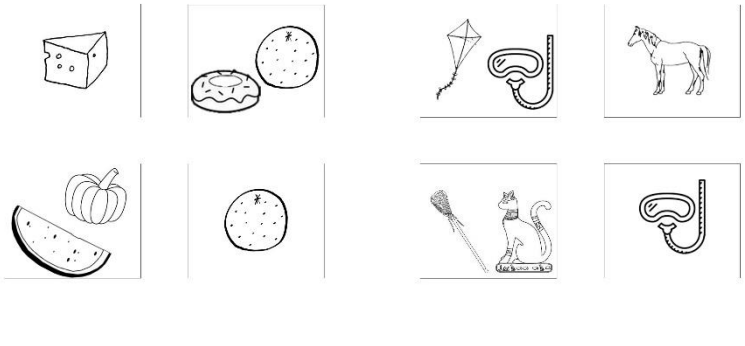
<u>Overlap prime</u>

Weak: The scarecrow

Alt: The feather and the scarecrow

<u>Target</u>

The scarecrow



No overlap prime

Weak: The doughnut

Alt: The orange and the doughnut

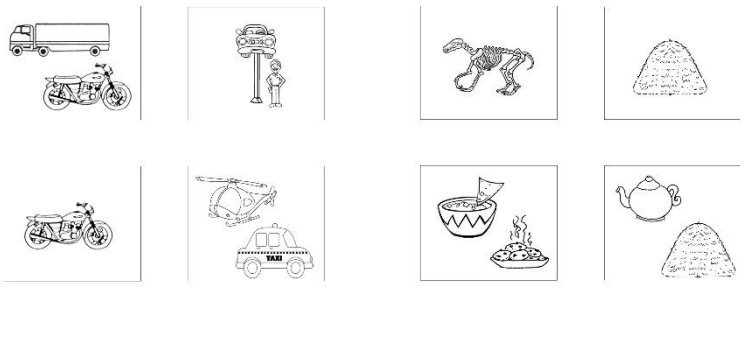
Overlap prime

Weak: The scuba mask

Alt: The scuba mask and flip-flops

Target

The scuba mask



No overlap prime

Weak: The lorry

Alt: The lorry and the motorbike

Overlap prime

Weak: The hay bale

Alt: The hay bale and the chicken

Target

The hay bale

<u>No overlap prime</u>

Weak: The fireman

Alt: The fireman and the nurse

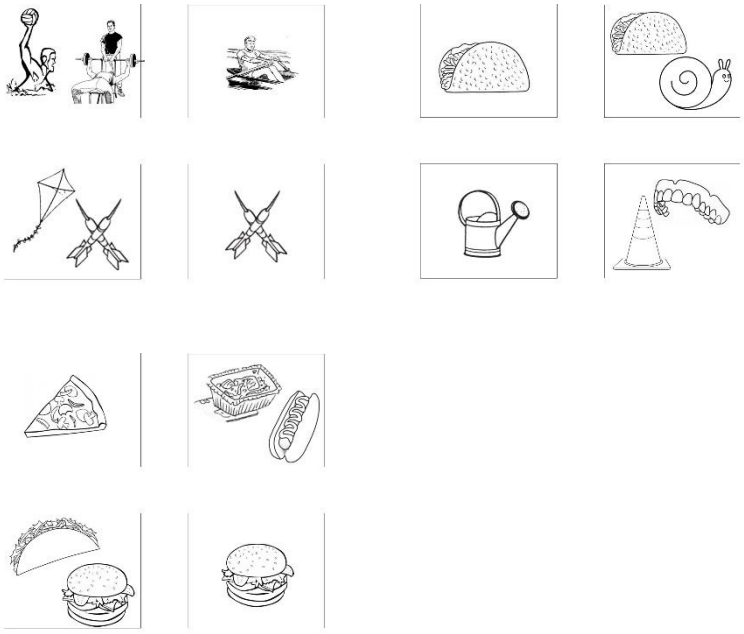
<u>Overlap prime</u>

Weak: The mitten

Alt: The mitten and the scarf

<u>Target</u>

The mitten



<u>No overlap prime</u>

Weak: The kite

Alt: The kite and the darts

<u>Overlap prime</u>

Weak: The taco

Alt: The taco and the burger

<u>Target</u>

The taco

No overlap prime

Weak: The bath

Alt: The bath and the sink

Overlap prime

Weak: The plant pot

Alt: The plant pot and the flower

Target

The plant pot

No overlap prime

Weak: The nose

Alt: The nose and the arm

Overlap prime

Weak: The parcel

Alt: The parcel and the letter

Target

The parcel

<u>No overlap prime</u>

Weak: The frog

Alt: The frog and the swan

<u>Overlap prime</u>

Weak: The peg

Alt: The peg and the iron

<u>Target</u>

The peg

<u>No overlap prime</u>

Weak: The sprouts

Alt: The sprouts and the milk

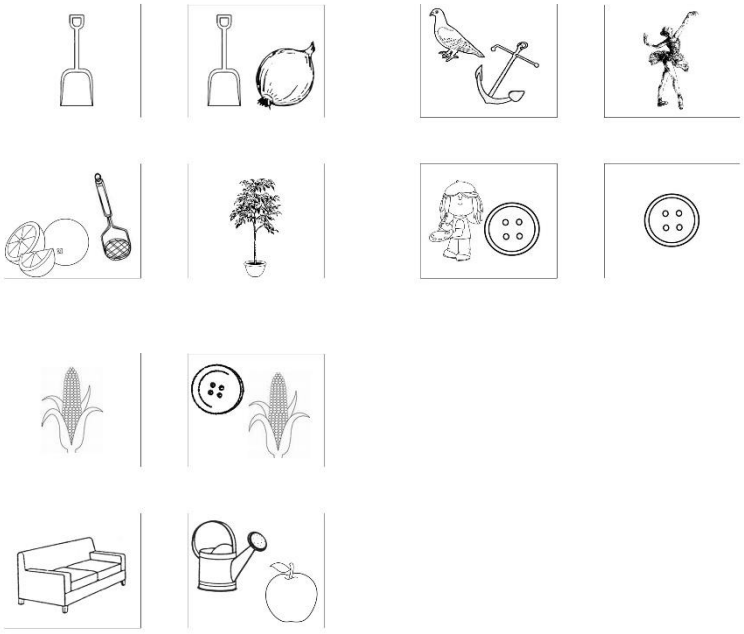
<u>Overlap prime</u>

Weak: The ice skate

Alt: The ice skate and the hot chocolate

<u>Target</u>

The ice skate



No overlap prime

Weak: The onion

Alt: The onion and the spade

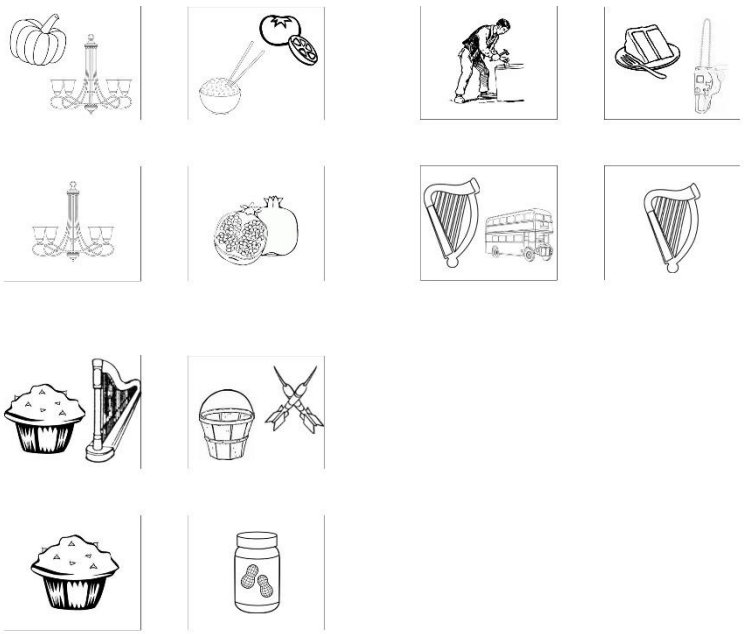
Overlap prime

Weak: The button

Alt: The button and the corn

Target

The button



No overlap prime

Weak: The pumpkin

Alt: The pumpkin and the chandelier

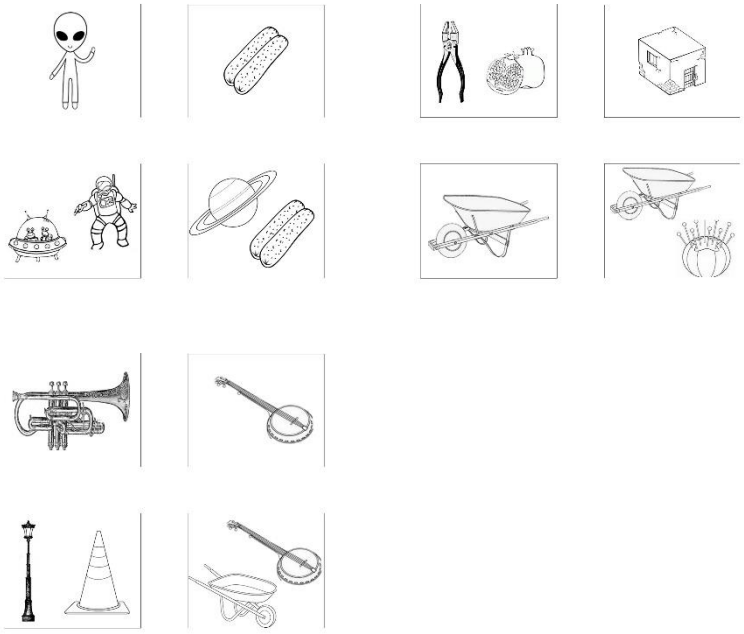
Overlap prime

Weak: The harp

Alt: The harp and the muffin

Target

The harp



<u>No overlap prime</u>

Weak: The planet

Alt: The planet and the sausages

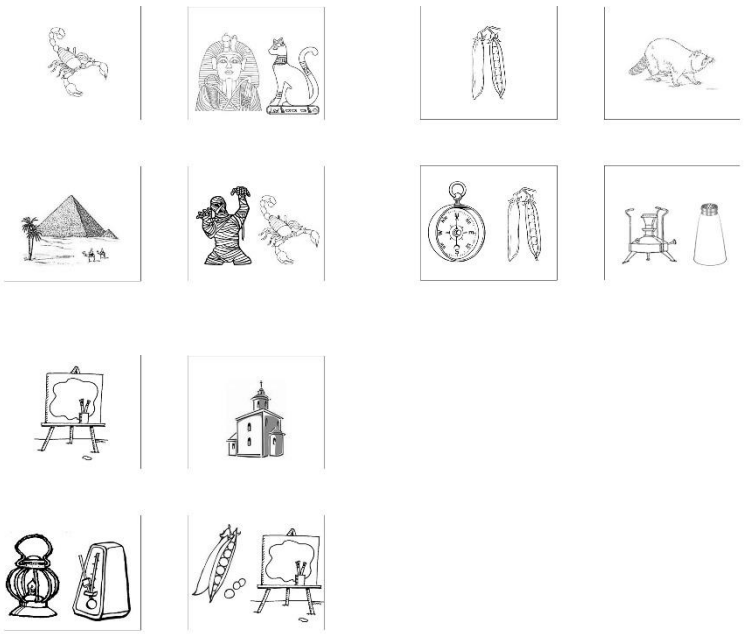
<u>Overlap prime</u>

Weak: The wheelbarrow

Alt: The wheelbarrow and the banjo

<u>Target</u>

The wheelbarrow



<u>No overlap prime</u>

Weak: The mummy

Alt: The mummy and the scorpion

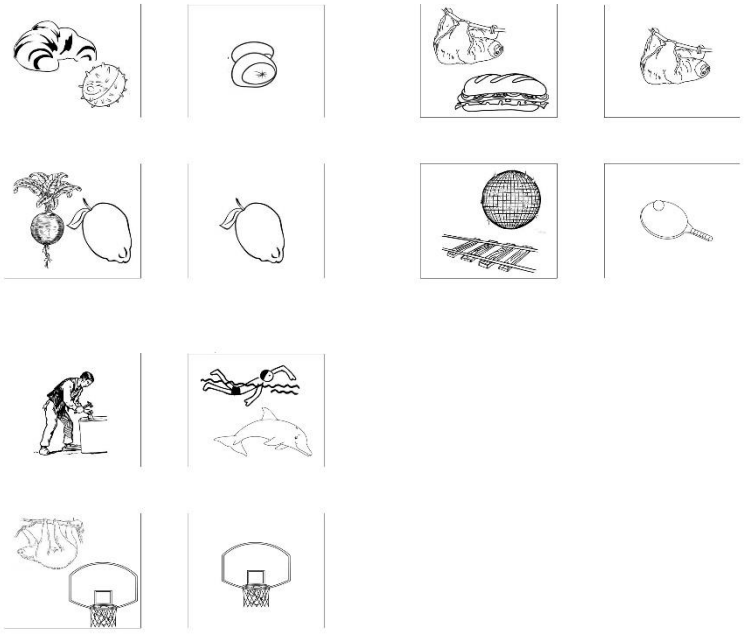
<u>Overlap prime</u>

Weak: The peas

Alt: The peas and the easel

<u>Target</u>

The peas



No overlap prime

Weak: The turnip

Alt: The lemon and the turnip

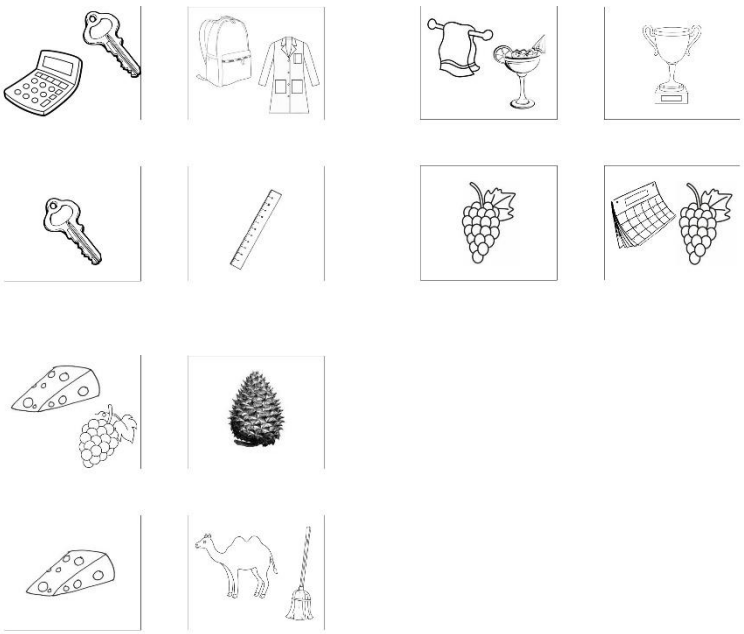
Overlap prime

Weak: The sloth

Alt: The sloth and the net

Target

The sloth



No overlap prime

Weak: The calculator

Alt: The key and the calculator

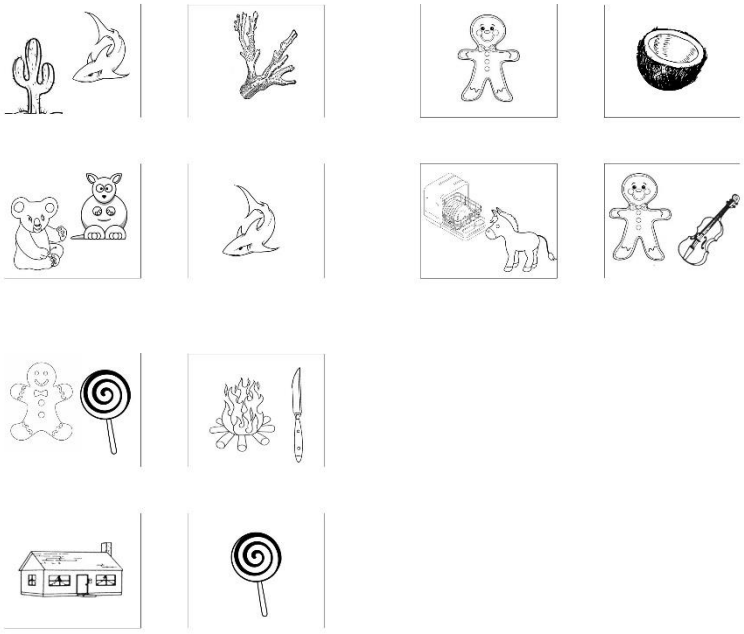
Overlap prime

Weak: The grapes

Alt: The grapes and the cheese

Target

The grapes



<u>No overlap prime</u>

Weak: The cactus

Alt: The shark and the cactus

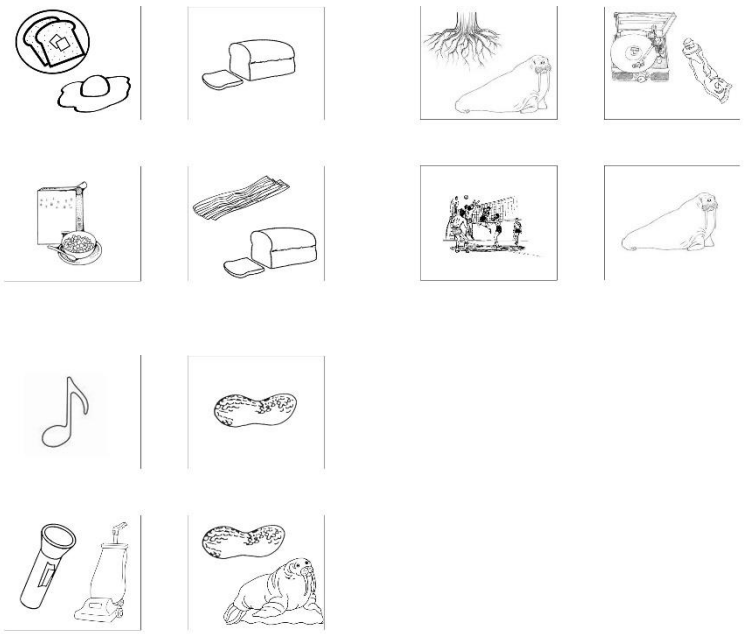
<u>Overlap prime</u>

Weak: The gingerbread man

Alt: The gingerbread man and the lollipop

<u>Target</u>

The gingerbread man



<u>No overlap prime</u>

Weak: The bacon

Alt: The bacon and the bread

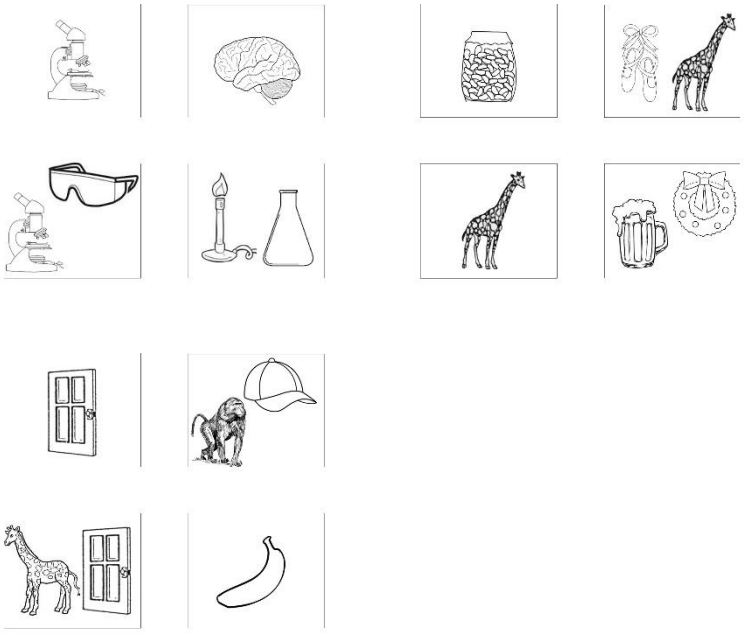
<u>Overlap prime</u>

Weak: The walrus

Alt: The walrus and the peanut

<u>Target</u>

The walrus



<u>No overlap prime</u>

Weak: The goggles

Alt: The microscope and the goggles

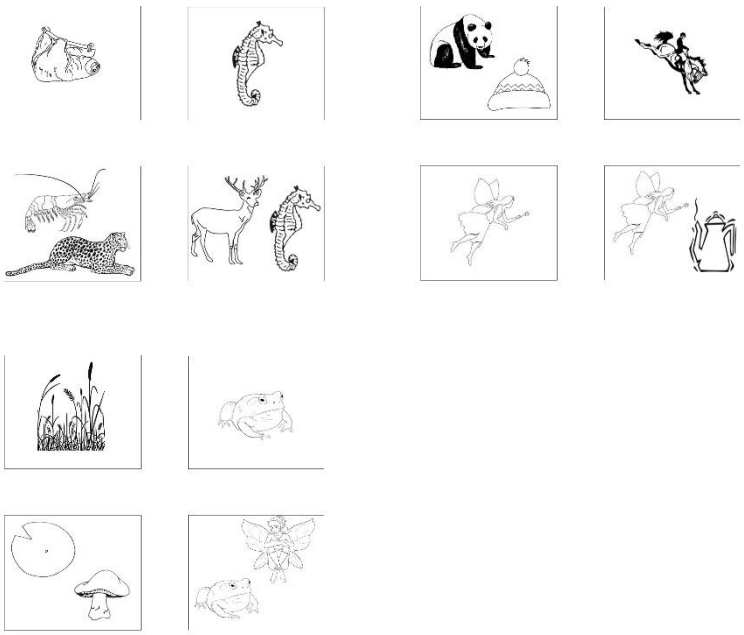
<u>Overlap prime</u>

Weak: The giraffe

Alt: The giraffe and the door

<u>Target</u>

The giraffe



<u>No overlap prime</u>

Weak: The deer

Alt: The seahorse and the deer

<u>Overlap prime</u>

Weak: The fairy

Alt: The fairy and the toad

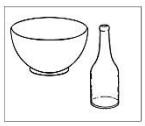
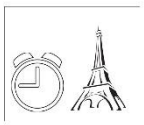
<u>Target</u>

The fairy









No overlap prime

Weak: The oven

Alt: The oven and the shaver

Overlap prime

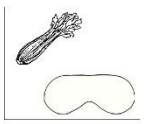
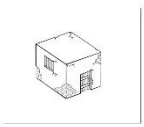
Weak: The bowl

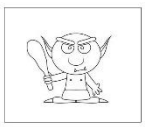
Alt: The bowl and the frying pan

Target

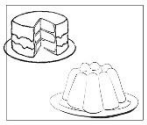
The bowl










No overlap prime

Weak: The plate

Alt: The plate and the handcuffs

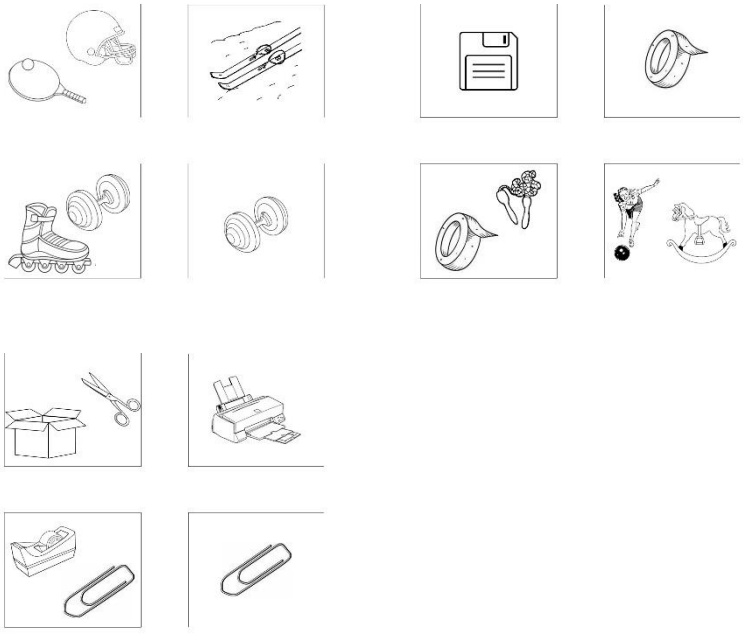
Overlap prime

Weak: The ice cream

Alt: The ice cream and the pie

Target

The ice cream



<u>No overlap prime</u>

Weak: The rollerblade

Alt: The rollerblade and the weight

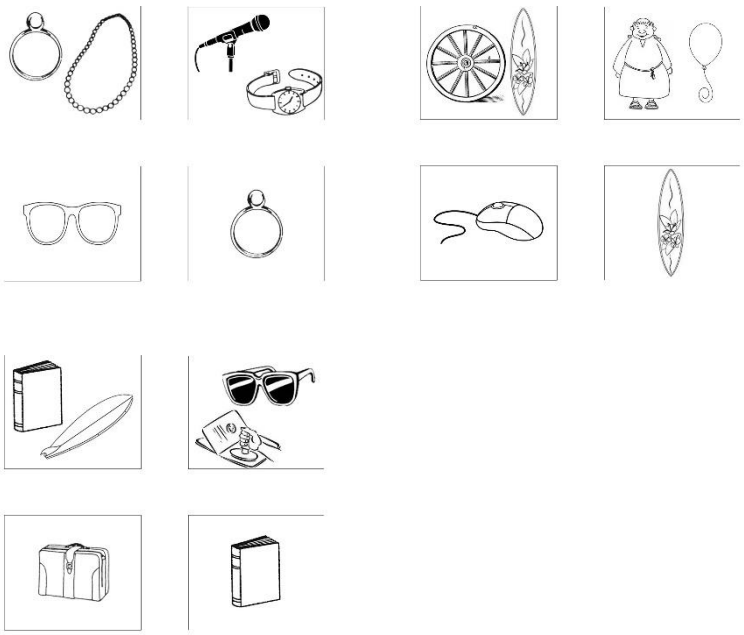
<u>Overlap prime</u>

Weak: The sellotape

Alt: The sellotape and the paper clip

<u>Target</u>

The sellotape



<u>No overlap prime</u>

Weak: The necklace

Alt: The ring and the necklace

<u>Overlap prime</u>

Weak: The surfboard

Alt: The surfboard and the book

<u>Target</u>

The surfboard












<u>No overlap prime</u>

Weak: The sword

Alt: The sword and the princess

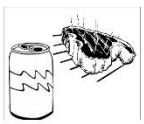
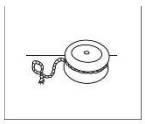
<u>Overlap prime</u>

Weak: The pram

Alt: The pram and the chain

<u>Target</u>

The pram






<u>No overlap prime</u>

Weak: The steak

Alt: The steak and the can

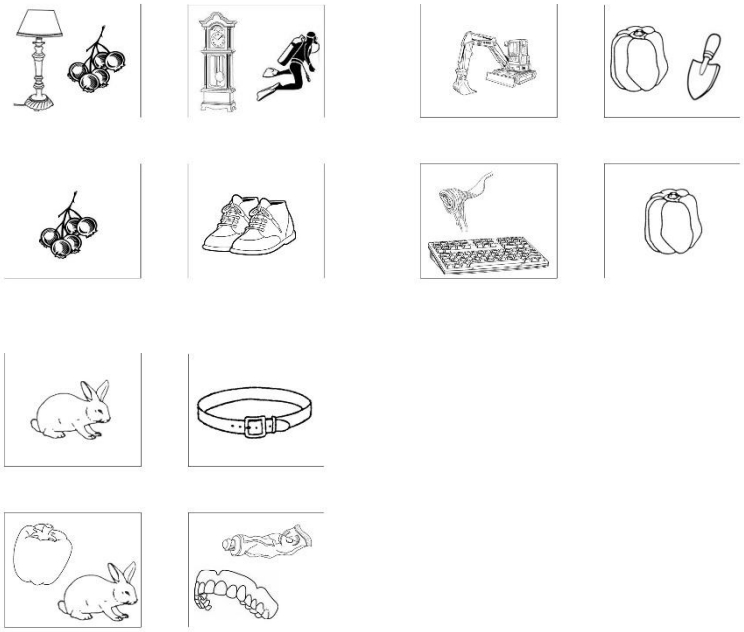
<u>Overlap prime</u>

Weak: The compass

Alt: The compass and the skirt

<u>Target</u>

The compass



<u>No overlap prime</u>

Weak: The lamp

Alt: The lamp and the berries

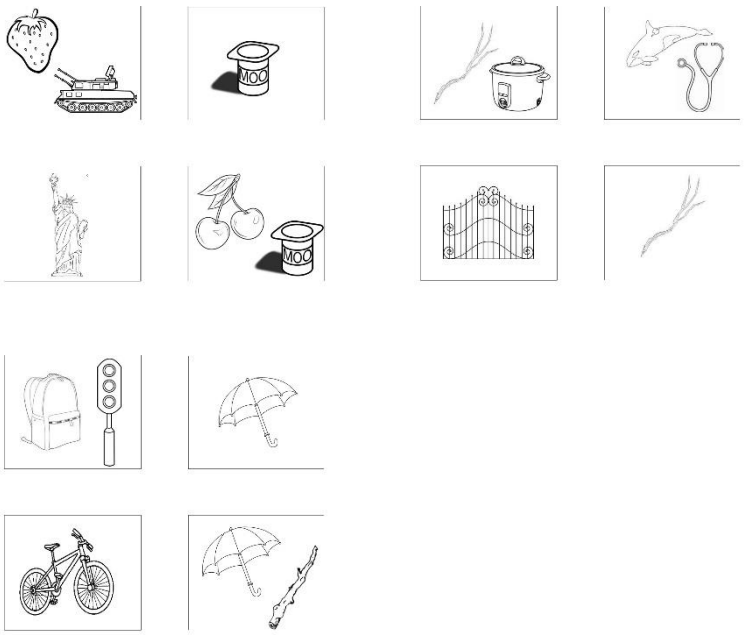
<u>Overlap prime</u>

Weak: The pepper

Alt: The pepper and the rabbit

<u>Target</u>

The pepper



<u>No overlap prime</u>

Weak: The cherries

Alt: The cherries and the yoghurt

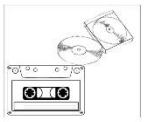
<u>Overlap prime</u>

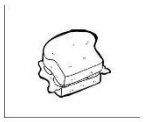
Weak: The stick

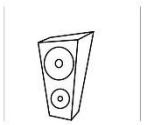
Alt: The umbrella and the stick

<u>Target</u>

The umbrella









<u>No overlap prime</u>

Weak: The CDs

Alt: The CDs and the cassette

<u>Overlap prime</u>

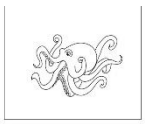
Weak: The lobster

Alt: The jug and the lobster

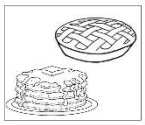
<u>Target</u>

The lobster










<u>No overlap prime</u>

Weak: The rocket

Alt: The rocket and the pine cone

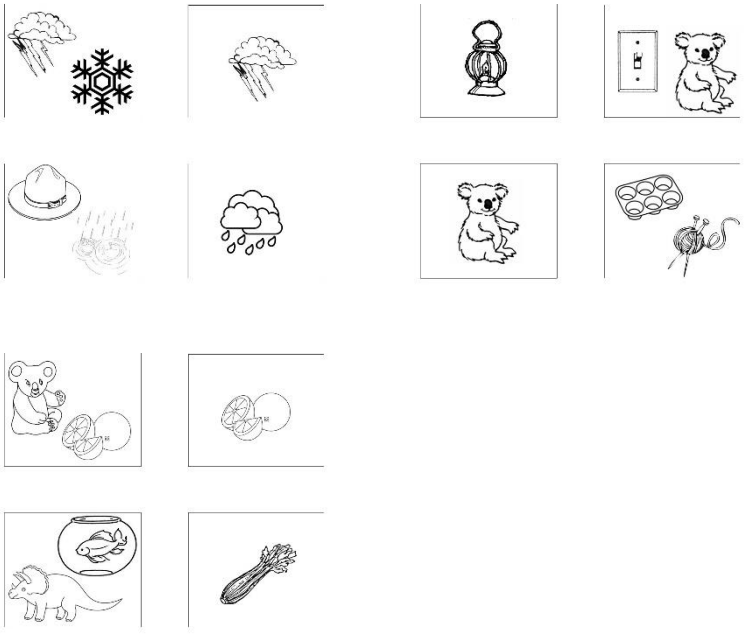
<u>Overlap prime</u>

Weak: The pancakes

Alt: The razor and the pancakes

<u>Target</u>

The pancakes



No overlap prime

Weak: The snowflake

Alt: The snowflake and the lightning

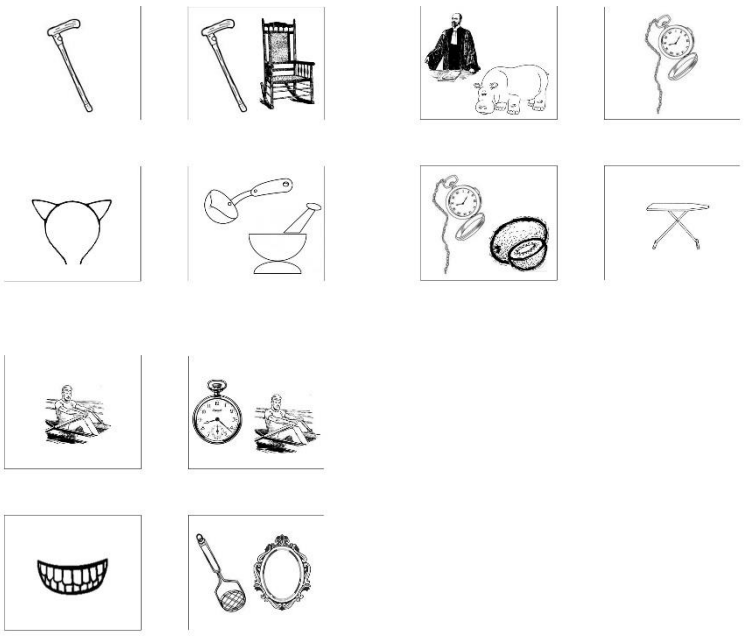
Overlap prime

Weak: The koala

Alt: The koala and the grapefruit

Target

The koala



No overlap prime

Weak: The chair

Alt: The chair and the walking stick

Overlap prime

Weak: The pocket watch

Alt: The rower and the pocket watch

Target

The pocket watch

<u>No overlap prime</u>

Weak: The oven glove

Alt: The funnel and the oven glove

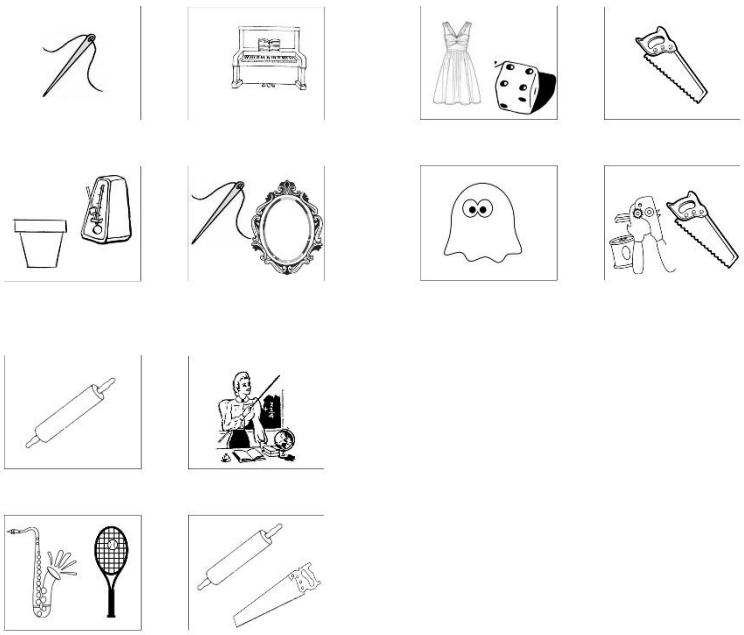
<u>Overlap prime</u>

Weak: The filing cabinet

Alt: The chocolate and the filing cabinet

<u>Target</u>

The filing cabinet



<u>No overlap prime</u>

Weak: The mirror

Alt: The mirror and the needle

<u>Overlap prime</u>

Weak: The saw

Alt: The rolling pin and the saw

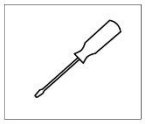
<u>Target</u>

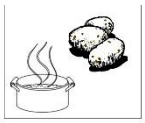
The saw

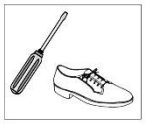












No overlap prime

Weak: The tent

Alt: The boot and the tent

Overlap prime

Weak: The screwdriver

Alt: The shoe and the screwdriver

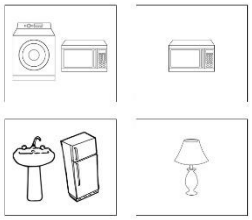
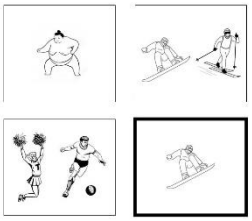
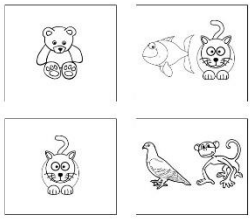
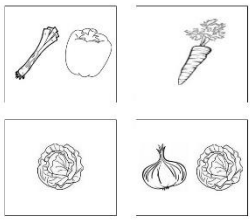
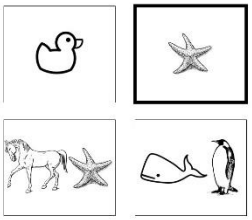
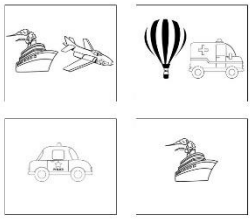
Target

The screwdriver

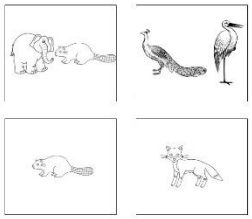
Appendix 3: Chapter 4 Stimuli

Experiment 1

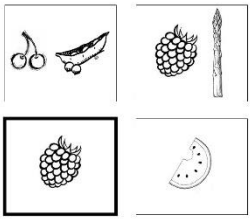
A->A sequence

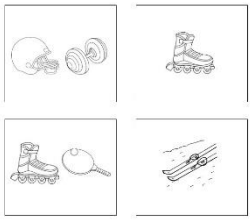
Prime	Description	Target
	The microwave The cat	
		
	The cabbage The ship	
		

The beaver

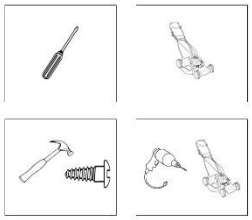


The rollerblade

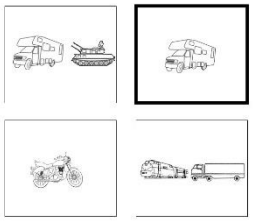


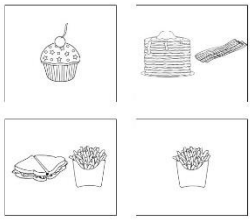


The lawnmower

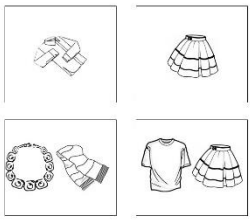
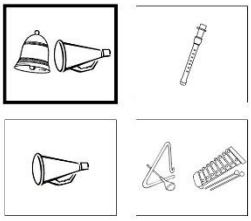
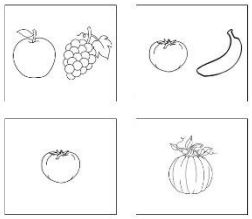
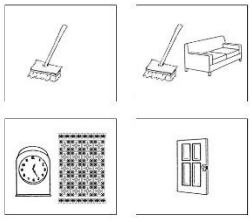
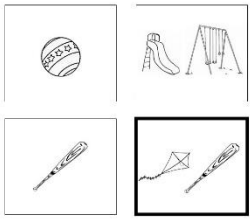
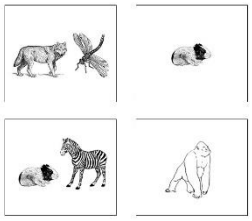


The chips

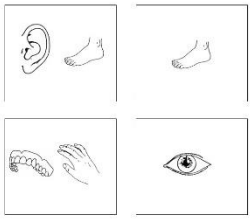




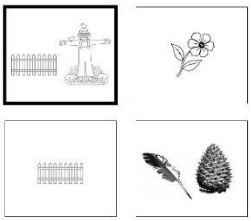
A->AB sequences

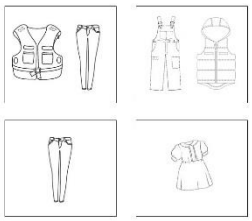
Prime	Description	Target
	The skirt The tomato	
		
	The broom The guinea pig	
		

The foot

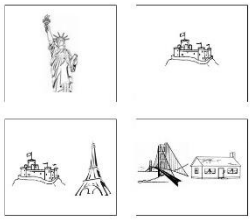


The jeans

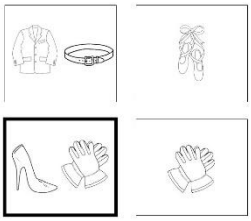


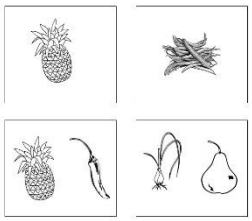


The castle

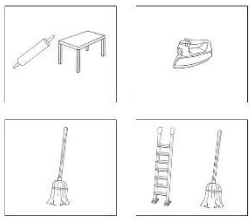
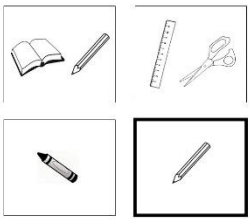
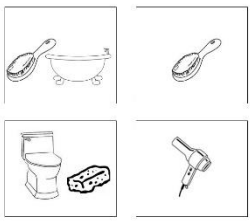
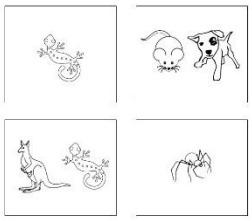
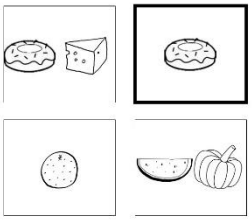
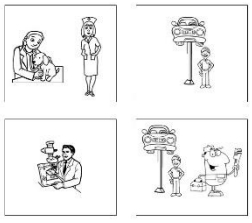


The pineapple

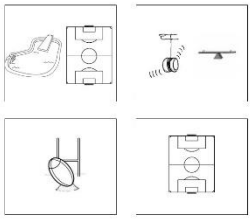




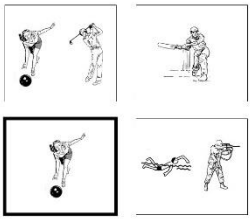
AB->A sequences

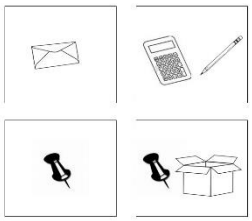
Prime	Description	Target
	The ladders	
	The bathtub	
	The kangaroo	
	The plumber	

The swimming pool

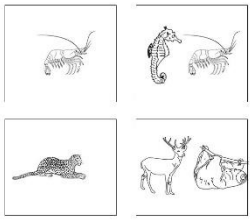


The box

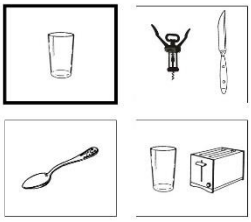


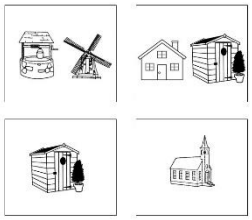


The seahorse

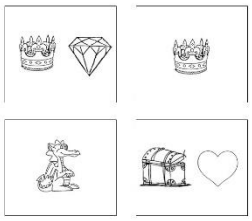
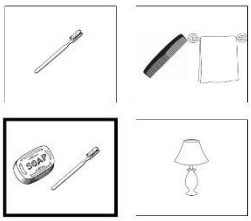
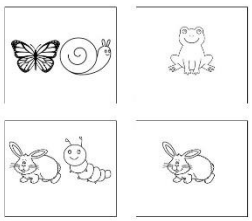
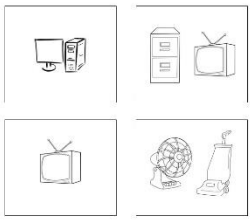
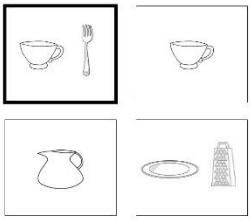
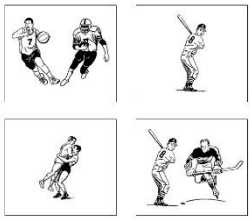


The house

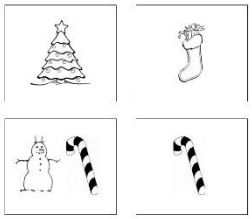




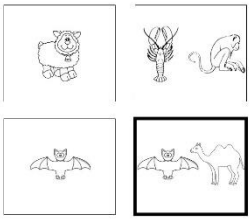
AB->AB sequences

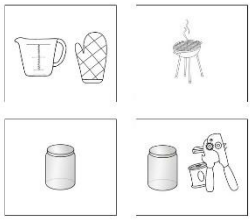
Prime	Description	Target
	The diamond The caterpillar	
		
	The filing cabinet The hockey player	
		

The snowman



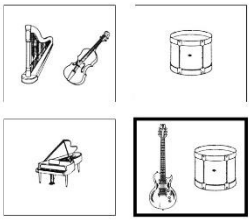
The can opener

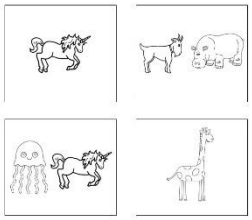




The tennis racket

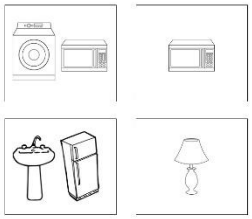
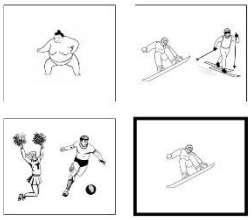
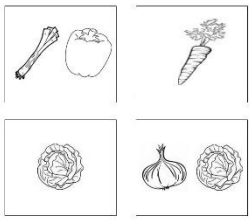
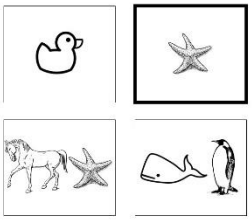
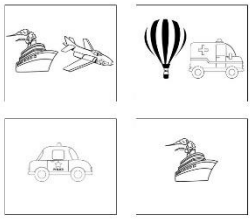
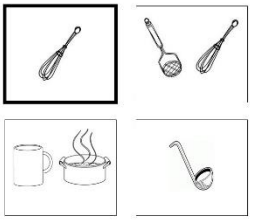
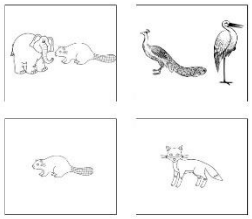
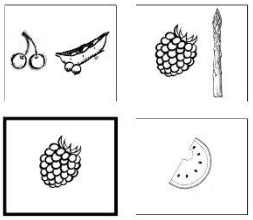
The jellyfish



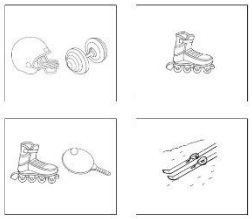


Experiment 2

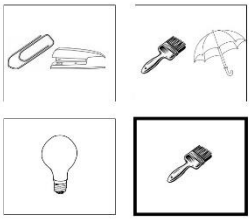
A->A sequences

Prime	Description	Target
	The microwave The microwave on its own	
	The cabbage Only the cabbage	
	The ship The ship on its own	
	The beaver Just the beaver	

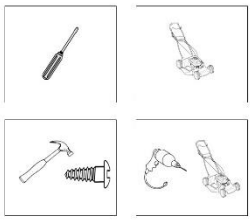
The rollerblade



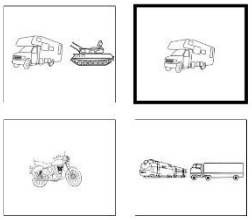
Only the rollerblade



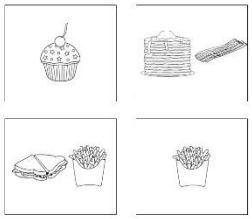
The lawnmower



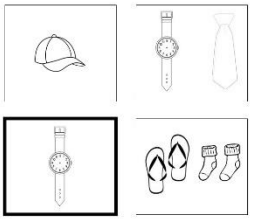
The lawnmower by itself



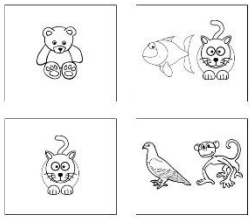
The chips



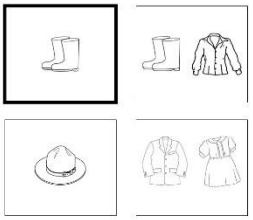
Just the chips



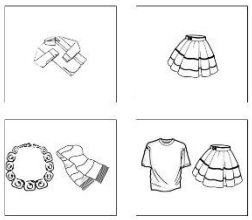
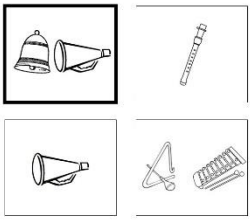
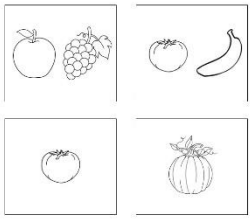
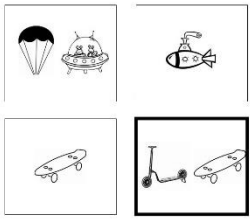
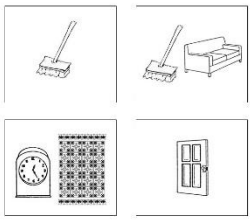
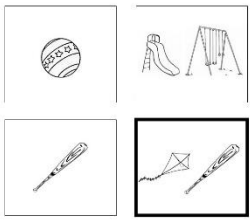
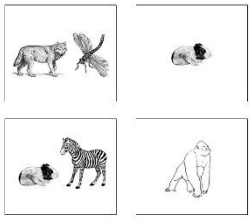
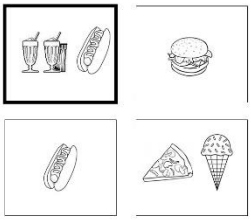
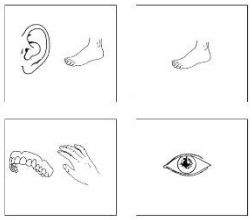
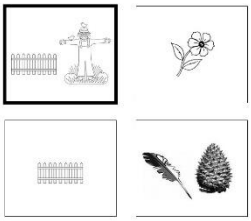
The cat



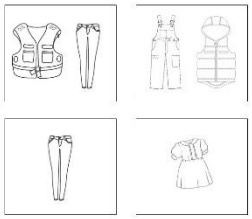
The cat by itself



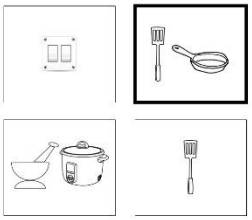
A->AB sequences

Prime	Description	Target
	The skirt The skirt on its own	
	The tomato The tomato by itself	
	The broom The broom by itself	
	The guinea pig The guinea pig on its own	
	The foot Only the foot	

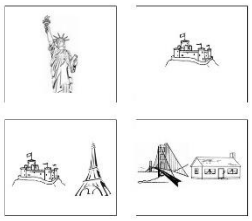
The jeans



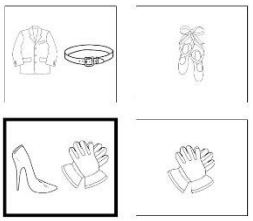
Only the jeans



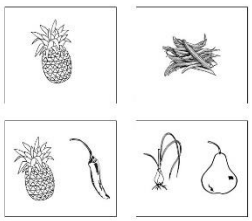
The castle



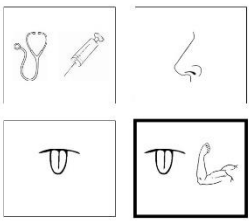
Just the castle



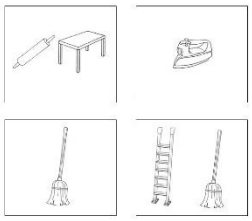
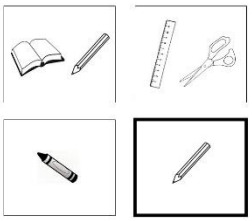
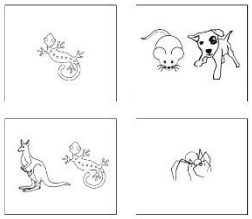
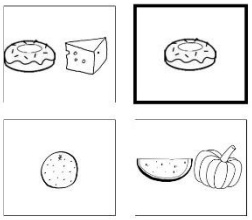
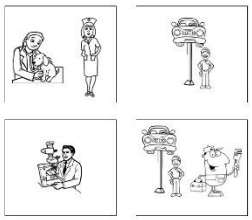
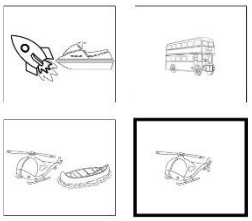
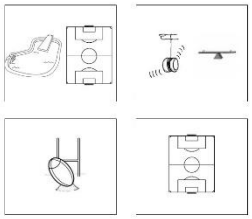
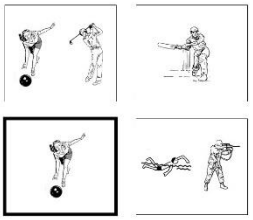
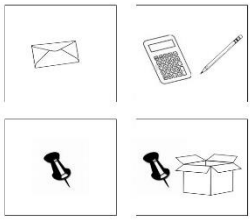
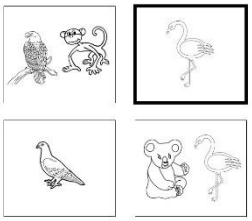
The pineapple



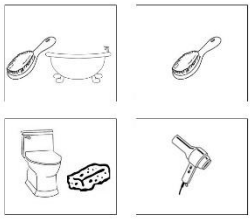
Just the pineapple

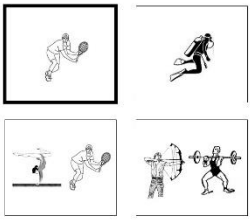


AB->A sequences

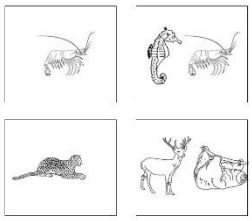
Prime	Description	Target
	The ladders	
	The kangaroo	
	The plumber	
	The swimming pool	
	The box	

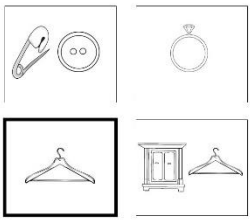
The bathtub



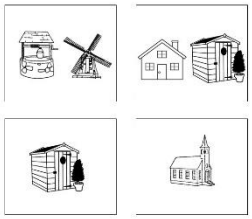


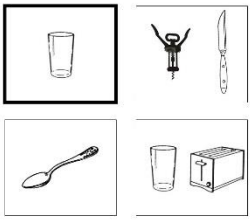
The seahorse



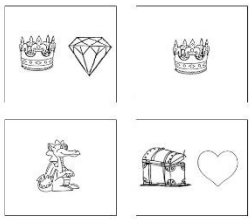
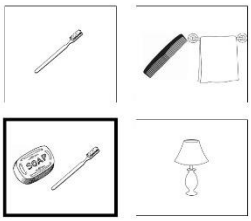
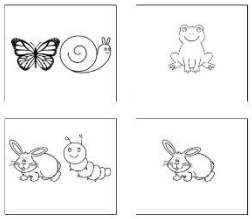
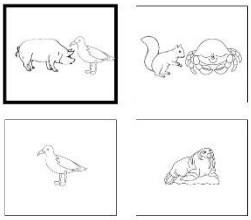
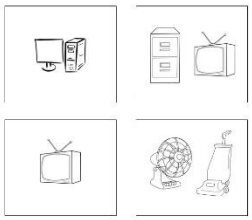
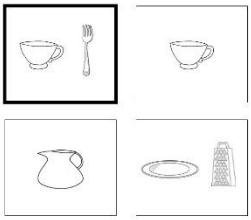
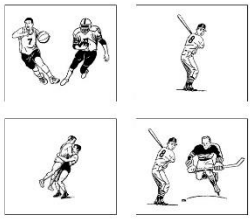
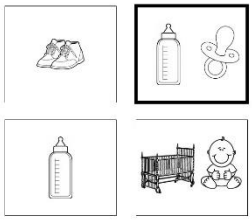
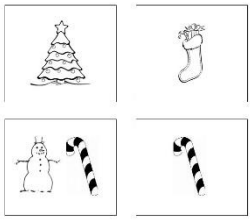
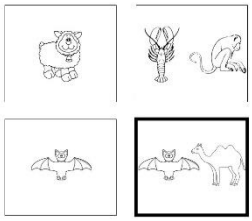


The house

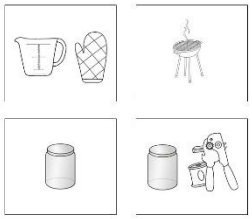


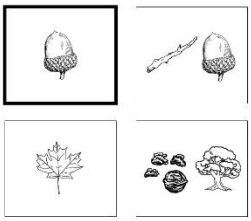


AB->AB sequences

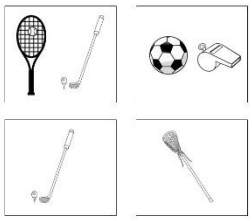
Prime	Description	Target
	The diamond	
	The caterpillar	
	The filing cabinet	
	The hockey player	
	The snowman	

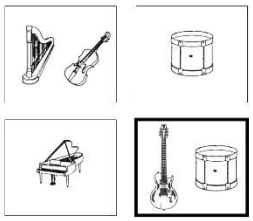
The can opener



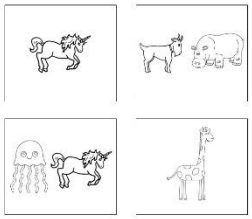


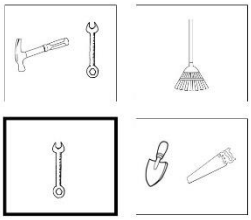
The tennis racket





The jellyfish





Experiments 3 & 4

The stimuli were the same as in Experiment 2. In Experiment 4 half of the A primes were presented with a modifier in any one list. This was counterbalanced across so that across participants all A card primes were heard with and without a modifier.