DOES EXHAUSTIVITY REQUIRE LINGUISTIC PROCESSING?

An Exhaustive Research

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Abstract: An experiment was designed to investigate whether exhaustivity is a concept that requires linguistic processing. A small sample size of participants were shown pairs of images, one image could be described using exhaustivity, the other could not. Their implicit recognition of this category was measured through pregaze, using an eye-tracker. The first question to answer was whether or not exhaustivity could even be recognised implicitly. It is concluded that exhaustivity is implicitly recognisable as pregaze does occur. The second question was to see if the recognition required linguistic processing. Verbal shadowing was introduced to overload the language centre. Mixed linear models were made to see if verbal shadowing had a significantly destructive impact on pregaze. The results appear inconclusive.

1 Introduction

Exhaustivity is a concept used in wide variety of subjects. It encompasses the meaning of "all-ness".

As an example you could say that all boys are wearing a safety vest (see the left side of Figure 1.1). This means that *all* the boys are wearing a safety vest and, quite crucially, *that there are no exceptions.* There is no boy that is not wearing a safety vest. In language, this concept is embodied by constructions like quantifiers and definite descriptions. But is exhaustivity a linguistic concept, or can it be recognised by general cognitive processes? And how would we investigate that?

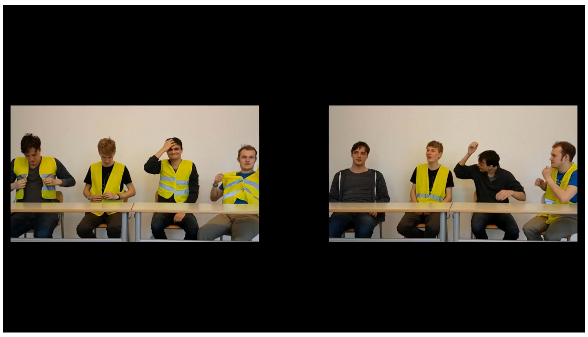

Figure 1.1: Exhaustivity Example

One way is to use eye tracking to measure recognition. Suppose there is a task where there are always two images on screen. One on the left and one of the right, like in Figure 1.1. These images represent two classes, in this case the exhaustive class and the distributive (or: non-exhaustive) class. If the participant is trained to always look at the exhaustive class one could measure recognition of that class with an eye tracker. Measuring the amount of time the eye focused on either side of the screen could tell you whether the participant was "correct" or "incorrect" depending on where they looked and the position of the exhaustive image. These ideas are based on the research of Nordmeyer (2011) and Margulis (2014) and will be explored further in the next section. One great advantage of using an eye tracker is you can measure recognition *implicitly.* There is no need for the participant to be conscious of the recognition of the class in order to measure a response.

Additionally verbal shadowing could be used to research what concepts require linguistic processing. A task integrating geometric and non-geometric information used verbal shadowing to overload the language centre (Hermer-Vazquez, Spelke, and Katsnelson 1999). They found that performance of the information integration task decreased much more with shadowing than some other task that was assumed to not require linguistic. Their conclusion was that this task required linguistic processing.

Combining the use of an eye-tracker to measure recognition and using verbal shadowing to detect tasks that require linguistic processing is a very powerful method to answer our questions. This method of seeing which tasks require linguistic processing has been proven to be effective for other concepts as well, such as negation (Nordmeyer 2011) and second order and higher relations (Margulis 2014). We will study exhaustivity in a similar way.

There are two questions we hope to answer in this study. The first, and most simple question, is whether or not exhaustivity will be recognised *at all* using this implicit method. Perhaps its features are too subtle, or the relationship is too abstract for it to be recognised. Because exhaustivity is so central in language, we hypothesise that it will be detected. Secondly, we would like to know if exhaustivity is something that requires linguistic processing. To measure this we introduce verbal shadowing and a control task. The next section explores previous research on this subject and how it influenced our design.

2 Background

We want to know if exhaustivity requires linguistic processing, but what is exhaustivity? Exhaustivity is best explained with the use of quantifiers, as it is the core of universal quantification. Take the following sentence.

(1) "*All* people like Keanu Reeves."

This expression can be seen as a relationship between two sets.[1] In this interpretation the entire set of people, exhaustively (all, without exception) like Keanu Reeves. That is to say, there exists no such person that does not like Keanu Reeves. This is distinct from other quantifiers that are not exhaustive. For example:

(2) "*Some* people like Steven Universe."

suggests that there could exist at least one individual in the set of people that does not like the Cartoon Network show Steven Universe. Exhaustivity can also exist outside of quantifiers. For example:

(3) "The thespians like being loud."

[1]In fact, universal quantifiers like *all* and *each* are interpreted as just that in generalised quantifier theory (Barwise and Cooper (1981)).

also exhausts the set of thespians without the use of a quantifier. This is called a definite description.

How can we determine which tasks require linguistic processing and which tasks require general cognition? It is generally accepted that linguistic processing is distinct from general cognition. Certain areas of the brain have been found to be more active in linguistic processing (Acheson and Hagoort (2013), Greenlee, Oya, Kawasaki, Volkov, Severson III, Howard III, and Brugge (2007), Bigler, Mortensen, Neeley, Ozonoff, Krasny, Johnson, Lu, Provencal, McMahon, and Lainhart (2007)). Let us refer to those areas collectively as the language centre. Previous research has also shown that we can find out which tasks require linguistic processing using multitasking.

For example in the research of Hermer-Vazquez et al. (1999) participants were presented with a task where they had to combine geometric and non-geometric information. Some participants were asked to perform rhythmic tapping while they had to combine these different streams of information. They heard a rhythm first and had to copy it afterwards. Other participants were asked to perform verbal shadowing instead. Verbal shadowing involves the participants speaking along with an audio-book that is played through a headset, this is a far more language demanding sub-task than the rhythmic tapping.

The experiment of Hermer-Vazquez et al. (1999) was designed like this because they wanted to study the involvement of language in this information integration process. More specifically, they wanted to find out if it was something that required language. As the verbal shadowing was a very linguistic processing heavy sub-task, they hypothesised that this would be very destructive to the performance of the main task. They also hypothesised that subsequently the less linguistic processing intense subtask of rhythmic tapping would be less destructive to the performance of the main task. The rhythmic tapping therefore functioned as more of a control. To compare the impact of general multitasking, versus the impact of same type cognition multitasking. They concluded that combining geometric and non geometric information indeed required linguistic processing.

This method of seeing which tasks require linguistic processing has been proven to be effective for other concepts as well, such as negation (Nordmeyer 2011) and second order and higher relations (Margulis 2014). This research seemed like a good starting point to answer our research questions and so these methods became an inspiration for our own work. The paragraphs below provide a brief explanation of their respective methods and results.

2.1 Negation

Negation is widely accepted to be a central part of language. It's perhaps more ubiquitous than exhaustivity, but it never the less presents us with a nice analogy of our own research questions. The methods that can be used to study negation, are also useful tools for ourselves. Here we turn to Nordmeyer (2011). Nordmeyer used a combination of eye-tracking and verbal shadowing to determine whether or not negation was a feature of language that fundamentally required linguistic processing.

Nordmeyer's experiment was designed as follows. There were two tasks, a negation task and a natural kind task. The negation task was the task of interest, and the natural kind task was the control task. The control task was needed for the reasons described above.

In Nordmeyer's experiment participants their gaze was measured using an eye-tracker. In both tasks two images were presented on a computer screen. One image was presented on the left and the other on the right. For the negation task one of the images would be affirmative and one would be negative. The images appeared still at first, but the image of the target class (negated) would animate after a few seconds. An example pair from the

Figure 2.1: Negation task image set

study is an image where a lamp is on, paired with an image where a lamp is off (see Figure 2.1). The image where the lamp is off would be the negation (and target) stimulus.

For the control task 26 image pairs were used. One image would be of a natural object and one would be of a man-made object. The images were chosen to be similar to each other, as the images in the negation task were also similar. For example a

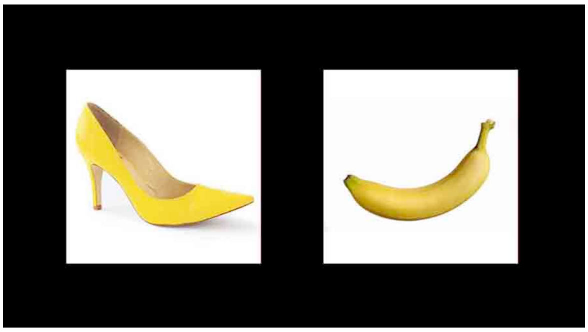

Figure 2.2: Natural kind task image set

picture of a banana paired with a picture of a shoe (see Figure 3.3) were used. The banana would be the target stimulus.

The measure of interest was the *anticipatory gaze*, or pregaze. People would look to the side of the screen containing the target stimulus when both images were not moving. This was in *anticipation* of the animation that would follow in that image. This behaviour seemed to be unconscious as participants would express this behaviour but could not give an accurate characterisation of the pattern in animation if tested afterwards.

Nordmeyer concludes that negation is a concept that requires linguistic processing as the anticipatory gaze disappears in the negation task when verbal shadowing is introduced as a distractor task, but the anticipatory gaze remains in the control task. Meaning that shadowing was more destructive for the negation task, as would be expected for a linguistic task as mentioned in the introduction.

2.2 Second Order Relations

Margulis (2014) used a similar method with a similar set up. For her target task she was interested in second order relations. These were depicted by images of rock formations. Each formation contained one of three relationships that were explained and named beforehand (see Figure 2.3). Here the image of the target stimulus would animate as well after some time. Margulis also had a control task. The

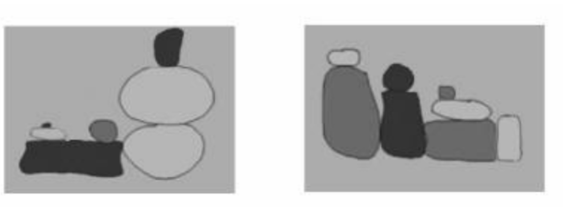

Figure 2.3: Second order relations

control condition was a little more complicated. Two prototypes of faces were made, both representing a family (see Figure 2.4). These prototypes were then modified via strict rules. These modification were presented after having seen the prototypes. The image belonging to family A would always animate, the image belonging to family B would not. The goal was to test participants on being able to recognise general feature based categories.

Figure 2.4: Prototype faces

Some precautions were made in the data set. It could be the case that one type of rock formation, or one prototype of face, typically makes up a more (or less) uniform picture than its counter type. This would mean that participants might perceive a pattern in animation other than the intended target stimulus (namely the relevant second order relation). This alternative pattern is called variance. Variance has been shown to be easy to spot, even for animals with no major language capabilities (Vonk and Povinelli 2012). To avoid the subject being able to use this lower level feature of variance to increase their anticipatory gaze, the categories are made deliberately similar in variance.

Here, an eye-tracker was also used to measure anticipatory gaze. Unlike with Nordmeyer, participants were instructed to detect 'the rule' of which face would animate. This instruction was given to prompt participants to be aware of there being a pattern without revealing what exactly that pattern was. This instruction was added after a pilot study showed that participants often missed the categories completely.

Margulis concludes that second order relations are a concept that require linguistic processing as the anticipatory gaze disappears in the shadowing condition for the second order relation task but remains in the shadowing condition of the control task. This means that shadowing was more destructive to performance in the second order relation task, which was hypothesised to require language, than the control task.

2.3 Exhaustivity

We've taken a look at some research in related concepts now, but how do these relate to our own research questions? Let us first look at negation.

Negation is a fundamental concept in language, but is it also primarily linguistic? Nordmeyer's findings suggest that it is. Exhaustivity is also a fundamental concept, but can we also conclude that it is primarily linguistic? Using a method very closely to Nordmeyer we hope to detect just that.

Then there are second order relations. Exhaustivity can also be seen as a second order relation. Two groups of people exhaustively doing two different activities can be considered "the same", even if these groups and these activities look nothing alike. This relationship by which they could be considered is a second order relation, specifically the second order relation of exhaustivity. Then, if exhaustivity is a second order relation and we follow Margulis' conclusions, we must hypothesise exhaustivity to be a concept that requires language. Furthermore we can assume that it can be studied in a very similar way. In our research we examine this further.

3 Methods

In total 19 participants took part in the study. Being a native Dutch speaker was a requirement for taking part in the study, because a Dutch audio book was used. Their mean age was 25.7 years, the age ranged from 19 to 56 years old and 5 participants were male. For 12 participants no additional shadowing task was done, for the other 7 participants it was.

Participants were told that they would see two images, one of which would animate after 3 seconds. They were instructed to find the pattern of what image would animate.

As we are investigating exhaustivity, images were needed to depict it. In total 26 image sets were made. Each set includes two images featuring between 3 and 5 boys doing an activity or interacting with an object. The exhaustive images animate by playing a short video clip of the boys. Each set featured an image where the set of boys is exhausted over an object or activity, and one image where it is not. For example an image where all boys are wearing a vest and an image where only some are wearing it. Additional variance is also introduced

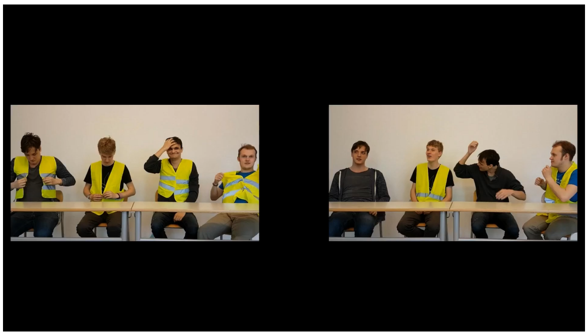

Figure 3.1: Exhaustive task image set

in some images. So an exhaustive image might, for example, feature an extra prop such that the image is less uniform (see Figure 3.2). The extra variance was introduced to make sure that the image with the least amount of variance would not always be the target image. This was done to prevent participants from using variance as a cue instead of exhaustivity. This was explained in a little more detail in section 2.2 on second order relations.

A control task was also needed to compare results with the exhaustive task. For this purpose we took the images of the natural kind task from Nordmeyer (2011). This task had a very similar set up as the negation task. In total 26 image pairs were shown. One image would be of a natural object and one would be of a man-made object. The images were

Figure 3.2: Variance in the exhaustive task

chosen to be similar to each other, as the images in the negation task were also similar. As with the exhaustive task the target image would animate. For

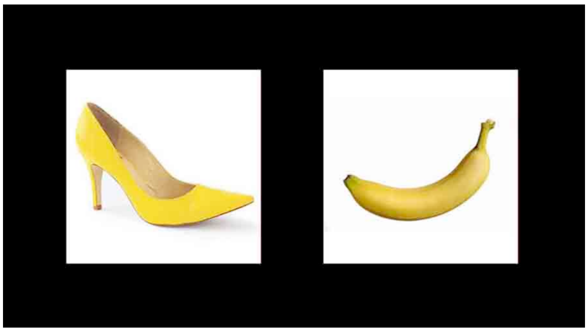

Figure 3.3: Natural kind task image set

example a picture of a banana paired with a picture of a shoe (see Figure 3.3). The banana would be the target stimulus.

To overload the language centre we used verbal shadowing. The audio book *Bruidsvlucht* by Marieke van Pol was used for the shadowing. Participants were trained to shadow for one minute. The training, the natural kind task, and the exhaustive task all had their own sections of the book. This book was chosen because it contained a lot of prose without the interruption of dialogue.

For both tasks the images were presented for an initial 3 seconds. After that, the target image would animate. In case of the exhaustive task the images are stills of a video and the stills would animate by playing the rest of the video. For the natural kind task a cartoon foot would come down and squish the target image to 20% its original height, after which the foot would leave again and the image would reform to its original dimensions. These animations took an additional 3 seconds, so the images were presented for a total of 6 seconds. The side on which the target images appeared was randomised.

A DuoLink eye-tracker was used to record the gaze position. A tracking dot was applied to the forehead to track the head. Samples were taken at 500 Hz and the right eye was recorded for all but one participant. This participant had their left eye recorded due to a hairstyle that made it difficult to attach a tracking dot to the right side of their face.

A 2x1 between subjects design was used where participants either did the shadowing or non-shadowing condition for both tasks. Participants were randomly assigned to conditions. There was a short one minute break between both tasks. One participant only did the control task as the eye-tracker failed to track her eyes after the break between the two tasks. Half the participants did the control task first, the other half did the exhaustive task first.

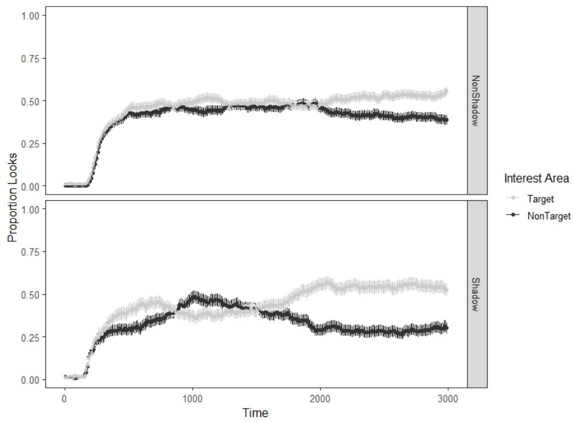

Figure 4.1: Exhaustive task average looking proportions

4 Results

The DuoLink data viewer was used to generate sample reports. The R package `VWPre` was used to preprocess the data. Two areas of interest were dynamically created. The first area consists of the bounding box of the target image, the other area is the bounding box of the non-target image. The data is binned in samples of 10 ms and only a three second period after the images appear is considered.

Plotted in Figure 4.1 and Figure 4.2 are the average proportional looking times per area of interest for the exhaustive task and the control task respectively. The non-shadowing case is at the top, and the shadowing case is at the bottom. In Figure 4.2

The mean looking time to the target image and the non-target image was also compared. This mean looking time is the average time spent looking at either area of interest during a trial. Following the results of Nordmeyer, a t-test was performed to compare the mean looking times to the target image and the non-target image for both tasks and for both the shadowing and the non-shadowing conditions. Participants looked significantly more to the target than the non-target for all cases. These results are shown in Figure 4.3 and can be compared to Figure 3 in Nordmeyer (2011), who only

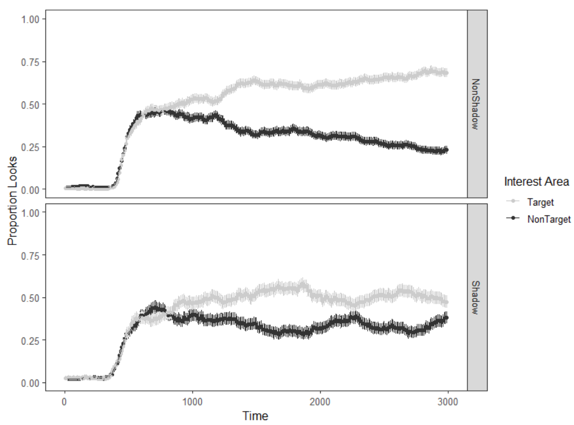

Figure 4.2: Natural kind task average looking proportions

found a significant difference in the exhaustive non-shadowing case.

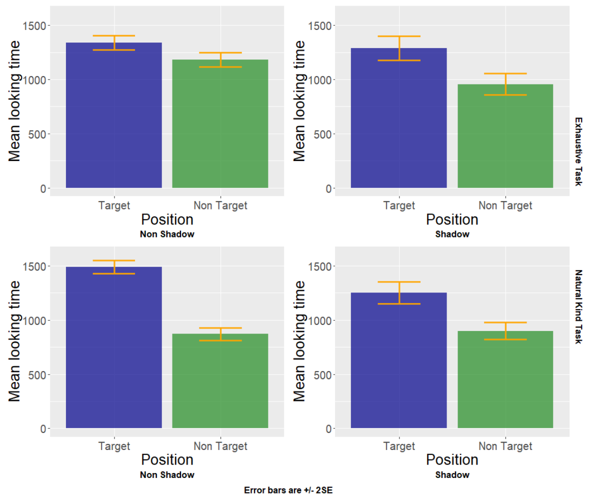

Figure 4.3: Mean looking times

The statistics represented in the graph are as follows.

For the exhaustive task: For non-shadowing exhaustive task the target($M = 1340.10, SD = 578.96$) and non-target ($M = 1183.43, SD = 576.80$) conditions; $t(621.99) = 3.39$, $p >= 0.00075$. For shadowing exhaustive task the target($M = 1290.71, SD = 755.73$) and non-target ($M = 956.61, SD = 664.79$) conditions; $t(356.21) = 4.48$, $p >= 1.015e - 05$.

And for the control task: For non-shadowing natural kind task the target ($M = 1489.07, SD = 560.40$) and non-target ($M = 870.28, SD = 543.68$) conditions; $t(673.38) = 14.57$, $p < 2.2e - 16$. For shadow natural kind task the target ($M = 1252.24, SD = 669.76$) and non-target ($M = 898.60, SD = 523.64$) conditions; $t(342.09) = 5.61$, $p >= 4.14e - 08$.

Mixed linear models were made for the exhaustive task. The models attempt to predict the difference in proportion of time looking at the target and looking at the non-target. This difference is the anticipatory gaze, or pregaze, discussed in section 2. The first model, which can be found in Appendix A, table A.1, is a model using the shadowing condition as a fixed effect and the trial number, the side of the screen on which the target appeared, the subject number and the used image pair as random effects. Using AIC scores it was determined that this was the optimal model (that used the shadowing condition), so no factors were excluded. This model's AIC score was compared with a model without using the fixed effect of the shadow condition and only using the random effects, see Appendix A, table A.2. The AIC of the model without the fixed effect was 1 lower than that of the model with the fixed effect. Thus, the model with the fixed effect is not significantly better than the model without ($p >= 0.28$), and such the shadowing condition is not a significant predictor of pregaze.

A similar analysis was conducted for the control task. The same two models were made and compared. The AIC of the model with the fixed effect was 11 better than the AIC of the model with only random effects. So, here too, shadowing was not a significant predictor of pregaze ($p >= 0.27$).

5 Discussion

Let us first discuss our first hypothesis. In section 1 we hypothesised that the features of exhaustivity could be recognised implicitly through image sets depicting exhaustivity and non-exhaustivity, using animation as a natural reward. The difference between the looking time at the target image and the non-target image were significant for both conditions of the exhaustive task. This suggests that the anticipatory gaze was indeed achieved, and participants did predominantly look at the target image before the animation started. This means that target images were correctly identified as a coherent set. Thus, exhaustivity was recognised implicitly, confirming our first hypothesis.

Then, we hypothesised that the shadowing would be more destructive for the exhaustive task than for the control task with the natural kind images. This was hypothesised as we suspect that exhaustivity requires linguistic processing, which the shadowing requires as well. The control is there to establish a base line, as it is a task that does not require linguistic processing.

Figure 4.1 and 4.2 show average looking time proportion for both conditions. The moments where the target looking time proportions are higher than the non-target looking time proportions we consider to be pregaze. The bigger the difference between the two, the greater the pregaze. It is easy to see there is less pregaze occurring in the non-shadowing condition of the exhaustive task than the shadowing condition, though the difference is rather small. This is the opposite of the expected result. In the control task the pregaze was much larger for the non-shadowing condition than the shadowing condition, however these gaps were expected to be the same size. It also seems that there is a much larger onset time for pregaze in the exhaustive task than the control task, this was also not expected.

The more precise results are found in the mixed linear models. The mixed linear models did not show that the shadowing condition was a significant predictor of pregaze. This seems to suggest that overloading the language centre using verbal shadowing was in fact not destructive to pregaze, definitely not more so than in the control task. As such, we cannot accept our hypothesis that exhaustivity requires linguistic processing.

However, exhaustivity seems like a core linguistic concept, being a core part of quantifiers and other linguistic expressions. It seems worth exploring possible other reasons why the results were not significant than that there is no effect to be measured.

Firstly, it could be the effect size was too small for us to detect with our small number of participants. Nordmeyer had a total of 67 participants, in our study we only tested 19. Nordmeyer also maintained some criteria by which to exclude certain participants. These criteria were not implemented in this study. Nordmeyer excluded people who's total looking proportions go below 60% and people who stop shadowing for more than 2 seconds at a time, in total she excluded 18 out of 67 participants. For our own research, neither of these groups were excluded because (i) we already had very few participants, (ii) we did not record who stopped for more than 2 seconds and (iii) too many participants go below 60% as the eye-tracker often lost track of them for some time during the experiment. If we had more participants and these groups would have been excluded, the results may have been different.

Furthermore, the image sets created for the exhaustive task could also be at fault. Perhaps seeing the exhaustive class was too easy, or perhaps participants saw something else entirely, like the variance cue discussed in section 2.2. Perhaps the animation being different could also have had an effect. It could be that the cartoon foot is a better natural reward than simply animating into a video. Perhaps the exhaustive images were too 'busy' for the eye, as there were many more features in the exhaustive images than the control task images. Then the 3 second period before the animation might not be enough time to process all the visual input. This idea seems supported by the large onset period found in Figure 4.1.

It could also be that the control task and the exhaustive task were not similar enough. Margulis (2014) made sure that her control task used the same *type* of recognition, without having to use language. She made sure the target and control task were very similar, such that their results could be better compared. It could be that an entirely different control task should be designed.

It could also be that the audio book was not intensive enough, the narration contained a large number of pauses, some of which were rather long. These pauses may have made it possible for the participants to recognise the pattern, while their language centre was no longer being overloaded, thus removing the destructive shadowing effects from the results. It could be that trimming the audio book to not let the participant 'rest' could change the results.

6 Conclusion

An experiment was designed to investigate whether exhaustivity is a concept that requires linguistic processing. A small sample size of participants were shown pairs of images, one image could be described using exhaustivity, the other could not. Their implicit recognition of this category was measured through pregaze, using an eye-tracker. The first question to answer was whether or not exhaustivity could even be recognised implicitly. It is concluded that exhaustivity is implicitly recognisable as pregaze does occur. To see if the recognition required linguistic processing, verbal shadowing was introduced to overload the language centre. Mixed linear models were made to test if verbal shadowing had a significantly destructive impact on pregaze. The results appear inconclusive.

Further research into the confounding factors described in section 5 could provide a more conclusive answer for the above research question.

Firstly, a larger sample size could greatly improve the results. The effect appears to be too small to be detected by a small sample size. Furthermore, a greater sample size would allow for the exclusion of participants who do not continue to shadow consistently or whose eyes are not consistently tracked. Removing these participants from the analysis should increase the effect size, as the conditions to invoke the effect are more consistently present. Thus, increasing the sample size could increase both effect size and sensitivity.

Secondly, future research should investigate the effects of the pregaze period length on the destructive effects of verbal shadowing. As discussed in section 5, the images could very well be too complicated to process completely in the 3 second pregaze period the participants were allowed in this study. Increasing the pregaze period length might also increase effect size as there is more time to recognise the images while not increasing the availability of the language centre.

Thirdly, some other experimental conditions could be improved on as well. The control task might be made to fit better with the exhaustive task. For instance creating images with a similar amount of features and variance. This improvement could help align the pregaze onset, as both image sets would require a similar amount of processing, and in general make the results of the exhaustive task and control task more comparable. The audio book used for the shadowing could also be improved upon. The pauses in the speech might have dissolved the destructive effects of the shadowing on the exhaustive task.

Other forms of audio shadowing could be tested, like the rhythmic tapping in Hermer-Vazquez et al. 1999. Rhythmic tapping is a form of audio shadowing that does not require linguistic processing, and such it could be used as a control for the verbal shadowing. Comparing rhythmic tapping with verbal shadowing could prove whether audio shadowing in general causes an effect, or just verbal shadowing, due to the linguistic processing required, further strengthening a conclusion that exhaustivity requires linguistic processing.

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A Appendix

Table A.1: Exhaustive task full Linear Mixed Effects Model = Proportion Looking Time Target Interest Area - Proportion Looking Time Non-Target Interest Area S̃hadowing Condition + (1 — Trial Index) + (1 — Target Location) + (1 — Subject Number) + (1 — Item Name)

Random effects:			
Groups	Name	Variance	Std.Dev.
Item Name	(Intercept)	0.0086119	0.09280
Trial Index	(Intercept)	0.0148288	0.12177
Subject Number	(Intercept)	0.0298965	0.17291
Target Location (*Right Side*)	(Intercept)	0.0008485	0.02913
Residual		0.6742185	0.82111
Fixed effects:			
	Estimate	Std. Error	t value
(Intercept)	0.20626	0.06027	3.422
Shadowing Condition (*Shadowing*)	-0.08838	0.08118	-1.089

Table A.2: Exhaustive task only random Linear Mixed Effects Model = Proportion Looking Time Target Interest Area - Proportion Looking Time Non-Target Interest Area (̃1 — Trial Index) + (1 — Target Location) + (1 — Subject Number) + (1 — Item Name)

Random effects:			
Groups	Name	Variance	Std.Dev.
Item Name	(Intercept)	0.0086022	0.09275
Trial Index	(Intercept)	0.0148762	0.12197
Subject Number	(Intercept)	0.0317057	0.17806
Target Location (*Right Side*)	(Intercept)	0.0008891	0.02982
Residual		0.6742182	0.82111
Fixed effects:			
	Estimate	Std. Error	t value
(Intercept)	0.1753	0.0542	3.235

Table A.3: Control task full Linear Mixed Effects Model = Proportion Looking Time Target Interest Area - Proportion Looking Time Non-Target Interest Area S̃hadowing Condition + (1 — Trial Index) + (1 — Target Location) + (1 — Subject Number) + (1 — Item Name)

Random effects:			
Groups	Name	Variance	Std.Dev.
Item Name	(Intercept)	0.011367	0.1066
Trial Index	(Intercept)	0.011166	0.1057
Subject Number	(Intercept)	0.010048	0.1002
Target Location (*Right Side*)	(Intercept)	0.006773	0.0823
Residual		0.763967	0.8741
Fixed effects:			
	Estimate	Std. Error	t value
(Intercept)	0.05504	0.07118	0.773
Shadowing Condition (*Shadowing*)	0.05373	0.04790	1.122

Table A.4: Control task only random Linear Mixed Effects Model = Proportion Looking Time Target Interest Area - Proportion Looking Time Non-Target Interest Area (̃1 — Trial Index) + (1 — Target Location) + (1 — Subject Number) + (1 — Item Name)

Random effects:			
Groups	Name	Variance	Std.Dev.
Item Name	(Intercept)	0.011369	0.10663
Trial Index	(Intercept)	0.011183	0.10575
Subject Number	(Intercept)	0.010758	0.10372
Target Location (*Right Side*)	(Intercept)	0.006782	0.08235
Residual		0.763967	0.87405
Fixed effects:			
	Estimate	Std. Error	t value
(Intercept)	0.07483	0.06926	1.08