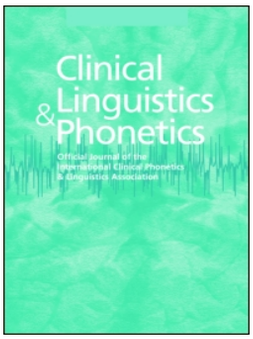

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Linguistic, concept and symbolic composition in adults with minimal receptive vocabulary

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ABSTRACT

In this paper, we examine some basic linguistic abilities in a small sample of adults with minimal receptive vocabulary, whose receptive mental verbal age ranges from 1;2 to 3;10. In particular, we examine whether the participants in our study understand noun phrases consisting of a noun modified by an adjective. We use stimuli that they can recognise by name. Except for one participant, we find that, while all of them understand the noun and adjective in isolation, none seems to understand these noun phrases, which means that they seem to not do linguistic composition. In order to test whether the difficulty is linguistic or conceptual, we ran two other studies, one on concept composition, and the other on iconic symbolic composition (composition of pictograms). Results suggest that linguistic composition is particularly difficult in this population, and that vocabulary breadth may not predict compositional abilities.

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Introduction

Almost a decade ago, Tager-Flusberg and Kasari (2013) remarked that, despite there being an estimate of 20–30% of non-verbal or minimally verbal autistic people, there was still a paucity of research addressing the social and cognitive capacities of such a profile. Since the publication of their paper, the situation has not improved much, probably given the difficulties associated with working with this population. The aim of this paper is to contribute to knowledge about *adults with minimal receptive vocabulary* (henceforth AMRV), not only because this is an under-studied population, but also because we know very little about their linguistic comprehension. In particular, the aim of this small-scale study is to test linguistic combinatorial abilities in a sample of adults with minimal receptive vocabulary. Our **first research question** is whether individuals with this level of receptive vocabulary also have some compositional capacity (in particular, whether they are able to comprehend complex noun phrases composed of a noun modified by an adjective). **Secondly**, we want to test whether inability to comprehend linguistic composition is related to a linguistic deficit or, rather, whether it goes along with inability to perform concept and symbolic composition.

To achieve these goals, we designed three empirical studies, the first one concerning linguistic composition. The rationale for testing concept and symbolic composition is to

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eliminate hypotheses in the event that they do not exhibit an understanding of adjectival modification of a head noun. Lack of understanding such complex noun phrases may be due to several reasons besides lacking linguistic knowledge/abilities. One such reason is that the person has difficulties composing concepts. Another such reason is that the person has difficulties understanding any kind of symbolic combination of two or more symbols. As we wanted to explore linguistic abilities, we also wanted to exclude such alternative hypotheses to an eventual difficulty in the linguistic task.

However, testing concept composition and symbolic composition in MRVAs is important in itself. Regarding concept composition, it is important to study whether difficulties with linguistic composition reflect or impact cognitive difficulties, or whether there can be dissociations between linguistic and conceptual abilities. Regarding symbolic composition, it is important to study whether understanding complex iconic representations is easier than understanding complex linguistic expressions. It has been shown that, at the atomic level, iconic representations are easier to understand than linguistic representations such as words (Carter & Hartley, 2021; Hartley & Allen, 2015). However, it has not been explored whether the same holds for complex representations, whose understanding requires compositional abilities.

In the following section, we delve into the characterisation of the population that is the object of our study and motivate the need for a study that collects data that go beyond what we know about their linguistic and cognitive abilities. Section 3 reports our study on linguistic composition. In particular, in our Experiment 1, we wanted to see whether AMRVs can interpret complex NPs composed of a N and an A they are familiar with. We were also interested in comparing their results in a word composition test with: (a) conceptual compositional abilities required in the classification and analogies subtest of the Leiter-3 (Roid & Miller, 2013) scale (our Experiment 2, Section 4), and (b) symbolic compositional abilities using an augmentative system of communication (pictograms), implemented on tablets (our Experiment 3, Section 5). The general discussion (Section 6) concludes the paper.

Adults with minimal receptive vocabulary

Why is it important to study AMRVs? Verbal Mental Age (VMA) is measured on the basis of vocabulary breath, either receptive or productive (see, e.g. Joseph et al., 2019). However, we do not know whether vocabulary measures translate into general linguistic comprehension measures. Garrido et al. (2015) show that there is no such correspondence in the case of pre-verbal autistic children, but they test grammatical structures (like coordinated sentences and relative clauses), using the CEG 2–4 test, the Spanish translation of Bishop's (2003) TROG, by Mendoza et al. (2005), which are beyond the comprehension abilities of our population of interest. Some results suggest otherwise: e.g. Åsberg (2010). In a similar line, Slušná et al. (2021) explore associations between expressive and receptive language, and between these and non-verbal intelligence, this time with school-aged and adult minimally verbal population. We set out to explore whether people with low levels of vocabulary do or do not have the phrasal meaning comprehension that is expected (from extrapolations from Typically Developing individuals) for people with such vocabulary scores. It is therefore important to investigate comprehension beyond individual words. In fact, Kambanaros et al. (2019) compare the interpretation of compound nouns such as 'mouse trap' in typically

developing and autistic children, to conclude that the latter exhibit more difficulties than the former. While this study also underscores the need to go beyond the interpretations of words in isolation, their sample is different from ours in that their participants have a higher verbal mental age (they are verbal but have 'language impairment').[1] In our study we investigate a basic comprehension ability in AMRV on the basis of a specific experimental study designed to address this issue.

The sample consists of eight adults from a local Day Care Center of Autistic Adults (ages ranging from 21 to 60) with intellectual disability (Non-verbal IQ scores from 30 to 64) and very scarce functional linguistic production (if any). In a previous testing phase, we saw that this group of adults has some receptive vocabulary, unlike 16 other adults from the same Day Care Center.[2] According to the receptive vocabulary test PPVT-III in Spanish (Dunn, Dunn & Arribas, 2006), their Verbal Mental Age (VMA) ranged from 1;2 (1 year, 2 months) to 3;10.

We considered this group particularly interesting for two reasons: first, as mentioned, people in this group were able to recognise some words in the PPVT test; second, while what we consider to be non-verbal people in the Day Care Centre were mostly at the sensation level in the ComFor test (ComFor-Forerunners in Communication, Noens et al., 2006), the participants in our study were, in many cases, at the presentation-to-representation, or even at the representational level in the ComFor, which indicates that they might be able to recognise that words name things in the world (i.e. they might understand the representational function of language: see Table 1 for the data, and Section 5 for discussion[3]). The group of people who were included in our study constitute half of the population in the non-verbal/minimally verbal group in the Day Care Center.

Going back to our first research question (remember: whether AMRVs have the ability to interpret complex phrases), the main motivation of our study is to gauge linguistic comprehension in this population. By means of tests of receptive vocabulary such as the PPVT-III, we can have an approximate idea of the range of vocabulary they master. However, there are no adequate standardised tests to explore linguistic comprehension as such in this population. Instruments such as CELF-5 (Wiig et al., 2013) are already way too demanding. Yet, families and caregivers are interested in knowing how much of what they say is understood. We were particularly interested in seeing whether people's linguistic abilities in our sample went beyond the word level. While there is not much literature about when in typical development children understand complex noun phrases (NPs) composed of a noun (N) and an adjective (A), at least following Lidz, Waxman & Freedman (2003), we can assume that already by 18 months of age, young children understand adjective modification

[1]Even if compound nouns and modified nouns involve different linguistic derivations, one could say they all involve linguistic composition abilities; in this sense their results are relevant to our research questions. Nevertheless, we would want to call into question the interpretation of the results they propose, namely, that these children would have problems at the conceptual-intentional system. Our study (see below) does not suggest that the problems our participants show in performing composition arise at the conceptual level.

[2]This phase was carried out as part of the work eventually published as Slušná et al. (2021). Not all participants in our study are part of Slušná's et al. sample, however. 4 of the 8 participants in the study became users of the Day Care Center at a later stage.

[3]The ComFor test is used to determine whether people are able to grasp what a representation is. It does so by testing whether people are able to pair together representations and what such representations represent. However, the test does not include word-object pairs (although it includes picture-object, and word-picture pairs). As a reviewer points out, results from Preissler (2008) suggest that matching words onto pictures is compatible with not grasping the referential nature of words. This is why we write that (some of) our participants *might* understand the representational function of language.

Table 1. Background information of adults in the Day Care Center that did NOT participate in our studies (IDs 17–9), compared to background information of those who participated (8–1). '-' flags that the test could not be administered, because of lag of pointing abilities.

ID	Chronical age	NVIQ (Leiter Scale)	VMA (PPVT-III)	ComFor
17	34	30	0	Sensation
16	24	30	_	Presentation
15	33	30	0;10	Presentation
14	41	53	0	Sensation
13	29	30	_	Sensation
12	32	30	_	Sensation
11	28	30	0	Presentation
10	25	30	0	Presentation
9	25	30	1;0	Presentation
8	21	50	3;0	Representation
7	33	30	2;5	Representation in development
6	34	53	2;6	Representation in development
5	60	43	1;8	Presentation
4	32	53	3;1	Representation
3	30	30	1;7	Representation in development
2	23	58	1;2	Representation in development
1	25	64	3;10	Representation

by colour adjectives, such as 'yellow bottle' in English. However, competence in adjective modification may actually arrive earlier in development: as Waxman and Booth (2001) show, by 16 months, children understand that adjectives pick out properties and not categories. Concerning size adjectives, which we also use as stimuli, Lidz et al. (2021) show that English-learning 30-month-olds understand size adjectives and can integrate them syntactically/semantically.

Experiment 1

Participants

As indicated above, participants were eight minimally-verbal adults. It is likely that the compositional capacity that we wanted to test appears early in development, but having the age of 18 months in mind, we selected people with at least 14 months of VMA according to the PPVT. Table 2 describes participants (8–1 above) according to chronological age, VMA, NVIQ and autism scores (Autism Diagnostic Observation Schedule, [ADOS], Lord et al., 2015). Note that one participant (n. 4) had an ADOS score way below the threshold. This person had been diagnosed as autistic long ago, which is the reason he was in the Day Care Center. However, he was still included in the study because we were more interested in

Table 2. Background information of the AMRVs.

ID	Chr.AGE	NVIQ (Leiter Scale)	VMA (PPVT-III)	ADOS Score (Threshold for autism: 16)
1	25	64	3;10	21
2	23	58	1;2	23
3	30	30	1;7	17
4	32	53	3;1	2
5	60	43	1;8	22
6	34	53	2;6	19
7	33	30	2;5	16
8	21	50	3;0	17

linguistic abilities in people with low receptive vocabularies than in the minimally verbal autistic profile as such. None of the participants were diagnosed with a comorbid condition besides intellectual disability, and they did not have any other disabilities (such as motoric, hearing, or seeing impairments). We lack information concerning their sensory profiles or sensorimotor abilities apart from their scores in the ADOS test concerning unusual sensory interests. All participants were occasional users of the Picture Exchange Communication System (PECs) while in the Daycare Center. Two months after we finished our first study some of them joined a pilot experience with an Augmentative and Alternative Communication (AAC) system that uses pictograms implemented on tablets (see Section 4). Communication at home was not based on any structured system. Expressive language in all cases is very low. A way to measure expressive vocabulary in the minimally verbal population is using the ADOS test (Joseph et al., 2019). In this regard, none of the participants uttered more than five words during the test; i.e. they were evaluated with Module 1, and the 'few or no words' scoring sheet.[4]

In this, as well in the other experiments, we obtained Ethical Approval from the University Ethics Committee, exp. n. M10/2019/205. Families of participants were adequately informed about the study, and signed an informed consent on behalf of the participants. As the study took place in a facility run by a local institution, we also obtained permission from this local institution.

Materials

Participants saw pictograms representing meanings of known words as per the PPVT-III test. Pictograms were selected from the ARASAAC database and displayed on a computer screen. Figure 1 shows an example of a screen that was presented to the participants.

Procedure

Given the steps involved in this first experiment, which we describe below, and the profile of our participants, one of the authors of this paper visited the Day Care Center regularly,

Figure 1. Screenshot of materials presented in Experiment 1.

[4]We did not use any other measure because our study concerns comprehension.

three days every week until lunch-time for one month. This way the researcher could become familiar with each participant, be almost identified as a regular team member of the Center, and cooperate with, and collect information from, caregivers. Caregivers themselves (a psychologist and two other therapists) suggested how to proceed in our study: i.e. when to test participants, for how long, how to detect the first signs of discomfort, how to proceed if discomfort increased, etc. Participants were invited to go to one of the rooms in the Day Care Center where they carry out activities with computers. Before starting the study, the participants had some familiarisation sessions with the researcher and one of the caregivers, where they would see pictures displayed on the computer screen, and a voice saying the names corresponding to such pictures. Once the caregivers evaluated that the participants felt comfortable enough in the room with the researcher and the activity, the researcher would call participants for ten-minute testing sessions. Caregivers would be in the room next to the testing room. At the minimal sign of discomfort, the researcher would cancel the activity, open the door, and call the caregivers. It was agreed with the director of the Center that participants could be offered pieces of biscuit every 3 min approximately so as to minimise restlessness. Before each testing session, the researcher would collect feedback from the caregivers about how participants were doing that morning. Some sessions had to be interrupted and resumed some other day.

The study itself was a phrase-picture matching task (1 critical item, 3 distractors), whereby the participant would listen to a female voice saying words and combinations thereof in Spanish (the language spoken by the participant's families and caregivers). The overall procedure consisted of seven consecutive phases of 16 trials each in [1], [3], [4], [5], [6], 24 for stage [2], and 32 for stage [7]): [1] Testing pointing, to ensure that participants could point at the relevant figures; [2] Testing colours, to see what colours they could recognise by name; [3] Testing objects, to see what pictograms of objects they could recognise by name; [4] Testing simple composition 1, to see if they could recognise N(oun) + Colour A(adjective) noun phrases (NPs), as shown in (1), on the face of 3 distractor items constructed out of the composition of other known Ns and As, as shown in (2);[5,6] [5] Testing sizes, to see if they knew the meaning of *pequeño* 'small' and *grande* 'big'; [6] Testing simple composition 2, to see if they understood N + Size A NPs, as shown in (3); and [7] Testing complex composition, to see if they could understand N + Colour A + Size A NPs, (4). We considered that participants succeeded in tasks [2], [3] and [5] if they pointed at the right pictogram in at least 2/3 of the 16 trials each task consisted of. Since we wanted to test if they understood N + A phrases, we wanted to be sure that they knew the words for the figures, the colours and the sizes *big* and *small*.

Figures of objects were selected on the basis of their performance on the PPVT-III: only brooms and drums were recognised by name by all participants. In phase [3], we tested whether such recognition was consistent. To ensure that the names of colours that we used were colours that they could recognise by name, we ran a colour recognition test [2] where they had to point at the colour named by a female voice within a display of four different colours. As said, there were 24 trials in this phase. On the basis of the results of this phase, we made individual designs for the Testing composition 1 phase [4] so that known objects

[5]In Spanish intersective adjectival modification of the sort tested in Experiment 1 the head noun precedes the adjective, so word order is Noun + Adjective.

[6]All nouns and adjectives bore singular marking, so no additional difficulties can be attributed to differences in number (singular vs. plural).

(drums and brooms) came in colours known to each person. That is, while one participant had to point at yellow or red brooms or drums, another participant had to choose between green and red brooms and drums. The rationale for this individualised approach was, as stated, that we were interested in gauging whether participants could compose words whose meanings they already knew.

(1) N + Colour Adjective

a. escoba {roja, verde}
broom red green
'{red, green} broom'
b. tambor {rojo, verde}
drum red green
'{red, green} drum'

(2) Example of picture matching task for escoba roja 'red broom'
(Critical item+3 distractor items)

(a) red broom
(b) green broom
(c) red drum
(d) green drum

(3) N + Size Adjective

a. escoba {pequeña, grande}
broom small big
b. tambor {pequeño, grande}
drum small big

(4) N + Colour Adjective + Size Adjective

a. escoba {roja, verde} {pequeña, grande}
broom red green small big
b. tambor {rojo, verde} {pequeño, grande}
drum red green small big

Results

One participant failed at preliminary stage [3], being inconsistent in his pointing at the target figures of objects, so only seven participated in [4] (simple composition 1). Regarding [6] (simple composition 2), only 3 participants succeeded in adequately pointing at representations of big and small objects, which means that 5 participants were excluded for stage [6]. In all, only participant 8 was above chance in simple composition 1, doing it at ceiling. Participant 1 pointed at the right figure and then at the right colour (in any other figure) sequentially, thus apparently failing to correctly interpret that 'N + Colour A' refers to a single entity. This participant, the one with the largest vocabulary breath according to the PPVT-III, also failed to correctly identify sizes in the Testing sizes task. In simple composition 2, participants 4 and 8 performed at ceiling, thus showing that one of them could not do generalised composition (since he failed in [4]). Participant 8 also succeeded in [7], complex composition. Table 3 presents the results of Experiment 1.

Table 3. Results of Experiment 1. '-' signals that the participant did not take the test because their previous result did not reach the established threshold.

ID	NVIQ	VMA	ADOS	[3] N/16	[4] N + Color A/16	[5] Size/16	[6] N + Size A/16	[7] N + A + A/32
1	64	3;10	21	16	0	10	-	-
2	58	1;2	23	15	7	12	5	-
3	30	1;7	17	9	-	-	-	-
4	53	3;1	2	15	7	16	15	-
5	43	1;8	22	14	8	10	-	-
6	53	2;6	19	16	7	10	-	-
7	30	2;5	16	16	3	9	-	-
8	50	3;0	17	16	16	16	16	31

Discussion

Our aim in this part of the study was to examine whether participants who understood nouns like 'red', 'big' and 'broom', also understood complex noun phrases composed of a head noun modified by an adjective, such as 'red broom', 'big broom' and 'big red broom'. While this is a qualitative small-sample study, an interesting observation that we put forth is that VMA in typically developing (TD) individuals and VMA in minimally verbal adults do not match in linguistic abilities.

Two cases are particularly remarkable.

Participant 1 had the highest NVIQ and VMA. Yet, this person was not tested on N + Size A because he was not consistent in pointing at small and big planes and small and big keys (which were the stimuli we used) when prompted to point at *big* and *small*. More strikingly, he did not succeed in the composition task N + Colour A because, as mentioned, he pointed first at a picture of the required object (broom or drum), irrespective of what colour it had, and then at a picture of an object with the required colour (yellow or red). That is, if the instruction was 'tambor rojo' ('red drum'), he could point at a yellow drum first, then move to pointing at the red broom. In principle, this suggests that he was unable to perform modification in this task, displaying an inflexible word-by-word understanding, with no lexical integration. Alternatively, it may be that he was unable to bind concepts of colours and concepts of objects in the task. That is, the observed behaviour can be due to some difficulty pertaining to language as such or to some more general cognitive difficulty concerning concept composition. As we explain below, the participant performed well in the concept composition task, which in principle excludes this second interpretation of the observed results. However, we have to be cautious about explaining this participant's performance in terms of lack of linguistic compositional abilities. His performance is also reminiscent of the 'kindergarten path effect' in typically developing children, who show a similar inflexibility when parsing sentences such as 'Put the frog on the napkin in the box'; when faced with a frog on a napkin and a frog not on a napkin, children sometimes move the frog that is not on a napkin onto the napkin, and subsequently into the box (see Trueswell et al., 1999). One explanation is that children are less capable of recovering from an incorrect initial parse than adults, and it is this inability to revise a parse that explains their divergent behaviour. In light of this, it could be that participant n. 1 did not have a problem with linguistic composition per se, but was rather committed to picking out a referent as soon as he heard a word, and was then unable to backtrack to the intended phrasal interpretation. If so, he would be hindered to do composition, but not because he lacks compositional abilities.

The second remarkable case is the performance of participant 4 (non-autistic). This participant performed consistently above chance in all subtasks, except in the N + Colour A subtask. That is, he could adequately point at different colours, and he could also adequately point at the right figures when instructions were about combinations of sizes and objects. However, he did not display the same kind of understanding when asked to point at, e.g. a red drum. In this case, we say that this participant was unable to do generalised first level composition in the task. For some reason, the operation he performed in the N + Size A task, was not available to him when the stimuli were colour terms instead of size terms.

In what follows, we compare these results with the results of our tests of concept and symbolic composition, to provide reason to tease apart linguistic and non-linguistic composition.

Experiment 2

The goal of this study was to collect data about the ability of AMRVs to comprehend **concept composition**. To test this ability, we build on the Leiter-3 scale of non-verbal intelligence, which includes a test of 'classification and analogy'. In this test, the participant is presented with a string of cards with printed geometric figures (e.g. a blue square, a green square). Then, the experimenter places a card with a blue triangle following up on the string, and the participant has to choose among a set of alternatives, which includes a card with a green triangle, the correct figure. We assume that this ability underlies the capacity to comprehend that blue square is composed of the blue colour and a square, which can then be composed otherwise, for instance, green colour and square, or blue colour and triangle. Such an ability is taken to be definitory of concept possession, since according to the widely endorsed 'generality constraint' (Evans, 1982), for an individual to have a concept *C*, the individual must be able to combine *C* in systematic ways. In our study, we aim at testing whether AMRVs are able to engage in such systematic concept combinations, in order to compare concept and linguistic composition. Indirectly, we also test whether these participants can rightly be said to have the concepts we use in the task.

A caveat is in order. The 'classification and analogy' subtest of the Leiter-3 involves two abilities: one is concept composition; the other one is analogical reasoning. This means that participants may be able to compose concepts (e.g. TRIANGLE and GREEN), but fail to grasp that the subtest requires that they select the green triangle. In turn, this means that we can assume that participants who perform well in the subtest can do concept composition: however, not performing well does not imply that participants cannot do concept composition. The reason we chose this inconclusive way of testing (inconclusive if the result was below chance) is that we deemed adequate to use a test that required deployment of conceptual representations. It is assumed that higher order cognition, such as analogical reasoning, recruits conceptual representations (Machery, 2009; Murphy, 2002). In contrast, a mere classificatory task, such as putting together the red squares with the red squares or the green circles with the green circles, might be solved perceptually.

The participants in this experiment were five individuals. All of them had also participated in Experiment 1 and were administered the test of comprehension of N + A, because they had been able to identify colour [2] and object [3]; in particular: 1, 2, 4, 6 and 8 in Table 2. The reason we had to limit the sample to 5 participants is that we could not count on the other three participants that had taken part in the first study when we administered

Experiments 2, due to the restricted COVID protocols in daycare centres, which made some families prefer that their relatives stayed home so as to minimise risks.

In our design, we created four different trials (1-2-3-4). In each trial, the experimenter presented a set of four cards with geometric figures. We discarded the use of geometric figures in the first experiment after observing that most participants not only did not recognise them by name, but also that most of them did not learn their names easily. However, our participants are used to employing geometrical figures in different intervention tasks in the Day Care Center. We thus assumed they could recognise them, although this kind of recognition is not enough to claim that they have the relevant concepts for geometrical figures. So this second experiment is unlike the first one in that there was no previous assurance that participants had the concepts they had to try to compose. The test is more of a conditional form: if they have concepts for geometrical figures and they have concepts for colours, will they be able to compose a colour concept and a geometrical figure concept?

We also discarded using the stimuli of the first experiment because the interesting combinatorics for the sequences involve four objects that can appear in four different colours; brooms and drums wouldn't have been enough. Finally, the experiment gives us information that the Leiter-3 test itself would not give us, first because more items are created, so that a higher number of trials can be used to avoid success by chance; second, because the dynamics of Leiter-3 sometimes involves going back and forth between 'easier' and 'complicated' displays, and third, that the task is the third one, after two tasks that may affect the participants' performance.

In trials 1 and 2, the first two figures have the same colour (green circle, green circle), and the third one is a different figure with the same colour (green square). In 3–4, the first two figures come in different colours (yellow triangle, blue triangle), and the third figure is different, but has the same colour as the first one (yellow diamond). In all situations, the participant has four cards with alternative figures to choose from, including, e.g. a green triangle and a red circle when the target is a green circle. Figure 2 below is an image showing an example of trial of the second type, and Figure 3 shows an example of an alternative set the participant can choose from in an example such as Figure 2.

The four trials are pseudorandomized to obtain 12 experimental trials in total, with orders (1-2-3-4, 2-3-4-1, and 3-4-1-2). Before starting the experiment, there is a training phase where the experimenter shows the participant what he is supposed to do with similar trials but fewer alternatives. In the training phase, the experimenter is allowed to give

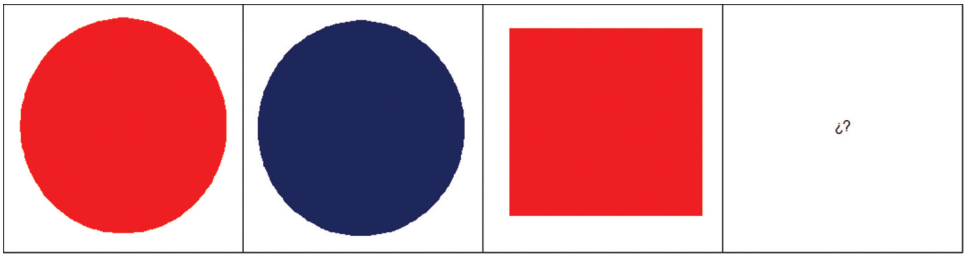

Figure 2. Example of trial in Experiment 2.

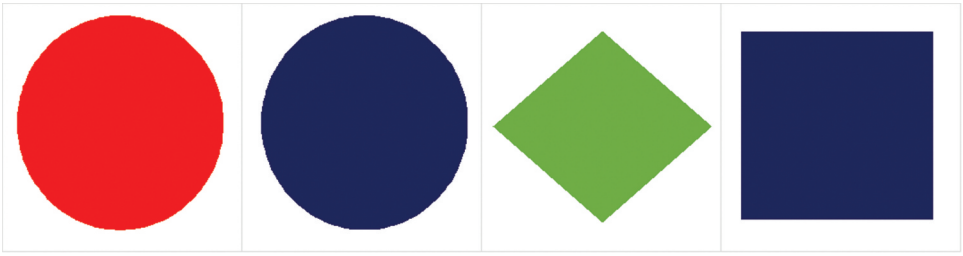

Figure 3. Set of alternatives participants can choose from to solve the trial presented in Figure 2.

feedback. Once the experimental trials start, the experimenter will not provide feedback. Also, following the instructions in the Leiter scale, verbal commands are disallowed. This way we ensure that the ability that is being tested is not facilitated by language.

The results are presented in Table 4.

Table 4. Results of Experiment 2.

ID	Successful trials	Percentage of success
1	8	67%
2	0	0%
4	1	8%
6	2	17%
8	7	58%

Discussion

Two of the five participants performed above chance in our extension of the 'classification and analogies' subtest of the Leiter-3, performing at ceiling in trials 1 and 2. While, as noted above, we cannot conclude that the people who performed below chance even in such trials cannot do concept composition, we can conclude that the two who performed above chance have concept combinatorial abilities; i.e. they are able to combine concept representations of figures with concept representations of colours in a systematic way. While the conclusions we can extract from this experiment are limited, at least we can see that one participant (participant 1) performed better in this task than in the linguistic task, suggesting some particular difficulty with language.

Experiment 3

In a third experiment, we wanted to test **symbolic composition**. We characterise symbolic composition as the analogue of linguistic composition when words are substituted with some other atomic representations, which can be non-linguistic gestures, pictures or some other iconic representations. Participants in our study were familiar with an Augmentative and Alternative Communication (AAC) system that uses pictograms implemented on tablets. Actually, they formed part of a pilot study designed to extend the use of tablets among the adult minimally verbal population. While we had already seen that they were able to, inter alia, request an animal of a certain colour by clicking first on the pictogram for

the animal and then on the pictogram for the colour, we wanted to test their comprehension abilities in order to have a proper comparison with their linguistic comprehension abilities. In the design, we relied on the participants' attested ability to map the pictograms of a set of animals as presented on a tablet and the corresponding toy animals (a pig, a duck, a cow, a sheep), which come in different colours (blue, yellow, red, green). We selected the stimuli that they were more familiar with. The experiment was carried out by the same person (a worker in the Day Care Center) who is teaching them how to communicate with the tablets.

The participants were the same as in Experiment 2.

The procedure was as follows: on a screen which contained several pictograms of animals and colour spots, the experimenter clicked on a particular pictogram of an animal and then on a colour spot. That move cleared the screen and maintained a pictogram of the selected animal and another pictogram for the colour. The participant saw this action and was prompted by the experimenter to hand in the toy animal in the corresponding colour, given a set of alternative toy animals which came in different colours. Figure 4 shows an example of a screenshot on the tablet that participants could see at the beginning of the trial.

Specifically, we designed 12 throws, combining animals and colours (e.g. red pig, green duck, blue sheep, yellow cow, etc.). In each trial, there were four alternatives: the target animal with the wrong colour, the wrong animal with the target colour, a distractor, and the right animal in the right colour. The experiment started with two training trials to convey the participants what was expected from them, and where the experimenter was allowed to provide feedback. Once the instructions were clear, the experimental trials began, and no verbal instructions were allowed.

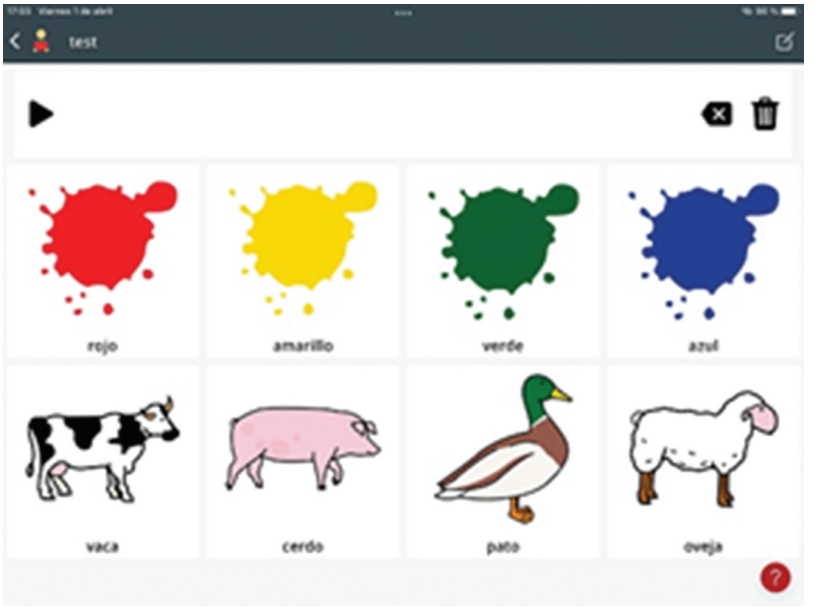

Figure 4. Screenshot of the tablet at the outset of Experiment 3.

The results are presented in Table 5.

Table 5. Results of Experiment 3.

ID	Successful trials	Percentage of success
1	12	100%
2	12	100%
4	12	100%
6	2	17%
8	12	100%

Discussion

Four of the five participants were able to hand in the requested object well above chance, including the two who did well in Experiment 2. Performing simple compositions of iconic representations does not seem to be problematic for these four participants, who, except one, nonetheless exhibited problems composing the analogue linguistic representations (i.e. words for objects and colours). Results from other studies already show that understanding individual photographs and pictures (mapping them to real objects) is easier than understanding individual words (Hartley & Allen, 2015). Our results show that the pattern extends to complex representations. Interestingly, one participant who was inconsistent in pointing particularly to colours in the first experiment, performed at ceiling in this task. Besides showing that AAC systems are indeed facilitators of communication also in adults, our results suggest that composition as such is available to several people with very low receptive vocabulary. However, our results do not tell us how such composition is performed. It is possible that composing concepts or composing iconic representations is different from composing linguistic units. Be it as it may, the operation participants performed to succeed in this task was not available to them when the instruction was linguistic. On the other hand, insofar as it is assumed that symbolic representations map onto concepts, the results of this task would show that four out of five participants could perform concept composition. That is, two participants who did not succeed in the previous task can in principle be regarded as not having difficulties composing concepts. As mentioned in fn. 1, this suggests that the problem does not arise at the conceptual level. Lastly, the results, though evidently limited by the number of participants, do suggest that some mental operations such as composition can be done in the absence of linguistic composition.

General discussion

Going back to our research questions, we wanted to find out whether AMRVs could comprehend phrases composed of vocabulary items they were familiar with. For this, we designed Experiment 1, which tested whether AMRVs who had a receptive vocabulary level that in typical development predicts the ability to comprehend two-word combinations, including a head noun modified by an adjective, did have such a linguistic compositional ability. Our results show that, except for one person, the rest of the people in our sample did not possess generalised linguistic compositional abilities. One of the participants in the sample could comprehend N + Size A, but not N + Colour A, despite understanding the words for the objects and the colours tested. The other participants who understood words seemed to understand them only individually, and not in more complex syntactic

structures. Our second research question inquired about the nature of the composition skills; in particular we wanted to find out whether being able to compose lexical items correlated with knowing how to compose concepts. We decided to compare the results in Exp 1 with performance on two other tasks: concept composition (Exp 2), and iconic symbolic composition (Exp 3). In the first case (Exp 2), the aim was to see whether the difficulties exhibited in Exp 1 were due to difficulties composing the meanings of the words, under the assumption that meanings of words are concepts. In general, the results were similar to the results of Exp 1, except that one of the participants who did not understand the complex 'N + Colour A' phrase, did perform well on concept composition, even when the task was in principle more demanding, as it included analogical reasoning. As mentioned, failure in this task is compatible with being able to compose concepts. In the second case (Exp 3), we saw that most participants performed well on symbolic composition, and did much better than on linguistic composition. This means that their difficulties in the word composition experiment do not relate to their having difficulties in mapping representations to their referents and then composing them. Rather, difficulties seem to relate to the particular symbolic vehicle, namely, the linguistic representational system. It is well known that iconic representations are easier to grasp than linguistic representations (Carter & Hartley, 2021; Hartley & Allen, 2015). However, studies that have compared performance on experiments testing iconic versus linguistic representations have done so at the level of atomic representations (e.g. photographs vs. words).

It is unclear whether the participants in our study are able to map individual words onto referents. Preissler (2008) suggests that success at mapping words onto pictures is compatible with not grasping that words represent objects in the world. Mapping words onto pictures may bebased on associations. As mentioned in Section 2, while according to the ComFor test, several participants in our studies do grasp the representational function of some symbols, we cannot know if they also grasp the representational function of words of a natural language. Therefore, it might be that the different behaviour displayed in Exp 1 and in Exp 3 is due to the nature of the atomic representations themselves: words, which participants do not fully master; and pictograms, whose function participants do understand. This is an explanation that we cannot discard with the data that we have collected, although anecdotal evidence suggests that at least some of the participants map words onto things in the world (e.g. participant 1 can lay the table according to the name of the dish they are going to eat). Still, it is interesting to see that the ability to map individual words onto pictures does not carry over to mapping more complex phrases onto their corresponding pictorial representations.

The other explanation of the difference between the results of Exp 1 and the results of Exp 3 is that the difficulties we have discovered are specific to minimally complex linguistic expressions. Our data may suggest that such difficulties may relate to linguistic rules of composition (i.e. the ability to comprehend phrases that are more complex than just a head), rather than to the nature of linguistic representations themselves (i.e. to their non-iconic character). Still, it remains unclear why four people in our sample were able to compose the meaning of iconic representations, but only one of them was able to compose meanings of words. Apparently, they could infer that a pictogram of an animal followed by a pictogram of a colour refers to a certain coloured object. It is surprising that they could not perform such an inference in the case of words. Likewise, while one could think that the problem about linguistic composition might lie in forming a meaning out of two words that come in a temporal sequence, such a hypothesis would have trouble explaining how

participants performed well in symbolic composition, where there is more delay between tokening the first symbol and tokening the second.

Although it is of course impossible to draw general conclusions from such a small sample, our results suggest, as a working hypothesis, that AMRVs may experience difficulties at the level of phrasal understanding that do not correspond to their receptive vocabulary measures, at least as expected from what we know from typical development.

Our results also suggest that AACs are indeed communication facilitators, not only at the level of breadth of atomic representations, but also at the level of representational complexity. Finally, all the participants but one have an autism diagnosis. From what we have seen, the results seem to relate more to their linguistic condition than to the autistic condition *per se*. While most AMRVs are also autistic, and have low vocabularies probably because of their autistic condition, we suggest that perhaps people with this profile in general exhibit similar difficulties in understanding phrases consisting of more than just a head (in our case, a head noun and an adjectival modifier). More research is obviously needed, but we think we provide the basis to begin answering an important question that families and caregivers always bring up, namely: 'how much of what I'm saying does my child/sibling understand?'. We think we can at least say that one should not make any conclusions based onreceptive vocabulary measures.

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