16 The effects of modality on BSL development in an exceptional learner

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16.1 Introduction

This chapter reports on the findings of an experiment into the learning of British Sign Language (BSL) in Christopher, the Linguistic savant, and a control group of talented second language learners. The results from tests of comprehension and production of morphology and syntax, together with observations of his conversational abilities and judgments of grammaticality, indicate that despite his dyspraxia and visuo-spatial impairments, Christopher approaches the task of learning BSL in a way largely comparable to that in which he has learned spoken languages. However, his learning of BSL is not uniformly successful. Although Christopher approaches BSL as linguistic input, rather than purely visuo-spatial information, he fails to learn completely those parts of BSL for which an intact nonlinguistic visuo-spatial domain is required (e.g. the BSL classifier system). The unevenness of his learning supports the view that only some parts of language are modality-free.

Accordingly, this case illuminates crossmodality issues, in particular, the relationship of sign language structures and visuo-spatial skills. By exploring features of Christopher's signing and comparing it to normal sign learners, new insights can be gained into linguistic structures on the one hand and the cognitive pre-requisites for the processing of signed language on the other.

In earlier work (see Smith and Tsimpli 1995 and references therein; also Tsimpli and Smith 1995; 1998; Smith 1996; Smith and Tsimpli 1996; 1997; Morgan, Smith, Tsimpli, and Woll 2002), we have documented the unique language learning abilities of a polyglot savant Christopher (date of birth: January, 6 1962). Christopher exhibits a striking dissociation between his linguistic and nonlinguistic abilities. Despite living in sheltered accommodation because his limited cognitive abilities make him unable to look after himself, Christopher can read, write, translate, and speak (with varying degrees of fluency) some 20 to 25 languages. This linguistic ability is in sharp contrast with his general intellectual and physical impairments. Due to a limb apraxia (a motor disorder which makes the articulation of planned movements of the arms and hands difficult or impossible), he has difficulty with everyday activities such as shaving,

doing up buttons, cutting his fingernails, or hanging cups on hooks. Apraxia is tied to damage to cortical regions that send input to the primary motor cortex (Kimura 1993).

Additionally, Christopher has a visuo-spatial deficit, which makes finding his way around difficult. Although Christopher is quite shortsighted and (probably) astigmatic, his prowess at comprehension of BSL fingerspelling shows that this condition has minimal affect on his ability to understand sign. Fingerspelling is made up of small, rapid movements of the fingers and hands, in a relatively restricted space. Christopher was almost perfect in his recognition of fingerspelled names produced at normal signing speed, indicating that he should be able to see the details of normal signing without difficulty. Lastly, Christopher presents some of the key features of social communication deficit associated with autism: he avoids engagement with his interlocutor, preferring instead to use single words or prepared sentences, avoids eye contact and often understands only the "literal" meaning of a conversational exchange (Smith and Tsimpli 1995; Tsimpli and Smith 1998). In this chapter we deal specifically with the linguistic aspects of Christopher's learning of BSL while making note of the influence of his limb apraxia and autism. We explore in more detail the role of apraxia and autism in his learning of BSL in Morgan Smith Tsimpli and Woll (in preparation a).

Apart from the dissociation between his "verbal" and "performance" abilities, Christopher also shows marked dissociations within his linguistic talent. His acquisition of the morphology and lexicon of new languages is extremely rapid and proficient, whereas his acquisition of syntactic patterns different from his first language appears to reach a plateau beyond which he is unable to proceed. Smith and Tsimpli (1995) have argued that this asymmetry reflects the distinction between those aspects of language acquisition which involve parameter setting and those which are dependent on either nonparametrized parts of Universal Grammar (UG) or on the central system(s). In a Fodorian framework (see Fodor 1983), human cognition is divided among a number of modular input systems, corresponding to the senses and language, and the nonmodular central system, responsible for rational behavior, puzzle-solving and the "fixation of belief." Whereas Fodor himself is sceptical about the possibility of any scientific investigation of the central system, we have argued (Tsimpli and Smith 1998) that it too is structured, consisting of a number of "quasi-modules," for theory of mind, music, moral judgment, etc. The language faculty has both modular and quasi-modular properties. Parameter re-setting is taken to be impossible (see also Tsimpli and Smith 1991), but the role of UG in second language acquisition is otherwise pervasive.

The dissociations already documented suggest that BSL should provide an interesting test arena for Christopher: will his linguistic prowess compensate for his visuo-motor deficits in the contexts of a signed language, or will these

disabilities preclude his acquisition of BSL? Assuming that he displays some ability to learn BSL, will his mastery of the language show the same linguistic asymmetries as are seen in his spoken languages?

16.2 The challenge for Christopher

The most obvious difference between BSL and the other languages Christopher has encountered is the modality in which it is produced. Signs are articulated through co-ordinated limb, torso, head, and facial movements in complex spatial arrays and, as communication is necessarily face to face, looking at the interlocutor while he or she is signing is the only means of access to linguistic information. In both production and perception, signers have to make use of configurations of movements and spatial information, and they have to be aware of their interlocutor's visual attention.

As we shall see, basic perceptual and articulatory processes, as well as higher-order ones (morphological, syntactic, and semantic and even paralinguistic), are integrated in the performance of normal signers of BSL, in that all of them involve the necessity of looking at the face and movements of the interlocutor to receive linguistic information (for a comparable description of American Sign Language, see Neidle *et al.* 2000). Accordingly, BSL provides Christopher with a new challenge, as it combines several aspects of behavior with which he has severe problems in the nonlinguistic domain with these behaviors now recruited for linguistic and communicative functions.

A less obvious, but crucial, consideration is that learners of BSL (or any signed language) are faced with the fact that it has no commonly used written script. Except for his native first language, English, all of Christopher's previous languages have been taught and acquired, at least in part, on the basis of a written input, using books, newspapers, and grammars. Even in English, the written word constitutes a major part of the input to him, and it is clear that he is obsessed with the written word, sometimes to the exclusion of spoken language. This lack of a written system constituted a major hurdle for Christopher to clear, before he could get properly to grips with the intricacies of the new grammar.[1]

Against this background we made the following predictions. It is clear that BSL combines properties that should make it simultaneously both congenial and uncongenial for him. On the one hand, it exemplifies the domain of Christopher's obsessional talent: it is a natural language with all the usual properties of natural languages. On the other hand, it exploits the visuo-spatial medium which causes Christopher such difficulty in performing everyday tasks. On the basis of the

[1] We have more recently attempted to teach BSL to Christopher through the Sutton Sign-Writing system (see Gangel-Vasquez 1997). Up to the writing of this paper he has looked favorably at this method of recording signs, but has found it difficult to reproduce the necessary spatial organization of symbols. We are continuing in this endeavor.

past work looking at Christopher, we expected that his linguistic talent would outweigh the disadvantages of the medium, and that his ability in BSL would mirror his mixed abilities in spoken languages: that is, he would make extremely rapid initial progress, his mastery of the morphology and vocabulary would be excellent, and that he would have significant difficulty with those syntactic properties that differentiate BSL from spoken English.

As well as teaching BSL to Christopher we also taught BSL to a comparator group of 40 talented second language learners, of volunteer undergraduate students at UCL and City University, London. Their ages ranged between 18 and 30 years and there were 30 females and 10 males. They were assessed as having a level of fluency in a second language (learnt after 11 years of age) sufficient to begin a first year degree course at University in one of French, Spanish, or German. The group was taught the same BSL curriculum as Christopher using the same teaching methods. We do not discuss this comparison in depth here (for more details, see Morgan, Smith, Tsimpli and Woll 2002) but occasionally refer to test scores as a guide to the degree to which Christopher can be regarded as a normal sign learner.

16.3 Christopher's psycholinguistic profile

Christopher scores relatively low on measures of nonverbal (performance) intelligence, as opposed to measures of verbal intelligence. This is indicated explicitly in Table 16.1, where the different figures show his performance on different occasions (the average normal score is in each case 100). There is no consensus on what exactly these tests of nonverbal intelligence actually tap,

Table 16.1 *Christopher's performance in five nonverbal (performance) intelligence tests*

Test	Score (average normal score: 100)
Raven's matrices (administered at ages 14 and 32)	75 76
Wechsler Scale: WISC-R, UK (administered at age 13.8)	42 (performance) 89 (verbal)
Wechsler Adult Intelligence Scale (administered at age 27.2)	52 (performance) 98 (verbal)
Columbia Greystone Mental Maturity Scale (administered at age 29.2)	56
Goodenough *Draw a Man Test* (administered at ages 14 and 32)	40 63

Source: Morgan *et al.* 2002

Table 16.2 *Christopher's performance in two face recognition tests*

Test	Score
Benton Facial Recognition test (administered at age 33)	Corrected Long Form Score: 27
Warrington face/word recognition test (administered at age 34)	Faces: 27/50; Words: 48/50

but common skills across these tests involve: the ability to visualize how abstract spatial patterns change from different perspectives, to co-ordinate spatial locations in topographic maps, and to hold these abstract spatial patterns in nonverbal short-term memory.

Unlike for instance, individuals with Williams syndrome, Christopher is extremely poor at face recognition, as shown by the results in Table 16.2. On the Benton test (Benton *et al.* 1983), a normal score would be between 41 and 54, and anything below 37 is "severely impaired." On the Warrington (1984) face/word recognition test, he scored at the 75th percentile, with 48 out of 50 correct responses on words, but on faces his performance was too poor to be evaluated in comparison with any of the established norms.

The preference for the "verbal" manifest in these data is reinforced by two other sets of results. First, in a multilingual version of the Peabody Picture Vocabulary Test, administered at age 28 (O'Connor and Hermelin 1991), Christopher scored as shown in (1).

(1) English 121; German 114; French 110; Spanish 89

Second, in a variant of the Gollin figures test (Smith and Tsimpli 1995:8–12) he was strikingly better at identifying words than objects. In this test, the subject is presented with approximations to different kinds of representation: either words or objects. The stimuli were presented in the form of a computer print-out over about 20 stages. At the first stage there was minimal information (approximately 6 percent), rendering the stimulus essentially unrecognizable. Succeeding stimuli increased the amount of information monotonically until, at the final stage, the representation was complete. The test was administered to Christopher and 15 controls. Christopher was by far the worst on object recognition, but second best on word recognition. (for details, see Smith and Tsimpli 1995:Appendix 1).

While no formal diagnosis has been made clinically, it is reasonably clear that Christopher is on the autistic continuum: he fails some, but not all, false-belief tasks, and he has some of the characteristic social manifestations of autism. He typically avoids eye contact, fails to initiate conversational exchanges, and

is generally monosyllabic in spontaneous conversation. (For discussion, see Smith and Tsimpli 1995, and especially Tsimpli and Smith 1998.)

16.4 Apraxia

On the basis of two initial apraxia batteries (Kimura 1982) and an adaptation of the Boston Diagnostic Apraxia Examination (Goodglass and Kaplan 1983) it appears that Christopher has a severe apraxia involving the production of planned movements of the limbs when copying nonrepresentational movements. He scored 29 percent correct on the Kimura 3-movement copying test, where anything below 70 percent is considered apraxic.

This limb apraxia contrasts with his normal performance in the comprehension and production of meaningful gestures. A version of the BDAE designed for signing subjects (described in Poizner *et al.* 1987) was carried out during the second period of Christopher's exposure to BSL (after four formal classes), and he correctly produced 12 of 13 test items: that is, he is within normal limits for controls (as reported in Poizner *et al.* 1987:168). When requested to demonstrate a sneeze, or how to wave 'goodbye,' or how to cut meat, Christopher responded without difficulty, although some of his responses were somewhat strange. For example, he indicated 'attracting a dog' by beckoning with his finger; for 'starting a car' and 'cleaning out a dish' he used the BSL signs for CAR and COOK, instead of imitating the turning of an ignition key or the wiping of an imaginary vessel with an imaginary cloth. Christopher produced more conventional gestures for these items when told not to sign. Apart from this interference, the only test item Christopher failed outright was 'move your eyes up.' As well as producing simple gestures he has normal comprehension of these gestures when produced by another person.

16.5 BSL learning

16.5.1 Input

A deaf native signing BSL tutor taught Christopher a conventional BSL class once a month, concentrating on the core grammatical properties of the language: the lexicon, negation, verb agreement, questions, topicalization, as well as aspectual morphology, classifier constructions, nonmanual modifiers, and spatial location setting. Over eight months there were about 12 hours of formal teaching. This formal teaching was supplemented by conversation with a deaf native signer, who went over the same material in a less pedagogic context between classes. The total amount of BSL contact was therefore 24 hours. All classes and conversation classes were filmed on video tape.

The 24 hours of BSL exposure were divided for the purposes of analysis into five periods: four of 5 hours each and a fifth of 4 hours. Each period was approximately 6–7 weeks in duration. After each subject area of BSL had been taught we assessed Christopher's progress before increasing the complexity of the material he was exposed to.

Christopher's uptake of BSL was assessed in each area, using translation tasks from BSL to English and from English to BSL, as well as analysis of spontaneous and elicited use of sign. In addition, we carried out a variety of tests of Christopher's general cognitive abilities. This battery of assessment and observational data are used to describe the development of his communicative behavior, on the one hand, and his acquisition of linguistic knowledge, on the other.

16.6 Results of Christopher's learning of BSL[2]

At the beginning of the learning period, Christopher reported that he knew some signing. When questioned further, this turned out to be letters from the manual alphabet, which he claimed to have learnt from deaf people. On his first exposure to BSL in the study, Christopher already manifested a number of behaviors in his production and reception of signs, which mark him out as an atypical learner. The most striking of these were his imitation of signs without understanding them and avoidance of direct eye contact with the signers around him. This sign imitation reduced over the learning period but did not disappear. As mentioned above, Christopher's conversation in spoken languages tends to be brief, indeed monosyllabic, and somewhat inconsequential, but there is rarely if ever any imitation of meaningless spoken or oral gesture. Nor does Christopher manifest echopraxia of speech.

In the first hours of exposure to BSL an interesting anomaly appeared. Christopher was very keen to communicate with the BSL tutor through spontaneously produced non-BSL gestures to describe objects and concepts presented to him in spoken English. For example, in attempting to represent the word 'live' (dwell) he tried to trace the outline of a large house. For the word 'speak' he touched his own teeth. His spontaneous attempt to mime or gesture is surprising,

[2] Signed sentences that appear in the text follow standard notation conventions. Signs are represented by upper-case English glosses. Where more than one English word is needed to gloss a sign, this is indicated through hyphens e.g. FALL-FROM-HEIGHT 'the person fell all the way down.' When the verb is inflected for person agreement, subject and indirect object are marked with subscripted numbers indicating person e.g. $_3$EXPLAIN$_2$ 'he explains it to you.' Lower-case hyphenated glosses indicate a fingerspelled word e.g. g-a-r-y. Repetition of signs is marked by '+,' and 'IX' is a pointing sign. Subscripted letters indicate locations in sign space. Nonmanual markers such as headshakes (hs) or brow-raised (br), and topics (t) are indicated by a horizontal line across the affected segment(s). When specific handshapes are referred to we use standard Stokoe notation e.g. '5 hand' or 'bent V.'

as it contrasts markedly with the absence of gestural behavior when he speaks. It also contrasts with his later difficulty in inference-making when learning iconic signs (see below).

16.6.1 Lexical development

Christopher made significant progress in his comprehension and production of signs throughout the investigation. Unlike subjects with psychological profiles comparable to Christopher's (e.g. the autistic signer, Judith M., reported in Poizner *et al.* 1987), Christopher showed no preference for particular classes of lexical items. Like Judith M., however, Christopher used 'fillers' or nonsense articulations, consisting of openings and closings of the hands, in his first period of exposure to sign.

As well as comprehension and production tests, we carried out sign-recall tests to enable the evaluation of Christopher's memory for new signs. His sign tutor showed him vocabulary items along with corresponding pictures or written words. The following week, he was asked to recall the signs by pointing correctly to the corresponding picture, and he was generally successful. Christopher's comprehension of signs in connected discourse, however, was less successful. Compared to the comparator group, Christopher was as good at recalling single signs as several other subjects, but performed significantly worse than the other learners in his general comprehension of signed sentences. This single sign comprehension ability was quite striking, especially in comparison with his general disability in producing the fine details of signs. In contrast with his relatively intelligible gross gestures (e.g. holding his palm out to produce the sign for FIVE, or moving his arms apart in a horizontal arc with the palms faced down to produce the sign TABLE), his articulation of small movements of the hands and wrists was impaired, presumably due to his limb apraxia. Across the learning period his developing ability to recognize and produce single signs was matched by a significant increase in the internal complexity of the signs he could use, where this complexity is defined in terms of the formational properties of the signs concerned. For example, gross handshapes became finer (e.g. distinctions appeared between the signs for the numbers ONE, THREE, and FIVE), and movements became more constrained (initially his sign for BOOK was produced with open arms, seemingly producing a newspaper sized book, but subsequently this sign became smaller with his greater distalization of movement).

Across the learning period, idiosyncrasies in his signs became more intelligible (e.g. his sign for WOMAN was produced by moving the index finger down his contralateral cheek, rather than on the ipsilateral side). These movement difficulties were of a greater degree than the articulation difficulties experienced by normal sign learners in hand co-ordination. Part of Christopher's difficulties

may be attributable to the difficulty he experiences in integrating linguistic and encyclopaedic knowledge. In learning new vocabulary, it may help if there is a potential inferential link between a sign and its meaning, where this link could be based on some visual property, such as the size and shape of an object, or a gestural/facial expression linked to an emotion or activity. Such linking, however, would require access to intact world knowledge, and presuppose some dependence on iconicity.

In order to test whether iconicity might be a significant determinant of Christopher's ability to master signs, we tested his identification of iconic vs. semi-iconic and non-iconic signs. During the second period of exposure to BSL Christopher and the comparator subjects were presented with 30 signs, repeated once, and asked to write an equivalent in English. The signs had been rated in previous research as "iconic" (transparent), "semi-iconic" (translucent), and "non-iconic" (opaque). None of the signs had been used in previous sign classes. Although their overall performance as shown in Table 16.3, is comparable, Christopher's incorrect responses to the iconic and semi-iconic signs were markedly different to those of the normal learners.

Some non-iconic signs were translated by Christopher as nonsymbolic equivalents. For example, he translated SISTER (made by a curved index finger touching the bridge of the nose) as 'rub your nose'; and he translated the semi-iconic sign MIRROR (made by an open hand twisted quickly with the palm facing the face) as 'wave your hand.' It seems then that Christopher was in some sense tied to a nonsymbolic interpretation when confronted by abstract form–meaning relations (for a discussion of his interpretation of pretend play, see Smith and Tsimpli 1996). This had subsequent effects in his late learning of more complex sign constructions. Confronted with a considerable amount of iconicity in BSL, adult learners of BSL and other signed languages characteristically use visual inference in their learning of sign vocabulary (see Pizzuto and Volterra 2000), but Christopher, in comparison, seems not to.

Table 16.3 *Test of identification of iconic vs. semi-iconic and non-iconic signs*

	Christopher	Comparator group (mean score)
Iconic	5/10	8/10
Semi-iconic	2/10	0/10
Non-iconic	0/10	0/10
Mean (as a percentage)	23.3	26.7

16.6.2 Morphosyntax

16.6.2.1 Negation. There are four main markers of negation in BSL:

- facial action;
- head movement;
- manual negation signs; and
- signs with negation incorporated in them (Sutton-Spence and Woll 1999).

Each marker can occur in conjunction with the others, and facial action can vary in intensity. Christopher identified the use of headshakes early on in his exposure to BSL, but he had extreme difficulty in producing a headshake in combination with a sign. In the Period 1 of exposure Christopher separated the two components out and often produced a headshake at the end of the sign utterance. In fact, as was ascertained in the apraxia tests, Christopher has major difficulty in producing a headshake at all. A typical early example of his use of negation is given in (2) and (3).

		t	br
(2)	Target:	NIGHT SIGN	CAN YOU
		'Can you sign in the dark?'	
			hs
(3)	Christopher:	NIGHT SIGN ME	
		'I sign in the dark no'	

Christopher became increasingly more able to produce a headshake while using a manual sign, but we observed in Period 3 that he often used a sequential marker of negation when signing spontaneously. Rather than shaking his head at the same time as the negated sign, the headshake was mostly produced at the end of the sentence after the manual components. Occasionally Christopher was observed to use the marker between the subject and the verb:

		hs	
(4)	Christopher:	ME	LIKE
		'I do not like'	

These patterns can also be argued to represent a re-analysis of the negation sign into a linguistic category which is not BSL-like, but is part of UG. If Christopher has assigned the negation morpheme morphological status, he would tend to use a sequential rather than a concurrent representation. In experimental tests of his understanding of negation, Christopher performed at a level comparable with that of the other learners of BSL as shown in the first two columns of Figure 16.1. The figure shows the results of six tests of BSL comprehension. Negation 1 and Agreement 1 are tests of signed sentence comprehension through Sign to English sentence matching, while Negation 2 and Agreement 2 are tests of grammaticality judgment. Classifier 1 is a signed sentence to picture match

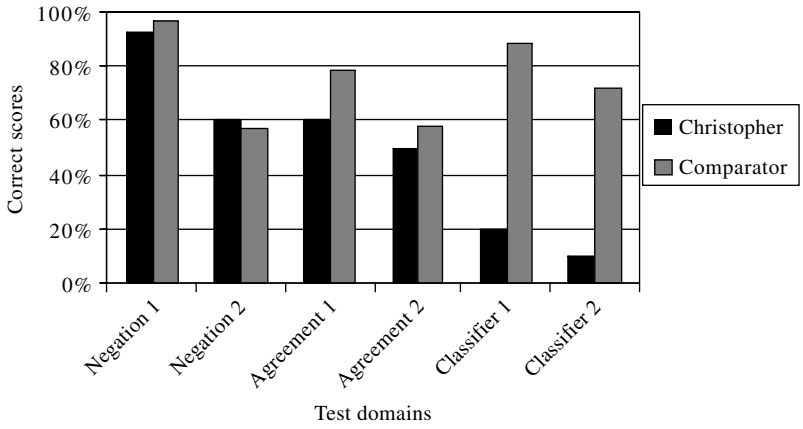

Figure 16.1 Assessments of comprehension across BSL grammar tests: Christopher and mean comparator scores

test and Classifier 2 is a signed sentence to written English sentence match. Comparator group scores are also included.

In the test of comprehension of the headshake marker (Negation 1), Christopher scored 93 percent correct (chance = 50 percent). The comparator group scored between 86 percent and 100 percent, mean = 97 percent, SD = 4.8 percent. These scores were significantly above chance for both groups. There was no statistical difference between Christopher and the comparator group's scores.

A grammaticality judgment test of comprehension of negation through morphological incorporation (Negation 2) was also carried out. BSL, like ASL, has a set of verbs that can be negated through a regular morphological modification (Sutton-Spence and Woll 1999; Neidle, Kegl, MacLaughlin, Bahan, and Lee 2000). Signs with stative meaning such as WANT, HAVE, KNOW, and BELIEVE can be negated through movement and opening of the hand away from the body, while the location of the sign stays the same. In order to recognize the ungrammatical element, subjects had to identify a sign that does not take incorporated negation (e.g. EAT) in a short signed sentence. The ungrammatical signs were produced with the regular morphological modification of negation. On this test Christopher scored 60 percent correct (chance 50 percent), the comparator group between 30 percent and 80 percent, mean = 57 percent, SD = 15.3 percent. There was no statistical difference between Christopher and the comparator group's scores.

The overall use of negation across the exposure period in Christopher's spontaneous signing is summarized in Table 16.4. Across the five learning periods

Table 16.4 *Use of negation markers across learning period: Types, tokens, and ungrammatical use*

Negation	Period 1	Period 2	Period 3	Period 4	Period 5
Types of negation	4	4	2	4	3
Total tokens	13	29	6	57	28
Percentage ungrammatical (occurrences)	7.7 (1)	24 (7)	50 (3)	1.7 (1)	7 (2)

Christopher displayed productive knowledge of the negation system in BSL, producing many more grammatical than ungrammatical tokens, with several different types of negation markers.

16.6.2.2 Verb agreement morphology. There are three basic classes of verbs in BSL:

- plain verbs, which can be modified to show manner, aspect, and the class of direct object;
- agreement verbs, which can be modified to show manner, aspect, person, number, and class of direct object; and
- spatial verbs, which can be modified to show manner, aspect, and location (Sutton-Spence and Woll 1999).

Here we concentrate on Christopher's mastery of the rules of verb agreement morphology. Verbs such as ASK, GIVE, TELL, TELEPHONE, and TEASE in BSL can include morphosyntactic information either through movement between indexed locations in sign space or between the signer and shifted reference points in the context of role shift. In Figure 16.2 the signer moves the sign ASK between a location on her right, previously indexed for the NP 'a man,' toward a location on her left, previously indexed for the NP 'a woman'

Figure 16.2 '(He) asks (her)'

Figure 16.3 'I like (her)'

(the signer is left handed). Moving a plain verb between indexed locations is ungrammatical, as in Figure 16.3 where the signer moves the sign LIKE toward a location previously indexed for the NP 'a woman.'

Verb agreement morphology in BSL is fairly restricted, being used only with transitive verbs that express an event. When Christopher first observed signers using indexed locations he seemed to treat this as deictic reference. He looked in the direction of the point for something that the point had referred to. He did not use indexing or spatial locations himself; whenever possible, he used a real world location. In the Period 1 he used uninflected verb forms when copying sentences.

(5) Target: g-a-r-y $_3$EXPLAIN$_2$ YOU
(verb inflection moves from third person to second person)
'Gary explains to you'

(6) Christopher: g-a-r-y EXPLAIN YOU
(no verb inflection; the sign is the citation form)
'Gary explain you'

When he first used agreement verbs he had persistent problems in reversing the direction of the verb's movement to preserve the meaning, copying the real world trajectory of the verb. Thus, when asked to repeat the sentence:

(7) $_1$TELEPHONE$_2$ 'I telephone you'

Christopher at first moved the verb inflection in the same direction as he had just seen it move, i.e. toward himself. His repetition therefore looked like:

(8) $_2$TELEPHONE$_1$ 'you telephone me'.

These reversal errors have been described in 3–5 year old children acquiring signed language (e.g. Petitto 1987). In contrast, errors in copying the direction of

verb agreement were minimal in the comparator group. Christopher's difficulty was largely resolved by Period 5 although there were still occasional examples of the error in his spontaneous productions.

By the Period 5 (after eight months of exposure), Christopher spontaneously produced correct simple directional affixes on verbs for present referents, indicating that he could reverse the direction of verb movements to preserve meanings.

		_____brow raise	
(9)	Target:	$_2$HELP$_1$	'Will you help me?'
(10)	Christopher:	$_1$HELP$_2$	'Yes I'll help you.'

However, throughout the learning period, he was unable to use sign space to set up stable spatial locations for nonpresent subjects and objects. Instead, he used the real location of persons and objects present, and avoided any use of sign space to assign syntactic locations for nonpresent referents.

When real world referents were used as locations for the start or end points of verb signs, Christopher managed to produce some inflections e.g. the third to second person location, indicating that in his production he was at least aware of the distinction between a plain verb and one inflected to agree with a location at the side of sign space. Although in Christopher's spontaneous signing there were very few examples of verb agreement for nonpresent referents, he did display a level of comprehension comparable to that of the comparator group.

In the tests of comprehension of verb agreement, Christopher scored 60 percent correct (chance was 50 percent) in the simpler of the two tests (Agreement 1), while the comparator group scores were between 60 percent and 100 percent, mean = 79 percent, SD = 13.3 percent. Neither Christopher nor the comparator group's scores were significantly above chance. In the more complex grammaticality judgment test (Agreement 2), he answered by alternating between grammatical and ungrammatical replies, indicating that he did not understand the task. He scored at chance (50 percent) while the comparator group scored between 40 percent and 100 percent, mean = 58.3 percent, SD = 16.6 percent. Again both sets of scores were not significantly above chance.

In a separate translation test he failed to translate any of six BSL sentences using person agreement morphology into English. The errors were characteristic of his translations as reported for spoken language (Smith and Tsimpli 1995) when trying to deal with a task involving high cognitive load (online consecutive translation). He characteristically made errors based on phonological similarity; e.g. in one sentence he substituted the verb ASK with the sign TEA (beverage) as the signs share place of articulation and handshape.

Overall Christopher's errors in using verb agreement arise either from omitting agreement (using a citation form of the verb plus pointing to the subject

and object), or by articulating the verb inflection in the wrong direction. These are typical developmental errors in young children exposed to signed language from infancy (e.g. Bellugi *et al.* 1990).

16.6.2.3 Classifiers.[3] Christopher was able to copy correctly some classifiers from his tutors' examples, but because he also produced many errors with classifiers it was not clear if this correct usage was productive or unanalyzed. For example, when copying the sentence in (11) Christopher used the same handshape (5 hand) with both hands rather than using one hand to sign a tall flat object (with a flat palm) and on the other hand signing a jumping person (with a bent V).

(11) Target: BOY CL-BENT-V-PERSON-JUMP-OVER-CL-B-WALL pursed lips
'the boy just managed to clear the surface of the high wall'

Christopher signed only the general movement of the sentence by crossing his hands in space, nor did he sign the 'effortful' manner of the jump, through facial action.

(12) Christopher: BOY hands-cross-in-space[4]

This difficulty may be a result of his apraxia. However, he did not attempt to substitute the marked bent V handshape with another, easier-to-produce handshape to distinguish between the wall and the person. This error indicates that Christopher was not using the classifier as a polymorphemic sign, and that his correct copies were unanalyzed whole forms. Even after substantial exposure to classifiers, Christopher preferred in his spontaneous signing to act out some verbs like WALK, SIT, and JUMP rather than to exploit a classifier: e.g. CL-BENT-V-PERSON-WALK.

Although Christopher found classifiers difficult in his own signing, he appeared to show some understanding of their use. He was occasionally able to pick out pictures for sentences signed to him such as 'a person falling,' 'a person walking,' and 'a small animal jumping.' In order to quantify this we carried out two tests of Christopher and the comparator group. The first test (Classifier 1) required subjects to watch 10 signed sentences involving a classifier and then choose one of three written English sentences. For example in one item the BSL target was 'a line of telephones' produced with a Y handshape articulated several times in a straight line in sign space. The choices were:

[3] This part of the research is the subject of a separate paper detailing the spatial aspects of BSL and the role of mapping in Christopher's learning (Morgan *et al.* in preparation b).

[4] Text in lower case in the sign gloss tier indicates that a gesture was used with a sign.

- a line of horses;
- a line of cars;
- a line of telephones.

In the second test (Classifier 2) subjects watched 10 signed sentences and then picked a corresponding picture from four picture alternatives.

Christopher performed significantly worse on the Classifier 1 test than the comparator group; he scored 20 percent correct (chance was 33 percent). Comparator group scores were between 80 percent and 100 percent, mean 89 percent, SD = 9.9 percent. On the classifier 2 test Christopher scored 10 percent correct (chance was 25 percent). Comparator group scores were between 50 percent and 100 percent, mean 72 percent, SD = 13.8 percent. There was no significant difference between the comparator group's scores on the Classifier 1 and Classifier 2 tests. Christopher and the mean comparator group's scores are presented in Figure 16.1.

The results presented in Figure 16.1 suggest that in the domains of negation and agreement Christopher's general comprehension and judgments of grammaticality are similar to other learners, but he does markedly less well than the comparator group on the classifier tasks. Many of Christopher's errors in the classifier tests appeared to be random, while members of the comparator group (when making wrong choices) seemed to use a visual similarity strategy. For example, the comparator subjects when matching a picture with a classifier often made choices based on a salient perceptual characteristic (roundedness, thinness, etc.) although the movement or spatial location of the sign was not accurately processed. Christopher, on the other hand, made several choices with no such apparent strategy.

16.7 Discussion

By the final period of exposure to BSL, Christopher's signing has greatly improved, and it is at a level where he can conduct a simple conversation. In this respect he has supported our prediction that he would find the language accessible and satisfying in linguistic terms. From the beginning of BSL exposure he has shown interest and a motivation to learn, despite the physical and psychological hurdles he had to overcome. Christopher has learnt to use single signs and short sentences as well as normal learners do. This supports part of our first prediction, that he would find vocabulary learning relatively easy. His understanding of verb morphology is comparable to that of the comparator group, but in production the complexity of manipulating locations in sign space is still beyond him. After eight months exposure he continues to use real world objects and locations (including himself and his conversation partner) to map out sign locations. Thus, verb morphology in BSL is markedly less well developed than in his other second languages (for example, as in his learning of Berber) where

he had comparable exposure. These findings do not support our prediction that he would learn BSL verb morphology quickly and easy, at least insofar as his sign production is concerned.

In his spontaneous signing, utterance length is limited, yet he does not use English syntax. He understands negation as well as other normal learners, although in production we have seen an impact of his apraxia on the correct co-ordination of manual and nonmanual markers. In general, in his production there is an absence of facial grammar. Thus, we have not observed the same extent of influence of English syntax on his BSL as we originally predicted. However, there is one domain where a difference in syntactic structure between English and BSL may have influenced his learning. Christopher's comprehension and production of classifier constructions was very limited. Although the comparator group performed less well in classifier comprehension than in the other linguistic tests, Christopher's scores were significantly worse than the comparator group only in this domain.

16.7.1 Modality effects

Christopher has learnt a new language in the signed modality less well than in the spoken modality. Christopher's apraxia impinges on his production but not comprehension of several domains of BSL. The pattern of strengths and weaknesses in his learning of BSL is similar to, as well as different from, that found in his learning of spoken languages. Our research has shown that the modality (including the use of simultaneous articulation of linguistic information in BSL) is responsible for partly supporting and partly falsifying our original predictions.

His vocabulary learning was good but his mastery of verb morphology was not. The restricted nature of verb-agreement morphology in BSL may have made patterns harder to internalize. We believe that the absence of a written version of BSL reduced his ability to maintain and retain in memory abstract morphological regularities. The persistent nonpermanence of the input increased the cognitive load for Christopher. We also suggest that exposure to a language that relies on many visual links between form and meaning increased the importance of iconically-based inference-making in adult learning. Christopher's difficulty in making these inferences based on intact world knowledge may have affected his progress significantly.

In his rather limited sentence production we observed less of an influence of his first language than was the case in his acquisition of other, spoken, languages such as Berber. Perhaps the contrast between the output modalities of signed and spoken language may have an inhibitory effect on transfer strategies. His difficulties in sign articulation caused him to slow his production down. In

general, the greatest influence of English in his other spoken languages is shown when he is speaking or reading quickly.

In one domain of Christopher's learning, there may have been a direct influence of modality. Christopher avoided the use of classifier constructions and performed very poorly in tests of their comprehension. This may either be attributable to the complexity of the use of space in the formation of BSL classifiers (a modality effect), or to the inherent linguistic complexity of classifiers (a nonmodality effect). On this latter view, Christopher's difficulty with classifiers is simply that they encode semantic contrasts (like shape) that none of his other languages do.

Support for the former view – that there is a modality effect – comes from his poor performance in using sign space to map out verb agreement morphology. Although the use of spatial locations for linguistic encoding was comprehended to the same general degree as in the comparator group, in his sign production the use of sign space was absent. Thus, if it is the use of sign space which is a problem, and classifiers rely on a particularly high level of sign space processing, his visuo-spatial deficits appear to impinge most in the use of this set of structures.

The analysis of Christopher's learning of BSL reveals a dissociation between spatial mapping abilities and the use of grammatical devices that do not exploit spatial relations. We have attempted to relate this dissociation to the asymmetry Christopher demonstrates between his verbal and nonverbal IQ. The general abilities needed to map spatial locations in memory, recognize abstract patterns of spatial contrasts and visualize spatial relations from different perspectives are called upon in the use of classifiers in sign space. Christopher's unequal achievements in different parts of his BSL learning can then be attributed to his apraxia and visuo-spatial problems. It is clear that certain cognitive prerequisites outside the linguistic domain are required for spatialized aspects of BSL but there are no comparable demands in spoken languages.

The fact that the aspects of signed language that are absent in Christopher's signing are those that depend on spatial relations (e.g. the classifier system) suggests that the deficit is actually generalized from outside the language faculty. In this case it might be said that underlying grammatical abilities are preserved, but they are obscured by impairments in cognitive functions needed to decode a visuo-spatial language.

In conclusion the dissociations between Christopher's ability in different parts of the grammar provide the opportunity to explore which areas of language are modality-free and which areas are modality-dependent, and the extent to which signed languages differ from spoken languages in their requirement for access to intact, nonlinguistic processing capabilities. Differences in

Christopher's abilities and the unevenness of his learning supports the view that only some parts of language are modality-free.

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