# Colour as a semiotic mode: notes for a grammar of colour 



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#### Abstract

This article presents a brief review of several approaches of 'grammar', as the basis for a discussion of culturally produced regularities in the uses of colour; that is, the possibility of extending the use of 'grammar' to colour as a communicational resource. Colour is discussed as a semiotic resource a mode, which, like other modes, is multifunctional in its uses in the culturally located making of signs. The authors make some use of the Jakobson/Halle theory of 'distinctive features', highlighting as signifierresources those of differentiation, saturation, purity, modulation, value and hue. These are treated as features of a grammar of colour rather than as features of colour itself. The article demonstrates its theoretical points through the analysis of several examples and links notions of 'colour schemes' and 'colour harmony' into the social and cultural concept of grammar in the more traditional sense.


## KEY WORDS

colour • discourse • grammar • multimodality • semiotics

## 1. THE QUEST FOR A GRAMMAR OF COLOUR

We know that colour 'means'. Red is for danger, green for hope. In most parts of Europe black is for mourning, though in northern parts of Portugal, and perhaps elsewhere in Europe as well, brides wear black gowns for their wedding day. In China and other parts of East Asia white is the colour of mourning; in most of Europe it is the colour of purity, worn by the bride at her wedding. Contrasts like these shake our confidence in the security of meaning of colour and colour terms. On the one hand the connection of meaning and colour seems obvious, natural nearly; on the other hand it seems idiosyncratic, unpredictable and anarchic.

The difficulties multiply when we look at attempted systematic accounts of the meanings of colour. Psychologists conduct their tests, and get their results; artists make their pronouncements, which differ from those of the psychologists and from each other. Why is there such a problem with the meaning of colour? And if there is, how can colour be brought into a semiotic theory and description?

Part of the problem may lie, not with colour or colour terms, but with our notions of meaning, or, in this case, grammar. We have used the term grammar in earlier work on visual communication (Kress and Van Leeuwen, 1996), although there we concentrated on composition and left the issue of colour largely unexplored. Can we use 'grammar' in relation to colour as well?

The term 'grammar' has been given many meanings. In popular usage it tends to mean first and foremost 'rules of appropriate linguistic practice or behaviour', and it is entirely connected with notions of 'correctness'. That is, its meaning refers us to socially established and maintained convention, and either to adherence or deviation from that. In professional usage, there is an overlapping set of meanings around the idea of codification; here the term means something like 'the codification of the linguistic practices of a group of users of a language'. In this case we can have grammar books, which become authoritative sources of information on the practices, even though they are simply records of these. However, here power intervenes inasmuch as these records tend to be of the practices of those who are regarded as belonging to a group whose usage can be accepted as definitive, and may as a result be imposed on other groups as well. There is a further use by professionals which differs somewhat: here 'grammar' describes the regularities of 'what people do' irrespective of their group membership and irrespective of codifications which may exist, within one society, of what might still be regarded as the 'one' language.

The unspoken assumption in all these uses (though least so in the last-mentioned) is that 'the' grammar applies to everyone, that it is accepted by all members of the group, that there is a convention and that there is a consensus. The grammar of English, in that meaning of the word, applies to all of English, at least as it is spoken in England. But if it applies to all speakers of English, anywhere in England, then this is so because there are sufficient common interests across this group to want to maintain the agreement about commonalities and shared interest. The mode of communication at issue, let us say speech, is so important that not to have such agreements would entail too high a price for the group and its individual members. The unity of 'the' grammar, meanwhile, remains a mythic notion, as the last-mentioned definition indicates: 'what people do' differs from place to place, from group to group, and even for individuals as they move across places and groups. Nevertheless, in the case of language, the users are willing to adhere to the myth, because it has essential functions.

The question is: which of these definitions serves us best in thinking
about the grammar of colour? At first sight it would seem that, in the case of colour, there are only small groups, constituted around specific interests, each attempting to develop their understandings about the regularities of meaning that might surround the uses of colour. In other words, there is no large or sufficiently powerful group which could sustain a shared understanding of the meanings of colour across 'all of society'. Instead there are specialized interests of small groups, at times even just of individuals, all with their very specific professional or personal interests. When two people meet, unless it is as members of such a group, all they could do is to share their difference in understanding growing out of their differential interests. On the other hand, some discourses of design are taught in art and design colleges across the world, and some practices and products - the ranges of colours made available by paint manufacturers, the uses of colour portrayed in fashion and home decoration magazines - are now globally distributed. As we demonstrate in this article, this is not entirely an either-or matter. The micro and the macro, the 'local' and the global' exist at the same time, and interact in complex ways.

In either case, however, there are regularities, and they arise from the interests of the sign makers. In this sense colour is a semiotic resource like others: regular, with signs that are motivated in their constitution by the interests of the makers of the signs, and not at all arbitrary or anarchic. The task is then to understand the differential motivations and interests of signmakers in the different groups, be they small or large, local or global.

So far we have stayed quite general in the discussion, making no distinction between the signs of 'lexis' and the signs of 'syntax' or grammar, or the signs of textual organization. The questions we need to ask are the more specific ones: is colour a mode of communication in its own right? Does it have the full affordances of mode? Is there the possibility of lexis alone, or are there both the affordances of lexical elements and the combinations of them in a 'grammar' to fulfil the tasks of a mode?

This question requires a brief digression in order to say what it is that makes mode fully mode-like, and what it is that makes grammar fully grammar-like; or perhaps to say that this may not be the most fruitful approach to the question. The traditional approach during the 20th century had been to assume that a communicational system either adheres to all criteria that make it such - irrespective of what these are or of who might have set them - and then to rule whether such a 'resource' (the more likely terms have been 'system' or 'language') either fulfilled the criteria or not. If it did, it would have the status of communicational system conferred; if it did not meet them, it would not. That has been the criterion for ruling on distinctions between (human) language and animal 'noises'.

Our approach, by contrast, within a broadly social semiotic multimodal framework, is different. It is clear that cultures do not expend the same energy at all times on all the potentially usable semiotic resources: hence some are highly developed and become fully articulated for all the
communicative and representational purposes of that group, while others are partially articulated or hardly at all. Our decision is not to draw a boundary between mode and non-mode on that basis. If the resource is sufficiently developed for sign-making we will call it a mode; similarly with the question of grammar. Some modes are highly articulated; others less so. In either case we are prepared to speak of the grammars of the resource.

What makes a mode mode-like is its availability as a resource for making signs in a social-cultural group. What makes a grammar grammarlike is that it has characteristics that can be contravened. In other words, a group's sense of the regularities of the resource allows it to recognize when these regularities have (not) been met. In older-fashioned terms, we can say that we know that there is a grammar when we can recognize an ungrammatical use of the resource.

The task, then, is to discover the regularities of the resource of colour as they exist for specific groups: to understand them well enough to be able to describe what the principles for the use of the resource in signs are; to understand how specific groups' interests in colour shape the signs of colour; and to understand what general principles of semiosis and of the specific semiosis of colour emerge from this that might provide a principled understanding of all uses of colour in all social-cultural domains.

## 2. THE COMMUNICATIVE FUNCTIONS OF COLOUR

In Reading Images (Kress and Van Leeuwen, 1996), we used Halliday's metafunctional theory (e.g. 1978) as a key heuristic. According to this theory, language simultaneously fulfils three functions: the ideational function, the function of constructing representations of the world; the interpersonal function, the function of enacting (or helping to enact) interactions characterized by specific social purposes and specific social relations; and the textual function, the function of marshalling communicative acts into larger wholes, into the communicative events or texts that realize specific social practices, such as conversations, lectures, reports, etc.

The various grammatical systems that are always simultaneously at work in utterances are, according to Halliday, specialized to realize specific metafunctions, that is, to realize either ideational, or interpersonal or textual meanings. An example of a grammatical system which realizes ideational meanings is transitivity, as it creates specific relations between 'participants', that is, between represented people, places, things and ideas; for instance, by representing one participant as the actor of an action and another as one to whom or which the action is done. Such representations are always social and cultural constructs. 'He married her' is a transitive clause - and also a construction of marriage in which the man is seen as the actor of the action and the woman as the one to whom this action is done. 'They married' is an intransitive clause - and also a construction of marriage in which marriage is seen as a joint action. Such clauses in fact do more than represent what is
going on in the world in a certain way, they also play an active role in the legitimation (or sometimes critique) of particular ways of organizing the social practice of marriage.

An example of a grammatical system which helps enact social interaction is mood, which offers a choice between different basic speech acts such as stating, questioning and commanding. Choosing the interrogative mood, for instance, helps enact the social interaction of questioning (e.g. interviews, exams, interrogations, surveys).

Finally, an example of a grammatical system which realizes textual meanings is the system of reference which has resources (articles and pronouns) allowing speakers to signal what they have already mentioned and what they are newly introducing, and this helps create flow and cohesion in texts and communicative events (e.g. There was once $a$ house ... it stood on a hill ..., etc.)

In Reading Images we were able, we think reasonably plausibly, to apply this model to a number of resources of visual communication (composition, the gaze, angle and size of frame, and so on), thereby reconstituting these resources as 'grammatical systems' in Halliday's terms. We did not, however, deal with colour in this way, even though it is, undoubtedly, a very important resource of visual communication. If we had done so, we now realize, we might have found it difficult to plausibly assign colour to just one and only one of Halliday's three metafunctions. It is true that there is a dominant discourse of colour in which colour is primarily related to affect - we will discuss the genealogy of this discourse in more detail later in this article. It is also true that Halliday and many of his followers (e.g. Poynton, 1985; Martin, 1992) see affect as an aspect of the interpersonal metafunction. Halliday (1978), for instance, says that the interpersonal function includes the speaker 'expressing his own attitudes and judgements' (p. 112). But the communicative function of colour is not restricted to affect alone. Arguably, colour itself is metafunctional.

Starting with the ideational function, colour clearly can be used to denote specific people, places and things as well as classes of people, places and things, and more general ideas. The colours of flags, for instance, denote specific nation states, and corporations increasingly use specific colours or colour schemes to denote their unique identities. Car manufacturers, for instance, ensure that the dark blue of a BMW is quite distinct from the dark blue of a VW or a Ford, and they legally protect 'their' colours, so that others will not be able to use them. Even universities use colour to signal their identities. The Open University, for instance, stipulates:

Two colours ... for formal applications such as high-quality stationery and degree certificates - blue (reference PMS 300) for the shield and lettering, and yellow (PMS 123) for the circular inset. Single colour stationery should be in blue (PMS 300) if possible. (Goodman and Graddol, 1996: 119)

On maps, colours can serve to identify, for instance, water, arable land, deserts and so on, and while there is, in this case, an iconic element in the choice of colours, in other cases there is not. On uniforms, colour can signal rank. In the safety code designed by US colour consultant Faber Birren (Lacy, 1996: 75) green identifies first-aid equipment, while red identifies hoses and valves (which play a role, of course, in fire protection). In the London Underground green identifies the District Line and red the Central Line, and both on Underground maps and in Underground stations many people look for those colours first, and speak of the 'green line' and the 'red line'.

Ideas have been expressed by colour for a long time, for instance in Medieval colour symbolism, in which black stood for penance, white for innocence and purity, red for the pentecostal fire, and so on. In the early 20th century abstract painters returned to the use of colour for the expression of ideas. For Malevich, for instance, black denoted a worldly view of economy, red the revolution, while white denoted action. With such building blocks more complex ideas could then be constructed. In work of this kind, as Gage (1999) has commented, 'colour offered an aspect of content as complex and resonant as, say, the iconography of the Madonna in the Italian Quattrocenti' (p. 241).

Many of the colour codes we have just discussed, whether those of the London Underground or of Malevich, have a limited domain of application within which the use of colour is strictly regulated. But this does not mean that the ideational function of colour can only ever operate within such limited domains. The work of Malevich, Mondrian, Kandinsky and others was in many ways a first attempt to explore the possibility of a broader, more widely applicable 'language of colour', and hence of a 'grammar' that might be accepted beyond a specific smaller socio-cultural group. As Gage has said, it 'offered the prospect of universality, (but became) thoroughly hermetic' (p. 248). Whether this signals the end of all such attempts, or merely a 'failed first try' (Halliday, 1993: 71) to change the semiotic landscape and develop a language of colour with wider acceptance remains to be seen.

Colour is also used to convey 'interpersonal' meaning. Just as language allows us to realize speech acts, so colour allows us to realize 'colour acts'. It can be and is used to do things to or for each other, e.g. to impress or intimidate through 'power dressing', to warn against obstructions and other hazards by painting them orange, or even to subdue people - apparently the Naval Correctional Center in Seattle found that 'pink, properly applied, relaxes hostile and aggressive individuals within 15 minutes' (Lacy, 1996: 89). According to The Guardian's Office Hours supplement:

Colours are very powerful and can reduce or raise stress levels, believes Lilian Verner-Bonds, author of Colour Healing. Bright reds are energising and are good for offices in the banking or entertainment fields. Green is useful if there's discord or disharmony
as it is soothing. Blue is rated as the best colour for promoting calm and pastel orange is good for gently encouraging activity. (3 September 2001: 5)

Elsewhere in the same article we learn that adding colour to documents can increase the reader's attention span by more than 80 percent and that 'an invoice that has the amount of money in colour is $30 \%$ more likely to be paid on time than a monocolour one'. In all these cases colour is not just ideational. It is not just the case that colour 'expresses' or 'means', for instance, 'calm' or 'energy', but that people use colour to actually try to energize or calm people down, or, more broadly, to act on others, to send managerial messages to workers, for instance, or parental messages to children, as we have shown in an analysis of a children's room (Kress and Van Leeuwen, 2001) - and also to present themselves and the values they stand for, again, in the context of specific social situations, to say 'I am calm', or 'I am energetic', and to project 'calm' or 'energy' as positive values. We address this in more detail later in this article when we analyse the use of colour in home decoration.

Finally, colour can also function at the textual level. Just as, in many buildings, the different colours of doors and other features on the one hand distinguish different departments from each other, while on the other hand creating unity and coherence within these departments, so colour can also help create coherence in texts. In Pasos, a Spanish language textbook (Martín and Ellis, 2001), the chapter headings and page numbers of each chapter have a distinct colour, all section headings ('Vocabulario en casa', 'Gramática', etc.) are red, throughout the book, and all 'activities' (e.g. 'Make phrases with es or está') have a purple heading and number. In an issue of the German edition of Cosmopolitan (November 2001), the film reviews have orange headlines and other uses of orange in the typography, in the background of textboxes, etc. The art reviews use green in a similar way, the book reviews red, and so on. In some cases this is cued by a salient colour in the key illustration of the first page of the relevant review section, for instance Cate Blanchett's orange hair in a still from the film Bandits in the film review section. Advertisements often use colour repetition to lend symbolic value to a product, as when the blue on an advertised soap packet repeats that of a tranquil lake in the accompanying photograph.

Textual cohesion can also be promoted by 'colour coordination', rather than by the repetition of a single colour. In this case the various colours of a page, or a larger section of a text (or of an outfit, or a room), have roughly the same degree of brightness, and/or saturation, etc. In computer software such as Powerpoint this is built in. Choosing the initial background automatically selects a range of colours, a colour scheme. If the initial colour is a pastel, then the other colours will also be pastels, for instance. It is possible to override this by selecting another colour from a Munsell atlas type display, but this takes more effort and skill.

It may well be that such 'colour schemes' are gradually becoming more important carriers of colour meaning than the single hues which have so far dominated the discussion. This would not be a historical first. In other cultures and periods, too, hue has been seen as a relatively unstable and unreliable aspect of colour, and practices of colour production and interpretation were based on colour families rather than individual colours. In Medieval paintings, for instance, St Peter was recognizable by the colour of his robe, blue and yellow. But this could, in one painting, become blue and yellow, in another green and chocolate brown, and so on, without the identification being affected (Gage, 1999: 71).

There are two further points to make here. First, colour fulfils these three metafunctions simultaneously. The colours on a map retain their interpersonal value, their appealing brightness, or stuffy dullness (also remember the example of the invoice here) and on maps, too, colours are coordinated to enhance textual cohesion. Again, contemporary scientific visualizations are thought of as primarily ideational. The colours are meant to make the different parts more distinct, as well as to suggest at least aspects of meaning, as in landsat photography (photographs taken by a series of artificial satellites designed to monitor the earth's resources), brain tomography, etc. But they are often as aesthetically appealing as abstract paintings and would not go amiss in a frame in a sitting-room.

Second, we are not arguing that colour always has and always will fulfil all three of these functions. Colour does what people do with it. We are not 'discovering' universal and suprahistorical facts about colour here. We are trying to document what kind of communicative work colour is made to do in today's increasingly global semiotic practices, and how. The examples perhaps provide a first indication that some of these uses of colour have fairly specific, limited domains, where they quite clearly relate to the specific interests of sign-makers (e.g. map-making, subduing prisoners) while others may have wider distribution (e.g. the use of colour coding in magazines as a means of cohesion).

Finally, if we are right, if colour, today, fulfils all three metafunctions, would it be a semiotic mode in its own right, along with language, image, music, etc? Maybe. But there is also a difference. Language, image and music have been conceived of (and have in various 'purist' practices often operated) as relatively independent semiotic modes. Although a novel is a material object, and a page a visual artefact, their communicative work is done primarily through language. Again, in an art gallery images traditionally come with a minimum of words, and in the concert hall everything is concentrated on the music, while expression through semiotic modes such as dress, bodily performance, etc., is held back, certainly by comparison to contemporary popular music-shows. This is not the case with colour. It is true that painters have tried to make paintings that use only colour and nothing else ('field painting', Rothko etc.), but this does not appear to have led to a whole new art form. It has remained an isolated 'meta' statement, the
exploration of a limit case. Then again, maybe colour is a characteristic mode for the age of multimodality. It can combine freely with many other modes, in architecture, typography, product design, document design, etc., but not exist on its own. It can survive only in a multimodal environment.

## 3. COLOUR AND AFFECT: THE GENESIS OF A

 DISCOURSEIn earlier times, pigments had value in themselves. ${ }^{1}$ Ultramarine, as the name indicates, had to be imported from across the sea and was expensive, not only for this reason, but also because it was made from lapis lazuli. Hence it was only used for high-value motifs such as the mantle of the Virgin Mary. Such pigments were not mixed, but used in unmixed form, or at most only mixed with white. Their material identity was to remain visible and distinct, as is the case with objects made from expensive materials. Around 1600, in Dutch painting, the technology changed. New techniques allowed each particle to be coated in a film of oil which insulated it against chemical reaction with other pigments and made more extensive mixing possible. As a result the status and price of specific paints went down, and paint became to some extent disengaged from its materiality. At the same time, the semiotic resource of colour gradually was no longer thought of as a collection, an extensive catalogue of distinctly different, individual pigments, but as a semiotic system, a kind of 'phonology', a system with five elementary colours (black, white, yellow, red and blue) from which all other colours could be mixed - and a system, therefore, which was also in the first place based on hue, which, as we have seen, was another innovation.

From this moment on, colour theory and colour practice developed in tandem, both aiming at further developing, refining and defining colour systems. In the early 18th century LeBon, an engraver, first distinguished between hue (the different colours themselves, e.g. red or green) and value (the shades of these colours in terms of light and dark), in a system with three primaries (yellow, blue and red) and two values (black and white). In the early 19th century another artist, the painter Runge (possibly influenced by Goethe, with whom he had corresponded, and whose famous treatise on colour had appeared a few years earlier) designed the Farbenkugel, a model plotting value against hue with six primaries. Not long after, a chemist, Chevreul, distinguished between flat and modulated colour (as Goethe had already done earlier) and showed how two colours influence each other when seen simultaneously. This was picked up again by painters such as Ingres, who saw value rather than hue as the key to the individuality of the colours of objects. By the second half of the 19th century people had already started writing 'grammars of colour' and producing pigments in accordance with these systems. The early 20th-century chemist Ostwald (1931) created a system in which a grey scale is applied to each hue on a colour circle with 24
hues, and collaborated both with painters like Mondrian and with paint manufacturers.

All these systems were geared to distinguishing a limited number of elements, of colour phonemes, or 'colouremes', you might say, that can combine to form many different colours, indeed, an unlimited number of colours, and it is this combinatorial, generative, 'grammatical' approach which contrasts with the earlier 'lexical' approach in which the semiotic resource of inventories of single colours is thought of as a 'lexicon', a list of pigments which is on the one hand much longer than the list of basic (idealized) units, 'colouremes', but on the other hand is finite, rather than the infinite number of colours which can be generated with a generative grammatical system.

Systems of this kind not only created the paradigm of 'colouremes', of basic colour units, but also concerned themselves with their permitted or 'con-sonant' and deviant or 'dis-sonant' combinations, at the level of combining hues and values into colours as well as at the level of combining colours into colour schemes. The key term here was 'colour harmony', and from Newton onwards, there have been at least four different approaches to it. The first was that of Newton, which was based on an analogy with the then still relatively new tonal-functional system of music. Newton plotted his seven basic colours (green, blue, indigo, violet, red, orange and yellow) on the tones of the octave, and then determined which colour combinations would be 'consonant' or 'dissonant' by analogy to musical intervals. In his time it inspired Castel to build an 'ocular harpsichord', a type of experiment which has cropped up again and again since, for instance in the interest in synaesthesia and audition colorée of early 20th-century psychologists and, more recently, in the work of abstract animation film artists and computer artists.

A second approach is based on theories of colour complementarity. In the context of the system of three (subtractive) primary colours, green, for instance, which is composed of the primaries yellow and blue, is said to harmonize with red, the third of the three primaries, while orange, which is composed of yellow and red, harmonizes with blue, and so on. Yet another approach, already in evidence in Ostwald (1931), is based on value and sees colours with equal value as harmonizing with each other. Itten (1970) extends this to saturation - colours which are equally 'pure' or 'diluted' also harmonize. Finally, there have also been more psychological approaches (cf. Gage, 1999: 191ff) based on people's reactions to colour.

New ideas about the meaning of colour developed alongside these ways of systematizing colour. Goethe (1970), while recognizing the conventional meanings of colours, and even suggesting 'a critique of uniforms and liveries' (p. 328), was the first to see the meaning of colour as an 'effect', or, in our terms, as 'interpersonal'. Colours could 'excite', 'inspire sentiments', 'disturb' and so on. He also thought that some people are more likely to feel these effects than others - 'primitives', for instance, and women and children, or southern Europeans as opposed to northern Europeans:

The female sex in youth is attached to rose colour and sea green, in age to violet and dark green. The fair-haired prefer violet as opposed to light yellow, the brunettes blue as opposed to yellow-red. (p. 328)

This approach to the meaning of colour was put into practice by artists. The German 'Lucasbund' painters Overbeck and Pforr, for instance, used the colour of hair and dress to express the 'character' of the women they portrayed - only the women, because they felt that in the case of men, their profession rather than their character determined dress. They had colours for 'proud and cool' yet 'cheerful and happy' personalities (black hair with black and blue, white and violet); colours for 'solitariness, modesty, goodheartedness and calm' (blonde hair with blue, grey and crimson); colours for 'happiness and good temper, innocent roguishness, naiveté and cheerfulness' (reddish brown hair with crimson, violet-grey and black); and so on (Gage, 1999: 189). In many ways the adjectives favoured in contemporary advertising and fashion still inhabit the same semantic field, and the work of these German Romantic painters was, no doubt, also a forerunner to the colour psychology that began to develop in the late 19th century, in which it was axiomatic that colour was 'instinctive' and 'sensual', a matter of immediate feeling rather than intellectual judgement, and toned down or repressed in the mature adult. Soon colour began to be used in personality tests in which personality could be ascertained through colour preferences, and in therapeutic applications in which hyperactive patients could be calmed by blue, lethargic ones stimulated by red and so on - the use of pink in the Seattle Naval Correction Center quoted earlier is by no means a novelty, even though presented as such in the press. Versions of this kind of colour psychology are still used by interior decorators and other colour consultants as the factual basis on which their expertise is grounded. Not least through countless popularizations in the media, it continues to be highly influential, as demonstrated in the discussion of colour in home decoration in section 5 .

The expertise of the modern colour consultant, meanwhile, continues to centre on hue, on 'the' meanings of red, blue, yellow, etc. And although chemists, painters and psychologists have produced and used 'pure', 'essential' reds, blues and yellows for their specific purposes, in everyday life 'red', 'blue', 'yellow' etc. are abstractions. Colours are determined by several factors, of which hue might not even be the most important one. Moreover, although the colours themselves could be standardized, the meaning of colour has turned out to be less easily standardized. Goethe (1970) called yellow 'serene, gay and softly exciting' (p. 307), Kandinsky (1977) said 'it has a disturbing influence and reveals an insistent, aggressive character ... it may be paralleled, in human nature, with madness, not with melancholy or hypochondriacal mania, but rather with violent, raving lunacy' (pp. 37-8). Wierzbicka (1996), a cognitive linguist, called yellow 'warm and sunny' (p. 315). StefanescuGoanga (1912), an early 20th-century colour psychologist said that blue was
'calming, depressing, peaceful, quiet, serious, nostalgic' (p. 609), whereas for Franz Marc it was 'the male principle, sharp and spiritual' (Gage, 1999: 193), and for Novalis 'female', 'especially attractive, and rare in nature' (pp. 186-7). Green has been seen as an 'irritant', and as 'sulphurous' (Goethe, 1970: 308) as well as 'calm and placid' (Kandinsky, 1977: 38-9). As Gage (1999) stated, 'the same colour can be found to have quite antithetical connotations in different periods and cultures and even at the same time and place' (p. 34).

Why this is so perhaps becomes a little clearer when we look at the reasons given for particular meanings - if any reasons are given, which is not always the case. Take this quote from Kandinsky (1977):

Pictures painted in shades of green tend to be passive and wearisome ... In the hierarchy of colours green is the 'bourgeoisie' - self-satisfied, immovable, narrow ... It is like a fat, extremely healthy cow, lying motionless, fit only for chewing the cud, regarding the world with stupid, lacklustre eyes ... (p. 38)

And elsewhere:

An attempt to make yellow colder produces green. The colour becomes sickly and unreal ... (p. 37)

In both these instances, the meaning of colour rests on association, and any colour can clearly be associated with different sources or carriers of that colour. Green, for instance, can be associated with the fields in which cows 'chew the cud' - or with the unhealthy pallor of a sick person, and doubtless with many other things as well. Such associations are then absolutized to become 'the' meaning of green in a decontextualized universal system. And this is not only done by painters. Wierzbicka (1996) describes yellow as sunny (p. 315), because to her it is 'obvious' that yellow is always and everywhere - in Scotland, or in the Sahara? - associated with the sun. However, it may be that in some cultures or situations other associations are more salient, for instance an association with gold, or with the skin of people suffering from liver disease. Kandinsky's view of green may be that of the jaded city dweller for whom country life lacks stimulation. But another view associates green with hope, and this clearly suggests another relation with the country and another set of experiences.

## 4. A DISTINCTIVE FEATURE APPROACH TO THE SEMIOTICS OF COLOUR

According to Kandinsky (1977), colour has two kinds of value, a direct value, which is the colour's actual physical effect on the viewer, which derives from the physical properties of colours so that they 'move towards us' or 'away
from us', and an associative value, as when we associate red with flames or blood, or other phenomena of high symbolic and emotive value.

Elsewhere (e.g. Kress and Van Leeuwen, 2001) we have argued that signifiers, and therefore also colours, carry a set of affordances from which sign-makers and interpreters select according to their communicative needs and interests in a given context. In some cases their choice will be highly regulated by explicit or implicit rules, or by the authority of experts and role models. In other cases, for instance in the production and interpretation of art, it will be relatively free. As we aim to show in the following analysis of the use of colour in home decoration, in most situations these two poles, constraint and creativity, are both in evidence and mixed in complex ways.

Like Kandinsky, we distinguish two types of affordance in colour, two sources for making meaning with colour. First there is association, or provenance - the question of 'where the colour comes from, where it has been culturally and historically', 'where we have seen it before'. This 'where' may be a certain substance, a certain kind of object, the dress of a certain kind of person, a period or a region, or all and more of these, and it is clear that any colour allows many such associations. Yet the associations actually taken up in communicative uses of colour, for instance in advertising - think of the proliferation of wine labels from 'new' regions - or the entertainment media, will usually be with substances, objects etc. that carry significant symbolic value in the given socio-cultural context. While the affordances of a colour may be limitless in theory, in practice they are not, and a plausible interpretation can usually be agreed on, provided the context of production and interpretation is taken into account, as we aim to do in the following analysis.

The second type of affordance is not so much the physical effect Kandinsky spoke of, as the affordance of the distinctive features of colour. These distinctive features indicate, as in Jakobson and Halle's (1956) distinctive feature phonology, a quality which is visual rather than acoustic, and is not systematized, as in phonology, as structural oppositions but as values on a range of scales. One such is the scale that runs from light to dark, another the scale that runs from saturated to desaturated, from high energy to low energy, and so on. Again, in ways that provide echoes of Jakobson and Halle, we see these features not as merely distinctive, as merely serving to distinguish different colours from each other, but also as meaning potentials. Any specific instance of a colour can be analysed as a combination of specific values on each of these scales - and hence also as a complex and composite meaning potential, as we now demonstrate.

## Value

The scale of value is the grey scale, the scale from maximally light (white) to maximally dark (black). In the lives of all human beings light and dark are fundamental experiences, and there is no culture which has not built an
edifice of symbolic meanings and value systems upon this fundamental experience - even though different cultures have done so in different ways. Painters who emphasize value, Rembrandt for instance, are often able to exploit this meaning potential in complex and profound ways.

## Saturation

This is the scale from the most intensely saturated or 'pure' manifestations of a colour to its softest, most 'pale' or 'pastel', or dull and dark manifestations, and, ultimately, to complete de-saturation, to black and white. Its key affordance lies in its ability to express emotive 'temperatures', kinds of affect. It is the scale that runs from maximum intensity of feeling to maximally subdued, maximally toned down, indeed neutralized feeling. In context this allows many different, more precise and strongly value-laden meanings. High saturation may be positive, exuberant, adventurous, but also vulgar or garish. Low saturation may be subtle and tender, but also cold and repressed, or brooding and moody.

## Purity

This is the scale that runs from maximum 'purity' to maximum 'hybridity', and it has been at the heart of colour theory as it developed over the last few centuries. As we have seen, many different systems of primary and mixed colours have been proposed, some physical, some psychological and some a mixture of both, and this search for primaries or basics has not resulted in a generally accepted system, but 'has proved to be remarkably inconsequential and ... freighted with the heavy burden of ideology' (Gage, 1999: 107). Some writers have seen the issue as closely related to the question of colour names (e.g. Wierzbicka, 1996). Colours with commonly used single names, such as brown and green, would be considered pure. The names of other colours, e.g. cyan, are mainly used by specialists, and non-specialists would refer to them by means of a composite name, e.g. blue-green. Such colours would then be perceived as mixed.

Terms like 'purity' and 'hybridity' already suggest something of the meaning potential of this aspect of colour. The 'pure' bright reds, blues and yellows of the 'Mondrian colour scheme' have become key signifiers of the ideologies of modernity, while a colour scheme of pale, anaemic cyans and mauves has become a key signifier of the ideologies of postmodernism, in which the idea of hybridity is positively valued. This is by no means the only way in which the affordances of this scale have been taken up, but it is a culturally salient one, and hence one which is currently quite widely understood.

## Modulation

This is the scale that runs from fully modulated colour, for example from a blue that is richly textured with different tints and shades, as in paintings by

Cézanne, to flat colour, as in comic strips, or paintings by Matisse. As we saw earlier, it was already recognized as a feature of colour in Goethe's Farbenlehre (1970). The affordances of modulation are various and, again, strongly value-laden. Flat colour may be perceived as simple and bold in a positive sense, or as overly basic and simplified. Modulated colour similarly may be perceived as subtle and doing justice to the rich texture of real colour, or as overly fussy and detailed. And as we have discussed in more detail elsewhere (Kress and Van Leeuwen, 1996), modulation is also closely related to the issue of modality. Flat colour is generic colour, it expresses colour as an essential quality of things ('grass is green'), while modulated colour is specific colour ('the colour of grass depends on the time of day and the weather'), it attempts to show the colour of people, places and things as it is actually seen, under specific lighting conditions. Hence the truth of flat colour is an abstract truth, and the truth of modulated colour a naturalistic, perceptual truth.

## Differentiation

Differentiation is the scale that runs from monochrome to the use of a maximally varied palette, and its very diversity or exuberance is one of its key semiotic affordances, as is the restraint involved in its opposite, lack of differentiation. In our section 5 analysis of an article from a home decoration magazine, a couple 'uses nearly the whole spectrum in their house' and comment 'it's great that there are so many bright shades in the house. It's a shame people aren't more adventurous. It's when you start being timid that things go wrong' (House Beautiful, September 1998: 21). So here high differentiation means 'adventurousness' and low differentiation 'timidity', but it is clear that in another context restraint might have a more positive value.

## Hue

This, finally, is the scale from blue to red. In a distinctive feature theory of colour it becomes only one of the factors constituting the complex and composite meanings of colour, and may not even be the most important one. Nevertheless, although 'the' meaning of red-in-general, of the abstract signifier 'red', cannot be established, the red end of the scale remains associated with warmth, energy, salience and foregrounding, and the blue end with cold, calm, distance, and backgrounding. The cold-warm continuum has many correspondences and uses. Itten (1970) lists transparent/opaque, sedative/stimulant, rare/dense, airy/earthy, far/near, light/heavy and wet/dry. In an actual red, meanwhile, its warmth combines with other features. An actual red may, for instance, be very warm, medium dark, highly saturated, pure or modulated, and its affordances for signmakers and sign interpreters flow from all these factors, in their specific combination. In the next section we see how such sets of affordances are
actually taken up in a specific context, and what context-specific interests and values are at work in this process.

## 5. HOME DECORATION: COLOUR, CHARACTER AND FASHION

What colours are used in home decoration and why? The answer depends on the socio-cultural context. There have been many different traditions, including, for instance, regional differences, such as the bright blues and greens of the doors and windows of farmhouses in Staphorst, a village in the Netherlands where traditional dress is still worn. But today a new approach has developed, in which the expertise of the colour consultant, and hence also the Romantic discourse of colour whose genesis we sketched earlier, play a key role. According to Lacy (1996) the entrance hall of a home signals the identity of its owner or owners:

> A yellow entrance hall usually indicates a person who has ideas and a wide field of interests. A home belonging to an academic would probably contain a distinctive shade of yellow as this colour is associated with the intellect, ideas and a searching mind .... A green entrance hall - say, a warm apple green - indicates a home in which children, family and pets are held in high importance ... A blue entrance hall indicates a place in which people have strong opinions there could be a tendency to appear aloof as they can be absorbed too much in their own world.

In expert discourse of this kind the colours of a home above all express character, express the identity, the personal characteristics, and the values and interests of the home owner or owners. As we have seen, the colours of work places (and prisons, schools, etc.) are more often discussed in terms of their effects on workers (prisoners, students etc.).

Most people will encounter this discourse in magazines and in television 'makeover' programmes, where it is mediated by journalists, although the expertise of colour consultants and interior decorators is often explicitly drawn on. Home decoration magazine features and television programmes therefore invariably start by introducing the home owner or owners, who may be celebrities or ordinary people, and then present their solutions to particular redecoration problems as exemplary. In magazines aiming at different sectors of the market different types of home owners or celebrities may be introduced (for instance the owner of a London art gallery versus an actor in a popular soap). Compare the following two quotes:

Her latest habitat (she moves as regularly and happily as a nomad) is surprisingly spare and elegant, as you might expect from someone with a sense of the aesthetic in her genes. After all, Jane's great aunt was Nancy Lancaster, of Colefax and Fowler fame, while her brother,

# Henry Wyndham, is chairman of Sotheby's ... (Ideal Home and 

 Lifestyle, September 1998: 60)Guessing what Hamish and Vanessa Dows do for a living isn't too difficult - a pair of feet on the house numberplate is a dead giveaway for a couple who are both chiropodists, but it's also an indication of the fun they've had decorating their home. (House Beautiful, September 1998: 20)

In the course of such articles colour choice is presented as an original and unique expression of the character and values of the home owners, as fully personal, rather than mediated by social codes. The two fun-loving chiropodists, for instance:

> ... use nearly the whole spectrum in their house, from mustard yellow and leaf green in the sitting room, to brick red and blue in the dining room. Their bedroom is a soft buttery yellow combined with orange, there's lemon and lime in the breakfast room and cornflower and Wedgwood blues on the stairs. 'It's great that there are so many bright shades in the house', says Hamish, 'It's a shame people aren't more adventurous. It's when you start being timid that things go wrong.' (House Beautiful, September 1998: 21)

This shows the reader how colour semiosis can work, but at the same time avoids the suggestion that such models can be slavishly followed, and suggests that colour semiosis should naturally flow from people's unique character and values.

Affordances are taken up accordingly. High colour differentiation and high saturation become signifiers of 'adventurousness', with differentiation standing for the absence of monotony and routine, and saturation for an intensity of feeling, for 'living to the full' and not being 'timid'. Note also the effect of naturalization that flows from the use of colour names connoting plants, flowers, and natural foods.

Looking at the actual colours in the illustrations of the article (Figure 1) shows that not all of their distinctive features are explicitly discussed in terms of this discourse. There are, on those bright walls, painted gold leafs and sunflowers which, Hamish and Vanessa say, 'give such a lovely Victorian feel'. Indeed, the photos show a very cluttered interior, with many retro objects, including fringed lampshades and statuettes of servile black servants. But even without the quote and without these objects the provenance of the leafs and sunflowers would be clear. And what is more, the colours themselves may be highly saturated, but they are also relatively dark and relatively impure, certainly by reference to Modernist bright and light interiors and Mondrian type pure colours, and this aspect of the colours, their provenance as 'historic' colours, is not explicitly discussed in the article.


Figure 1 Historic colours (House Beautiful, September 1998).

Such 'historic' colours were very much in fashion in the 1990s:

> The specialist paint firm Farrow \& Ball whose colours were used to recreate 18th and 19th century England in television adaptations of Pride and Prejudice and Middlemarch, reports that its sales have consistently risen by $40 \%$ each year over the past ten years. (Guardian Weekend Magazine, 19 January 2002: 67)

It may be that Hamish and Vanessa's interior is not just an original expression of their character, but also follows fashion, and also takes its cues from the media. It may be that Hamish and Vanessa not only use the affordances of the distinctive features of colour to express their unique interests and values, but also base their choice of colour on 'provenance', and thereby also express the values of the place, or rather time, where these colours come from. It may be that through the way they decorate their home, they symbolically identify with the values of that era, and with that nostalgia for a 'lost' Englishness which has been so salient throughout the 1990s, and which in this article is expressed in a covert way in which colour nevertheless plays an absolutely crucial role. It may also be that they do so in a way that is not uniquely their own, but socially constructed in and through the media.

## 6. COLOUR SCHEMES

In this final section we look at two further examples. One is a full-page advertisement which appeared in a Sunday supplement magazine (Figure 2); the other is a promotional leaflet for a major UK publisher.


Figure 2 Pashmina cashmere treasures (Observer Magazine,

September 2001).

All signs have to have a 'site of appearance'. The advertisement, for instance, appears in a Sunday newspaper 'colour supplement', and this entails not just a certain readership, but also a certain disposition on the part of the readership: relaxed, at ease, at home, at leisure. We are in the domain of indulgence, of self-pampering. (In fact, the term 'colour supplement', possibly somewhat quaint now, comes from the era when the use of colour was rare in newspapers, and its use therefore 'set a tone'). The commodity advertised belongs to this domain - a (relatively) newly fashionable and exotic material, Pashmina - as does the garment, a shawl (not - note - a scarf). The verbal description which glosses the product provides a range of signs which further suggest and circumscribe what the signs made through colour can be:

Now these supreme quality, soft as a whisper, pashmina cashmere treasures represent even better value for money with no compromise on quality

The Classic is a hand spun and woven mix of finest Himalayan Pashm - the soft under fur from the diminutive Capra Hircus goat - and pure silk. Lightweight yet warm, they make the ideal accessory. (emphases added)

Signs in the other modes, fabrics and the body - realized as texture, textile and fashion, and as signs of femininity, both expressed visually - act in the same direction. The garment is worn by a woman with long dark blonde, wavy hair, perfect slightly tanned skin, a heavy bracelet on her wrist, and long carefully tended fingernails. Everything about her speaks of sensuousness bordering on voluptuousness and eroticism. She wears the shawl in a manner that accentuates its softness, its 'warmness' yet lightness, falling in long smooth drapes from her right shoulder. Many of the features mentioned in the verbal description are repeated in the visual mode. The written mode and the visual mode reinforce each other (we avoid the term 'illustration', because each of the two modes makes a statement in its terms of one coherent set of meanings). Both sets jointly provide a semantic-semiotic environment that frames and predicts the meanings of the colours that appear. This environment of course also 'structures' - or is meant to structure - the kinds of signs to be made by the readers of the advertisement, and by the potential consumers of the commodity.

The Pashmina worn by the model is of necessity in a particular colour; called 'myrtle' in the accompanying colour chart. There is a colour harmony across the advertisement, in that the word 'perfect' in the top lefthand corner is printed in 'myrtle', and the top-right corner of the colour chart - located at the bottom right of the advertisement - has the colour square for 'myrtle'. The model's lips are painted in a less saturated form of 'myrtle', and there seem to be tiny highlights of this colour in her hair. The
background has a faint wash of the same colour. It strongly suggests that the essential qualities of the Pashmina shawl are best realized by 'myrtle', or, conversely, that ' $m y r t l e$ ' best embodies the meanings of the fabric and of the shawl. Colour is one of the potent signifiers of the complex of meanings which the makers of the product wish to see clustered around their product. Of course, 'myrtle' is an invented name for the colour, which might otherwise have been called something like 'plum', or 'fuchsia' perhaps. The name 'myrtle' itself brings with it certain kinds of exotic meanings, which neither 'plum' nor 'fuchsia' would - they would invoke other discourses, other domains.

In this instance it is possible to see colour as the sign of a complex of discourses around femininity, luxury, opulence and an exotic quality invoking certain western notions of 'the East'. We could ask at this point whether the product would have been equally well represented by any of the other colours in the range, such as 'aqua frost', or 'shocking' or 'argent'. But this is to focus on one single colour - though in this instance, the colour occurring in the context of all the other signs made in the other modes in its site of appearance, the advertisement. We think that the signs we have mentioned cohere semiotically and discursively - even though a number of distinct modes are used, and distinct discourses have been brought into conjunction here.

There is, however, the colour chart at the bottom right of the advertisement page. We briefly focus on three aspects of this chart: its internal order and coherence, the names of the colours, and the selection of colours themselves. First, its ordering. Unlike many colour charts this is not organized by hue. This might be a first indication of the specificity of the social domain - we are not in the domain of, let's say, household paint. The organization of this chart therefore does not have to observe the practical needs of the maker and user of household paints - even though those needs are also heavily shaped by discourses around taste and lifestyle as they emerge in the practices of interior or exterior design. And though the organization of the chart is traditional - a rectangular display of squares of colour - its internal organization is not. It seems to be rigorously 'disorganized' in fact, both in terms of the arrangement of the hues, and in terms of the provenance of the names. What need or function might this disorganization express?

Organization and coherence of the kind displayed by a 'traditional' colour chart can also be the signifier for meanings of order and orderliness, regulation - the very opposite in some senses of abundance and opulence. The dis-organization of the chart requires work from the reader/viewer, namely the kind of work that is entailed in 'rummaging around' in a rich collection of things, the work of finding, out of all the riches that are offered, the 'treasure' that you may wish to find for yourself. This chart is a collection rather than a system. If it were (already) organized by hue, then the invitation in the caption above the chart, 'And you can choose from these twenty one
wonderful colours', would have a different force. The dis-organized chart makes colour more colourful through contrast; whereas the organization by hues makes colour orderly, the orderliness both of nature and of physics.

The provenance of the names is a further feature. In an entirely unsystematic test we elicited a range of colour terms for the colour here called 'myrtle', including 'lilac', 'dark pink', 'plum', 'fuchsia' and 'magenta'. Each of these names brings with it the meanings of the domain from which it derives for the namer of the colour. Here there are a number of domains: food and drink of a certain kind (choc chip, cappuccino, glace?, soft olive?); plants, flowers, fruits (myrtle, rosehip, periwinkle, hyacinth, lilac haze, cranberry, soft olive); and 'fashion' - for want of a better category - (baby pink, shocking, baby blue, argent, aqua frost), etc. We find it difficult to find coherence, semiotically-semantically speaking, across these domains. If these colour names indicate, as no doubt they do, a lexical/semantic field, it is difficult to discover its principles of coherence. But maybe as with disorganization, here too in-coherence is a means of indicating 'wealth of domains' of taste. Maybe here too the signified is 'abundance', and what seems like incoherence is used to signify openness.

The question around the 'grammar of colour' arises at this point. Are there domains or names that would prove disturbing - 'ungrammatical' - in this chart? Would 'creamy white' disturb, or 'vanilla yellow'? Would 'steely blue', or 'chrome'? It is around such questions that the integrity and coherence of the domain could be discovered; as indeed it could by attempting to reconstruct this advertisement by altering the existing colour harmony. If 'aqua frost' had been used for the word 'perfect' and 'shocking' as a wash for the background, what would be the effect for the meaning both of the colours and the product? Just as speakers and writers have a developed sense (we want to avoid 'rule') of the potentials of collocation in spoken or written texts, we expect to find - indeed we have found and do find, as here such a 'sense' with the mode of colour. Where such a sense of what can readily go with what exists, we believe we are in the domain of grammar in the broad sense.

There is grammar in the syntagms constructed with the colour 'myrtle': the colour cohesion, the syntagm made through colour with its sites of appearance. There is also grammar in the sense of the syntagms that are produced across modes, the homology of word and colour, of textile word and colour, of model, colour, word.

The domains of colour brought together here - both in the selection of hues (and their degrees of saturation) and in the names indicating domains of provenance - leaves its effect on the potentials for the use of the resource of the mode of colour. Just as each instance of the use of linguistic entity - whether words or genres or clause types - changes the potentials of linguistic modes, so the use made here of the mode of colour leaves its effect on the potential uses of these colours, even if slight.

As a second example we look at a pamphlet produced to describe and

explain the corporate identity change of a major publishing house in the UK (Figure 3). A number of modes are involved - colour, typeface, icons of several kinds. The pamphlet briefly describes the function of each. In the case of colour, a caption states: 'The colour palette provides a harmonious selection of 16 colours, all carefully chosen to complement the corporate colour Palgrave silver, and they should be used wherever possible.' So the deliberateness and intent are clear. Rather than the traditional layout of the colour chart, here the corporate colour is central, to indicate its status and role, and the subsidiary colours cluster around in a regular display. This is already grammatical, in the sense of indicating hierarchical ordering. The clustering is organized - in part - on the principle of gradations in hue, though given the colours chosen, this cannot be achieved entirely in the manner of the traditional chart - there are gaps. It also invites different kinds of use to that of the advertisement: not selection according to the individual's taste, from the openness and abundance of the riches displayed, but the orderliness of those who will use this to reproduce the corporate identity. The choices are individually determined in the case of the shawl, and they are institutionally determined in the case of the colours in the pamphlet.

Here it is clear that coherence has been deliberately aimed for: all the hues have to be able to collocate with the corporate colour, in its support. There is, consequently, already a strong sense of grammar - both in the explicit hierarchy of colours, and in the delimiting of the range of permissible 'units'. In the case of the Pashmina advertisement one knows that the colours of the chart are the colours in which the shawls are available but one feels that others could be introduced as well - for if 'cappuccino', then why not 'latte', for instance, or if 'hot coral', then why not 'island green'? With the Palgrave colours the possibility of extension is not opened up; it neither suggests itself, nor does it exist as a possibility.

Comparing the two colour charts, what is astonishing is the great degree of agreement in the colours chosen. The one major difference is the absence of yellow (note our earlier comments on the 'vanilla yellow'), the presence of which changes the overall effect of the 'colour scheme'; the introduction of yellow brightens the Palgrave scheme. Its introduction in effect makes all the colours in its palette different in their meaningpotentials. It puts into this culturally given colour palette an accent of the sharp, the bright, the up-beat, in the words of the pamphlet 'active pursuit of ideas', 'rapid change', 'a world of challenges to be met', 'a new company and a global force in publishing', etc. These are realizations of very different discourses to those of the Pashmina advertisements. Yet the only clear difference is the addition of the yellow, for even the central corporate Palgrave silver is in effect there in the Pashmina chart, where it is called 'argent'.

This congruence draws attention to the fact that today colours - in part as a result of the developments we have outlined in section 3 of this article - are colours in a 'colour scheme', colours in systems of colour which can be defined on the basis of specific uses of the distinctive features we have discussed. We have come across several such schemes in the course of this article: the 'historic' colour scheme, based on differentiation, relatively high saturation and dark value; the modernist 'Mondrian' colour scheme, based on purity and high saturation; the postmodern colour scheme, based on hybridity and pastel values. All these colour schemes have distinct historical placements. But they live on beyond their historical period as recognized semiotic resources which can continue to be used and combined (the bright yellow accent in the overall postmodern scheme of Palgrave) to realize distinctly different ideological positions.

Such colour schemes, and the colours that belong to them, make reference to grammar (that is, to regularities), to the social in the form of discourses and their arrangements in ideological form. Yet, as the two examples here have shown, they are taken up differently in different contexts, where, in their combination with the specifics of the site of appearance and the way they are combined with other modes, they realize different meanings, different uses and distinctly different ideological positions.

## NOTE

1. This historical account relies largely on the work of Gage (1993, 1999).

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