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Introspection and subliminal perception

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Abstract. Subliminal perception (SP) is today considered a well-supported theory stating that perception can occur without conscious awareness and have a significant impact on later behaviour and thought. In this article, we first present and discuss different approaches to the study of SP. In doing this, we claim that most approaches are based on a dichotomic measure of awareness. Drawing upon recent advances and discussions in the study of introspection and phenomenological psychology, we argue for both the possibility and necessity of using an elaborated measure of subjective states. In the second part of the article, we present findings where these considerations are implemented in an empirical study. The results and implications are discussed in detail, both with reference to SP, and in relation to the more general problem of using elaborate introspective reports as data in relation to studies of cognition.

Key words: blindsight, introspection, nonconscious perception, Riddoch syndrome, residual phenomenality

Introduction

For many years, cognitive science has been interested in the question whether a stimulus is perceived even when there is no awareness of it. In itself, the idea that perception can occur without conscious awareness – and have a significant impact on later behaviour and thought – strikes many as counterintuitive. Given this, any finding that supports the notion of unconscious perception attracts attention, because it challenges the intuitive notion that consciousness is necessary for perception.[1]

In the first part of this article, we will present and discuss the basic idea behind the study of subliminal perception (SP). The scientific framework of SP is based on a variety of approaches, but here we will outline and discuss a few basic approaches that represent the vast majority of studies. Of central importance in these studies is the use of so-called contrastive analysis (CA) (Baars 1994) in which subjects participating in an experiment are told to report whether they have an experience of the stimulus or not. This results in a dichotomic measure of a person's mental state during a perceptual task. Drawing upon recent advances and discussions in the study of introspection and phenomenological psychology, we argue for the possibility and necessity of using an elaborated measure of subjective states, where subjects are

given less restrained conditions to report their experiences. Such an approach might potentially yield additional or even contradictory information to the contrastive approach.

In this line of arguing, we will present different cases where the CA is used, from studies of healthy volunteers and brain-injured patients to studies of unconscious states. Though the general interpretation of such studies is that the patients show so-called residual functions despite lack of conscious awareness, recent findings nevertheless argue for the possibility of what we will call 'residual phenomenality'. We argue that in some cases, the existence of many abnormal states – often thought of as showing unconscious processing – indicates that subjects have some level of awareness of stimuli.

In the second part, we provide a detailed report of an experimental procedure where subjects underwent a standard test of SP, but were using multiple categories for reporting their experience of the stimulus and its different features. The results and implications are discussed in detail, both with reference to SP, and in relation to the more general problem of using elaborate introspective reports as data in relation to studies of cognition.

The basics of subliminal perception

Studies of unconscious perceptual processes were initially performed with the use of introspective accounts, where subjects were to report whether a stimulus was consciously perceived or not. In an early study by Sidis (1898), subjects were shown small cardboard cards, each containing a single printed letter or digit. The distance between the subjects and the cards was such that the subjects often complained that all they could see on each card was a dim, blurred spot or nothing at all. Based on this, Sidis assumed that the subjects were unaware of perceiving either digits or letters. However, when he used a second measure, forced-choice guessing, he discovered that his subjects were able to guess the category of the card (digit or letter). Furthermore, he discovered that the subjects were better than chance at guessing the precise identity of the card. Thus, Sidis uncovered a dissociation between two measures of perception. The subjective, verbal measure from the subjects suggested that they did not 'see' the critical stimuli, while the behavioural measures from forced-choice guessing suggested that the subjects indeed had perceived the stimuli. Hence, the findings also provoked a theoretical discussion about the relationship between perception and consciousness.

However, many researchers felt uncomfortable with the idea that the concepts 'conscious' and 'unconscious' were subjectively defined. It is difficult, they argued, to know which criteria subjects might use when reporting their experiences (Dixon 1971; Kihlstrom 1987; Merikle 1984). The subjects' preconceived ideas about consciousness, as well as the division between conscious and unconscious states, could very likely affect their reports.

In the 1970s and 1980s, a so-called objective measure for studying unconscious perception was developed. It was based on a number of studies in which subjects, while not being able to discriminate between alternative stimuli, gave suggestive evidence that the stimuli nonetheless had an impact on the their behaviour (Farah 1989; Marcel 1983; Stambrook and Martin 1983). The new interest in unconscious perception was founded on an operationalisation of conscious perception as the ability to discriminate between stimuli. It was assumed that the inability to discriminate between stimuli indicated a complete absence of conscious perception for those stimuli.

As a consequence of these findings, the focus in studies of unconscious perception shifted from subjective measures towards an interest in the behavioural consequences of conscious and unconscious perception. Generally, the results from such studies are said to provide stronger evidence for the existence of unconscious perception than the results of introspective studies (Merikle et al. 2001; Merikle and Joordens 1997a).

However, objective measures have a significant pitfall that prevents us from fully accepting these studies. As Merikle and Daneman argue, it is "always possible to question whether any particular behavioural measure is an exhaustive measure of ALL relevant conscious experiences" (1998a, p. 8). There might be significant aspects of conscious experience that are not captured by the behavioural measures. In addition, whether or not one attempts to avoid discussing phenomenality in these cases, it proves hard to deny that the entire discussion of SP is, in the end, based on the phenomenal properties of the perceptual states. That is, when using behavioural measures for studying SP, it nevertheless depends on one or another conception and definition of what is conscious and what is not. Otherwise, one might question what we refer to with the very term 'subliminal'?

We are left with two insufficient but not mutually exclusive methods for studying unconscious perception. Merikle and Daneman provide the obvious conclusion that both methods should be used together, on different aspects of a given experimental study. In this way, they suggest, one should use introspective reports to distinguish conscious from unconscious perception, and then study whether these reports relate to different (e.g., biological, physiological) consequences with the use of objective measures.

In this respect, it is interesting to return to the Sidis' findings (1898), which were also supported by other researchers (Peirce and Jastrow 1884; Stroh et al. 1908). Of particular interest is the fact that the subjective reports of Sidis' subjects cannot be fitted into a simple dichotomy between conscious and unconscious perception. Subjects said they sometimes had *some sort of experience of the stimulus* (a blurred dot or spot). What they were not conscious of was the exact property of the stimulus. Rather, they had some sort of experience, which, of course, is very different from not having any experience at all. Nevertheless, this fact seems to have been ignored to the

advantage of a focus on SP, where stimulus awareness typically was said to be non-existing. Even to this day, it seems that the findings of Sidis and his peers have not been fully addressed. Instead, cognitive science used objective measures of perception. This approach is still dominant in the study of SP.

Methods of studying subliminal perception

The central hypothesis in most studies on SP is that stimuli presented below the subjective threshold – when subjects report they have had no experience of the stimulus – nevertheless have a significant effect on subsequent behaviour, such as making forced choices between a limited set of possible answers (Merikle and Daneman 1998b). Although other measures of subliminal effects, such as galvanic skin responses (GSR) do not make explicit use of introspective reports, the methods are still based on a conceptual dichotomy between conscious and unconscious perception. Therefore, studying GSR during very brief presentations never experienced by the subjects is still contrasted to conscious perception. This approach, however, is a very superficial one compared to the phenomenal descriptions given by the subjects in Sidis' experiment. Similarly, it is superficial compared to our personal visual experiences. Visual experiences seem much more complicated than what is captured by using just the two categories 'clear, vivid experiences' and 'nothing at all'. Thus, the rest of this article is an attempt to implement our considerations into empirical designs, hereunder a study recently performed by the authors.

In the majority of studies investigating perception without awareness, the main idea is to dissociate two measures of perception: Perception with or without conscious awareness (e.g., Merikle and Joordens 1997b). This has been addressed in a number of different approaches, which can be divided into two general categories: SP during normal states and SP during abnormal states. Here, we will present examples of both kinds of conditions.

Subliminal perception in healthy individuals

In presenting a stimulus below or at the threshold of conscious awareness, studies on healthy subjects use many different approaches. For example, in 1980 Kunst-Wilson and Zajonc reported a study where subjects were presented with 10 meaningless, irregular, geometric shapes. Each presentation was given five times for 1 ms each time. No subject ever reported seeing any of the shapes. By using a forced-choice recognition task (i.e., a measure of awareness of the stimuli) and a forced-choice preference task (i.e., a measure of unconscious perception), Kunst-Wilson and Zajonc demonstrated that subjects performed

significantly better than chance at guessing (the forced-choice preference task) the identity of the stimuli. In contrast, the performance on the forced-choice recognition task was not significantly better than chance.

Another approach in studying SP in healthy subjects is the earlier mentioned study of GSR for stimuli presented below the threshold of conscious detection. In a typical experimental procedure, Kotze and Moller (1990) presented emotional and neutral words subliminally while recording the GSR. Their results showed a significant increase in GSR response for emotional but not for neutral words. The authors conclude that their results confirm the hypothesis that auditory subliminal stimulation would produce an increase in the GSR. In effect, these studies demonstrate that even complex stimuli (such as words and faces) can be processed outside awareness.

SP has also been reported in special states in normal subjects. For example, Merikle and Daneman (1998b) wanted to find out whether SP is possible during unconscious states such as generalised anaesthesia. Anaesthesia is a term for the medical induction of unconsciousness during surgery, measured by the inaccessibility during the stimulus period and a lack of explicit, episodic memory for material presented during the period. During surgery, Merikle and Daneman gave their patients earphones and a tape recording of repetitions of a series of words. Following surgery, the patients were presented word stems such as *gui__*or *pro__*and asked to complete these stems to produce a common English word. While these word stems have many possible completions, patients more often used stems of words presented during general anaesthesia (e.g., 'guide' and 'proud'). Merikle and Daneman conclude that "memory for specific stimuli presented during anaesthesia shows that information is at times perceived without any awareness of perceiving during general anaesthesia" (2000, p. 498).

Response options

A variety of response options have been used in the study of SP, such as forced-choice discriminations among a small number of stimulus alternatives (e.g., Avant and Thieman 1985; Cheesman and Merikle 1984, 1986; Purcell et al. 1983), forced-choice, presence–absence decisions (e.g., Balota 1983; Fowler et al. 1981; Groege 1984, 1988; Kemp-Wheeler and Hill 1988; Marcel 1980, 1983), stimulus identification (e.g., Hines et al. 1986; McCauley et al. 1980), and forced-choice spatial or temporal localisation decisions (e.g., Greenwald et al. 1985; Groeger 1988). The general picture in these studies is that of the subject, while being unable to report awareness of the stimuli, nevertheless demonstrates an ability to distinguish the correct stimulus from a narrow variety of options.

Subliminal perception in brain injury

In addition to studying healthy volunteers, many approaches have also documented subliminal effects in a variety of pathological states. Though they represent different aetiologies and symptoms, the general picture in terms of SP is the same: stimuli that are not perceived consciously nevertheless have significant impact on subsequent forced-choice behaviour. Here, we present two cases of brain injury, prosopagnosia and blindsight.

Prosopagnosia

Prosopagnosia is a neurological condition rendering a person incapable of recognising faces, while still being able to distinguish faces from other objects. The syndrome is frequently associated with bilateral lesions to the temporal and occipital lobes, caused by multiple strokes, head trauma, encephalitis, or poisoning (Farah 1994). While these patients claim to have no recognition of a face, several studies repeatedly demonstrate residual functioning in face recognition. For example, in a classic study, Tranel and Damasio (1985) demonstrated that prosopagnosics "generated frequent and large electrodermal skin conductance responses [as measured with GSR] to faces of persons they had previously known but were now unable to recognize" (p. 1453). This kind of response did not appear for unknown faces. In other words, the prosopagnosics, while claiming no recognition of familiar faces, nevertheless showed an emotional, psychophysiological response.

In another study, Bauer (1984) conducted a case study in which a patient was shown two sets of faces, one of celebrities and the other of familiar faces. After each presentation of faces, he was given a series of five names, one of which was correct. While performing at chance levels at guessing the right name for each picture, electrodermal (GSR) responses provided a more accurate discrimination between correct and incorrect names. This suggests that the patient 'recognised' facial identity at the psychophysiological level, while being unable to do so at an explicit, phenomenal level. Furthermore, the findings from prosopagnosics demonstrate that even complex stimuli can be processed outside awareness.

Blindsight

When subjected to damage to the primary visual cortex, people will not be able to see stimuli presented to certain areas of the visual field. At the same time, evidence has been accumulating that hemianopic human subjects and monkeys possess wide-ranging residual visual capacities or 'blindsight' in the blind part of their visual field (Ptito et al. 2001). The term 'blindsight' was originally coined by Weiskrantz in 1986. It was believed that subcortical

networks with interhemispheric connections provide a plausible anatomy on which the behavioural results could rest. Fendrich and his colleagues questioned this idea (Fendrich et al. 2000) and claimed that blindsight can be explained by preserved islands of function within the striate cortex. Small eye movements, they argue, can enable a stimulus to move within the functional islands. However, the basic idea on blindsight prevails: Despite claiming not to be able to see stimuli presented in the blind field, patients are nevertheless better than chance at guessing the stimulus properties.

More recently, Marcel (1998) gave two patients with homonymous right hemianopsias a number of tests of conscious and non-conscious shape perception. In six different experiments Marcel demonstrated that blindsight patients perceive even complex aspects of visual shapes in the blind field. Both relate to the previously mentioned findings from normal subjects and from prosopagnosics, which demonstrate that SP is possible for complex stimuli.

Some researchers have questioned whether blindsight is a special or abnormal case. In a study of healthy volunteers, Kolb and Braun (1995) used a standard form of texture segmentation task, presenting the subjects with a background of oriented elements. In this array, they also presented a smaller sub-array whose elements were oriented at right angles to the background elements. On each trial, the subjects were to identify which of four quadrants contained the target area. Furthermore, they had to rate on a scale from 1 to 10 their confidence that the choice of target location was correct. In the standard procedure, Kolb and Braun demonstrated a high correlation between the rated confidence and actual performance – the subjects knew what they were doing (Georgeson 1997). The subjects' confidence was high when responses were correct, and low when incorrect.

However, in two modifications of the standard task, Kolb and Braun found that their subjects performed equally well (around 70–75% correct, where 25% is chance) but *did not know what they were doing*. In one of these experiments, the stimuli were presented to one eye only in a binocular rivalry paradigm. By summing the two eyes' images, the authors were able to eliminate conscious awareness of the target stimulus. Using the same procedure for reporting and forced choice, Kolb and Braun demonstrated that while subjects reported no awareness of the target area and claimed to be 'guessing', they were significantly better than chance at guessing the correct location of the stimulus. Kolb and Braun conclude that "binocular fusion of orthogonally oriented elements conceals a target from visual awareness but does not prevent its localization" (p. 337).

It is noteworthy that Kolb and Braun used a specifically constructed scale to be used by the subjects in their reports of confidence in their guesses. First, it is not clear why the authors chose to use a 10-point scale, instead of, say, a 5- or 20-point scale. In their article, the authors do not present any discussion about this choice. Second, Kolb and Braun define consciousness as 'knowing

what you are doing', in other words what can be thought of as a higher-order thought (Rosenthal 2000a, 2000b). In our view, there is little or no validity in the claim of equality between certainty of one's report and the level of conscious awareness of a perceptual process. Thus, we think that the Kolb and Braun 10-point scale of certainty is related but not identical to one's level of awareness of a stimulus. In line with this reasoning, there seems to be a need for a rating scale directed specifically at the awareness of a stimulus.

Signs of residual phenomenality

In addition to the problems associated with the Kolb and Braun study, several authors have questioned the claim that hemianopic patients are unconscious of stimuli presented in their blind field. Zeki and Ffytche (1998) document both early and recent studies of blindsight that demonstrate preserved awareness in the blind field in blindsight patients. The authors name the phenomenon the Riddoch syndrome, after a military doctor who in 1917 claimed that soldiers suffering from damage to the primary visual cortex still had vague feelings of stimuli presented to their blind visual field. Building upon Riddoch's claims, Zeki and Ffytche studied a patient, G.Y., who was hemianopic after a lesion to the primary visual cortex (area V1). Typically, G.Y claimed to have vague feelings of stimuli presented to his blind visual field, comparing this to moving his hand in front of his eyes while they are closed. In their 1998 article, Zeki and Ffytche propose a model of the relationship between visual discrimination and awareness, where a lesion to the V1 leads to the uncoupling of the two capacities. This leads to two separate phenomena, gnosanopsia (awareness without discrimination) and agnosopsia (discrimination without awareness). The latter is in reference to the traditional blindsight phenomenon. Presenting their patient with moving stimuli in different parts of the visual field, the authors demonstrate that in agnosopsia, activity in V5 is less intense than in gnosanopsia. This leads them to propose that there is a straightforward relationship between awareness and activity in the primary sensory cortices and the reticular-activating system.

It is worth noting that instead of asking G.Y. to report his experience of the visual stimuli in a dichotomic fashion ('seen – unseen'), Zeki and Ffytche constructed four categories of answers, as can be seen in Table 1. In the study, G.Y. and normal control subjects were required to make two separate responses; one to report the direction of the moving target, the other to indicate the awareness of the stimulus by the scale.

The scale captures the essence of G.Y.'s residual awareness in his blind field, when he describes it as 'dark and shadowy', a 'feeling of something happening', or as 'a black shadow moving on a black background' (Zeki and Ffytche 1998, pp. 29–30), all in line with the reports from Riddoch's early findings. Essential to this finding is that these kinds of experiences cannot fit

Table 1. Categories of response in Zeki and Ffytche (1998).

Response	Details	Score
Unaware	There was no feeling of something being there. A total guess	1
Aware	There was a feeling that something was there and guessed the direction	2
	Fairly confident of the direction	3
	Certain about the direction	4

into a dichotomic division between clearly conscious and unconscious perception, as is the usual procedure in consciousness (and blindsight) research. The use of a graded yet specific scale has probably alleviated the subjective reports for the hemianopic patients.

Following Zeki and Ffytche's study, it seems that blindsight, rather than seen as an abrupt disruption of the awareness of stimuli, must be understood as a graded disconnection of two capacities that are normally joined in the normal brain. That is, the Riddoch syndrome demonstrates that at least some hemianopic patients show not only residual functions, but also what we suggest calling *residual phenomenality* – remnant or partial awareness of stimuli in the otherwise blind field.[2]

Construction of a perception awareness scale (PAS)

In addition to alleviating the problem of dichotomic reports in blindsight patients, Zeki and Ffytche's study also points to a general problem in the current methodological considerations in the study of consciousness. We would like to point out the viability of such an approach to other domains of consciousness research, such as the study of subliminal perception. If we accept the claim that a conscious content – even in normal perception – comes in different degrees of clearness, this should be addressed in experimental settings as well. In the literature, these kinds of experiences are often referred to as 'fringe' experiences. Most often, non-sensory fringes are used to describe experiences such as the feeling of rightness and the feeling of knowing, but one can also speak of 'sensory fringes', or so-called 'peripheral-sensory experiences' (Mangan 2001; Norman 2002). While having many features in common with non-sensory fringes, such as low resolution and low intensity, sensory fringes are modality specific, have little or no impact on retrieval, and are of relatively limited scope and resolution capacity in the field of consciousness (Mangan 2001). Sensory fringes are often described as contextual properties of vivid experiences, but also in perception of stimuli that are presented at the threshold for conscious awareness.

Mangan (2001) argues that fringe experiences lack *introspective access*, resulting in their elusive quality. Yet, Mangan argues for the very existence

of fringe experiences not only by referring to third-person measures, but also by contemplating his own experiences: He has a 'feeling' of having fringe experiences. By the term 'introspection' one generally refers to a state in which one directs attention towards one's own experiences. Thus, using a first-person justification of fringe experiences and arguing that one lacks introspective access to them seems self-contradictory. We agree with Mangan in his arguments for the existence of fringe experiences, and, consequently, we will deny his claim that we have no introspective awareness of such states. A given perceptual content may appear in a clearly conscious or a fringe conscious kind of way, both of which can be noticed introspectively as well as non-introspectively. Accordingly, we find no principal argument against asking experimental subjects to introspect on 'vague' or 'blurred' experiential contents.

In describing and reporting sensations in terms of clearness, it is important to make the distinction between *degrees of clearness* and *degrees of certainty* about one's answer. As can be seen in the Zeki and Ffytche categories, this distinction is not made. Here, only the first two categories consist of reports of something that pertains to the experience of the stimulus, while all four categories use reports of certainty about the answer. Also, in the study by Kolb and Braun, the subjects scale their certainty rather than their conscious experience, although conclusions about the latter are made in the theoretical discussion of their findings.

We find it crucial that experiments claiming to be studying awareness (or conscious experience) made explicit use of subjective reports about perceptual awareness. We have no experimental verifications for the hypothesis that there should be a total overlap of what subjects find to be 'a report of which they are certain about its correctness' and 'conscious'. For instance, one could easily imagine subjects reporting themselves 'a little more certain' on the 10-point scale of Kolb and Braun without actually experiencing a clear phenomenal difference between the two instances of perceiving the stimulus. Furthermore, a number of influential authors refer to introspection as a 'separate process' (e.g., Jack and Shallice 2001; Schooler 2002; Lutz et al. 2002), and others even find empirical differences between reports explicitly about awareness and other kinds of reports (Marcel 1993; Overgaard et al. 2001; Overgaard and Sørensen, in press). If this idea proves correct, one should not assume such a total overlap, rather, one should assume the opposite. Even if one wishes to set aside these results, it should at the very least be evident that one cannot *a priori* assume that reports of certainty work as reports of awareness.

Following these speculations, we have constructed a 'perception awareness scale' (PAS) to be used in the study of degrees of awareness of a stimulus. The scale was originally constructed as tentative categories in a pilot study, but it soon became clear that our subjects found the categories both intuitive and easy to use.

An experiment on subliminal perception and introspection

Methods

We asked five subjects, age 22–32 years, with normal or corrected to normal vision, to view a computer screen and report what they saw. The stimuli were brief presentations of simple shapes; triangles, circles and squares, with one of three colours; red, blue and green. There were three possible locations of presentation (df = 2 for each variable). All three locations were 1.45° from the centre; one below to the left, one below to the right and one above. The viewing distance was fixed to 60 cm. The stimuli were presented on a black background, on a 15-in. SVGA colour computer screen (cathode ray tube; resolution 800 × 600) controlled by a 466 MHz CPU. The stimuli were programmed and the timing was controlled using Presentation version 0.40 on a Windows 98 interface. Some of the actual durations had an uncertainty of a few milliseconds. Based on this uncertainty and spread of duration times, we grouped the durations into five clusters, each representing approximately 35.2 ms (i.e., first cluster equals 16–51.2 m; second cluster equals 51.3–86.5 m, etc.).

The sequence of stimuli presentations was randomised, and no combination of form, colour, position and duration was delivered more than once. In all, each subject underwent 324 trials (all possible combinations of form × colour × position for 12 durations). Subjects were to focus on a fixation point (a white cross on black background) that was presented for a randomly selected duration, after which a stimulus was presented for a duration span ranging from 16 to 192 ms, with duration intervals about 16 ms (according to the monitor refresh rate). A mask consisting of all stimulus features merged together followed the presentation of a stimulus at all three possible locations, so that no single stimulus could be recognised (in free-view conditions) even when the stimulus and mask overlapped on the screen.

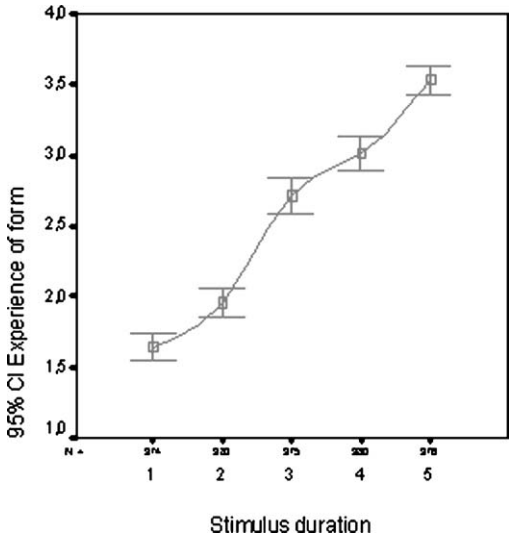
First, the subjects were told to report what they thought was presented, even if they had no experience of the stimulus. All stimulus features were to be reported (shape, colour and position). Second, for each property of the stimulus, they were asked to report the degree of clearness of experience. Here, we suggested that they could use a scaling going from ‘no experience at all’ to ‘a clear image’. The subjects were allowed to create their own categories. In accordance with the previously mentioned pilot study, all subjects ended up using a 4-point scale with the elements: ‘No experience’, ‘brief glimpse’, ‘almost clear image’ and ‘absolutely clear image’. The subjects differed somewhat in their labelling of the categories, but they agreed in their definitions of the categories (see Table 2). Two subjects started out using more than four categories, but in both cases, the extra categories were defined as being between two other categories (with no real definition on their own).

Table 2. A generalisation of all subjects' description of each category based on the interview following the experiments.

Category	Description
No experience	No impression of the stimulus. All answers are seen as mere guesses
Brief glimpse	A feeling that something has been shown. Not characterised by any content, and this cannot be specified any further
Almost clear experience	Ambiguous experience of the stimulus. Some stimulus aspects are experienced more vividly than others. A feeling of almost being certain about one's answer
Clear experience	Non-ambiguous experience of the stimulus. No doubt in one's answer

Furthermore, the subjects made almost no use of those extra categories (see Figure 1).

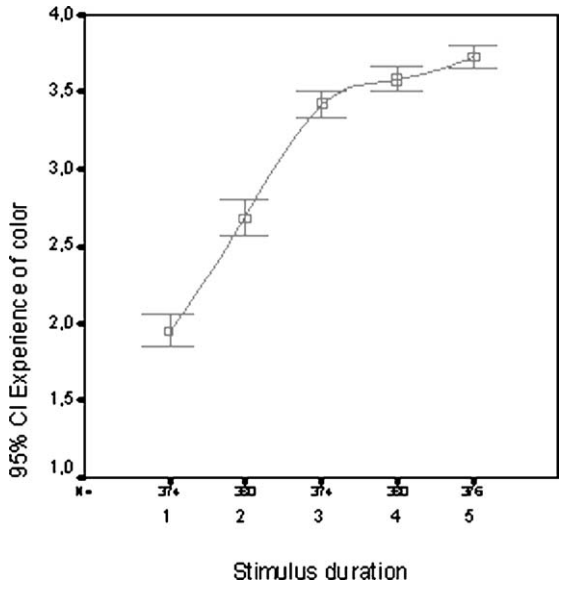
Typically, a subject would report "red square up there (points); the position was clear, the colour was a glimpse, I had no experience of the shape." Reports of the different stimulus features were scored for "clearness" (an ascending scale from 1 to 4, where 1 = "No experience," 2 = "Brief glimpse," 3 = "Almost clear image/experience," and 4 = "Clear image/experience"). After the trial, each response was scored (by the experimenters) for correctness (correct–incorrect).



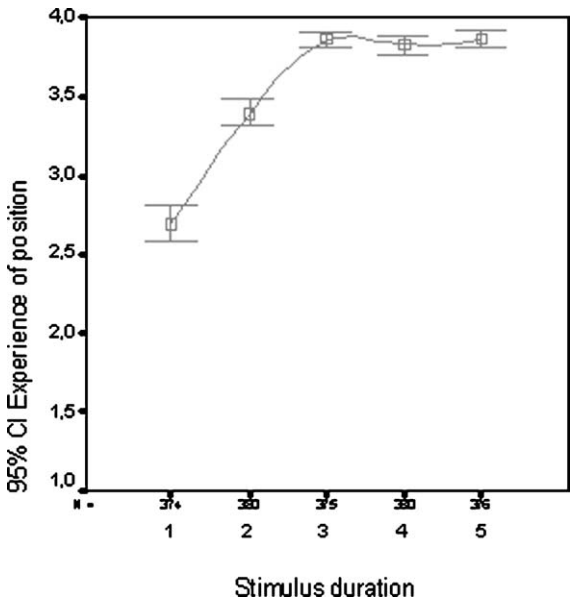
(a)

Figure 1. (a) Confidence interval between stimulus duration and PAS score for shape. (b) Confidence interval between stimulus duration and PAS score for colour. (c) Confidence interval between stimulus duration and PAS score for position.

(*Continued on next page*)



(b)



(c)

Figure 1. (*Continued*)

Results

Tables 3–5 show descriptive data for the reported experience of each of the stimulus properties. Subjects reported having *clear images* more often for stimulus position than for shape ($t = 12.88$, $p < 0.001$) and colour ($t = 5.92$, $p < 0.01$). The subjects also reported having *brief glimpses* more often for stimulus form than for colour ($t = 4.72$, $p < 0.01$) and position ($t = 4.56$, $p = 0.01$). For reports of 'almost clear image' and 'no experience/nothing' there were no significant differences between the stimulus features.

Table 3. Awareness of stimulus shape.

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Mean	S.D.
Nothing	196	102	84	3	99	96.8	61.38
Weak glimpse	122	94	81	130	93	104	18.71
Almost clear image	31	48	40	133	70	64.4	36.65
Clear image	48	154	42	133	94	94.2	44.59
Missing		1			43		

Table 4. Awareness of stimulus colour.

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Mean	S.D.
Nothing	61	59	47	3	89	51.8	28.02
Between 1 and 2					28	5.6	11.20
Weak glimpse	80	26	54	111	38	61.8	30.53
Between 2 and 3			34			6.8	13.60
Almost clear image	66	27	53	27	23	39.2	17.14
Between 3 and 4	2					0.4	0.80
Clear image	187	286	59	258	221	202.2	79.03
Missing		1					

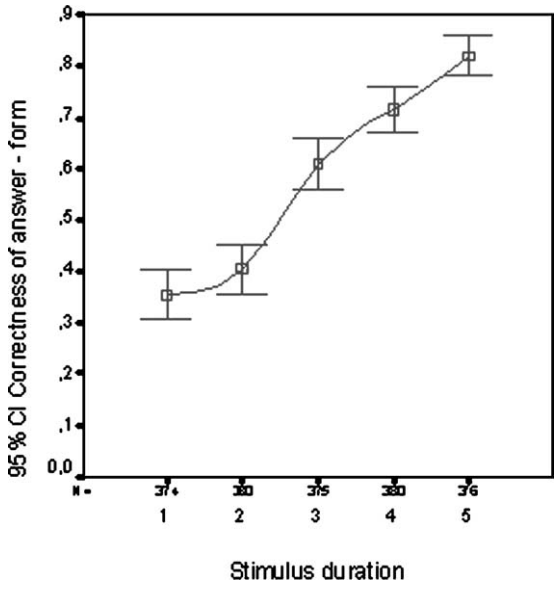
Table 5. Awareness of stimulus position.

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Mean	S.D.
Nothing	9	17	18	2	38	16.8	12.09
Between 1 and 2					14	2.8	5.6
Weak glimpse	89	4	30	35	58	43.2	28.62
Between 2 and 3			14			2.8	5.6
Almost clear image	55	11	13	45	23	29.4	17.59
Clear image	244	366	172	317	266	273	65.84
Missing		1					

An analysis of the data demonstrates a significant correlation between stimulus duration and experience of form ($r^k = 0.462$, $p < 0.01$), experience of colour ($r^k = 0.469$, $p < 0.01$), and experience of position ($r^k = 0.405$, $p < 0.01$). In all the cases, p-values are calculated using a general linear model subject-by-subject, repeated measures. Figures 1a–1c display confidence intervals for each relationship. However, in both colour and position, longer stimulus durations failed to show statistically significant differences in PAS score between the durations.

A further analysis shows a significant correlation between stimulus duration and level of correct guesses for form ($r^k = 0.317$, $p < 0.01$), colour ($r^k = 0.263$, $p < 0.01$), and position ($r^k = 0.103$, $p < 0.01$). The p-values were calculated subject-by-subject but were in each case <0.01. Figures 2a–2c display confidence intervals for each relationship. However, in both colour and position, longer stimulus durations failed to show statistically significant differences in correct guesses between the durations.

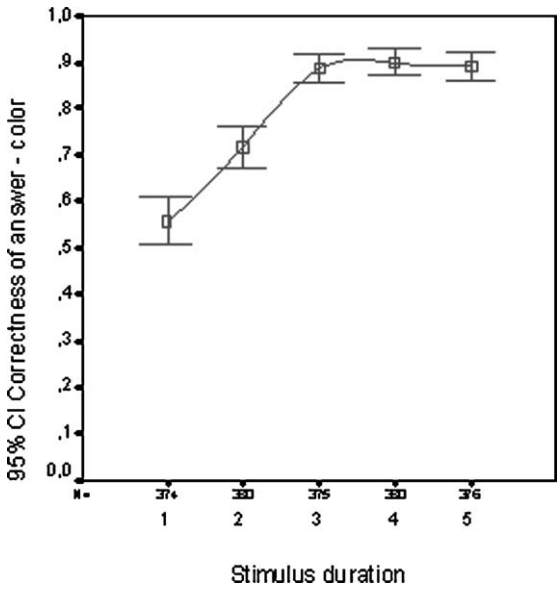
We note that there are possible ceiling effects in both PAS score and correctness in the relationships between durations and colour, and durations and positions. Consequently, we will therefore limit further analysis to the relationship between stimulus duration and the perception of form.



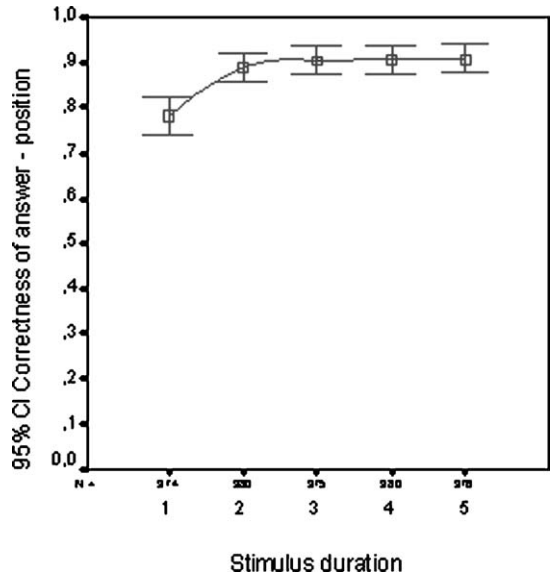
(a)

Figure 2. (a) Confidence interval between stimulus duration and correctness for shape. (b) Confidence interval between stimulus duration and correctness for colour. (c) Confidence interval between stimulus duration and correctness for position.

(*Continued on next page*)



(b)



(c)

Figure 2. (*Continued*)

Perception of shape and correctness

The relationship between PAS score for form and stimulus duration was statistically significant ($r = 0.282$, $p < 0.001$). By assessing the percentage

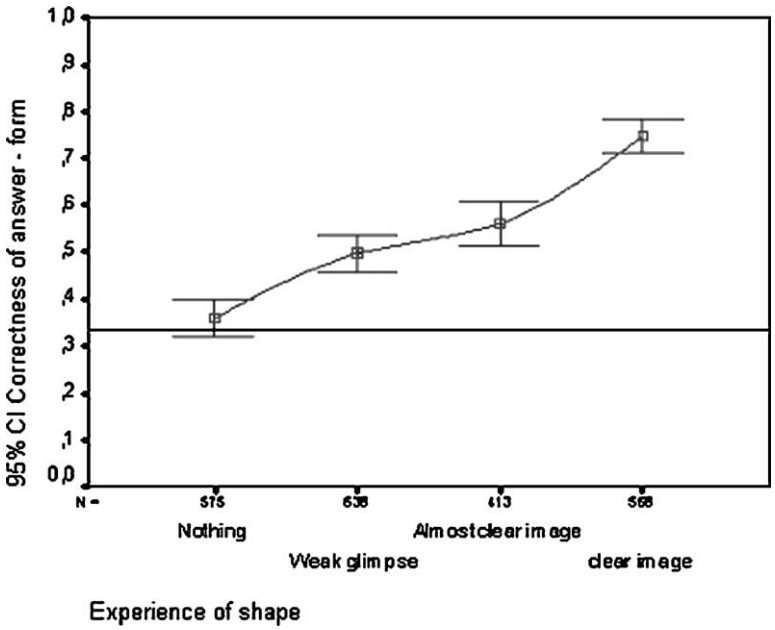


Figure 3. Relation between PAS score for shape and correctness of guesses. Horizontal line indicates chance level for guessing (= 0.33). Note that 'No experience' reports were not accompanied by better than chance levels of guessing.

of correct answers for each degree of clearness, we found that in the perception of stimulus form, the subjects were not significantly better than chance at guessing what was presented. For cases where subjects reported 'brief glimpse' experiences, though, the level of correct guesses rose to a statistically significant level ($p < 0.001$). The proportion of correct guesses grew as a function of the degree of clearness. The findings are illustrated by Figure 3, which shows the confidence intervals of correct responses for each experience category (the form of the stimulus). As shown, "no experience" guesses are not better than chance levels (the 0.33 line) while instances of "weak glimpse" guesses are significantly better than chance level and "no experience" guesses.

Discussion

As an initial precaution, we must point to the fact that even at the shortest stimulus durations subjects seldom reported having 'no experience' of a stimulus' colour or position. Furthermore, as illustrated by Figures 1b and 1c, the level of stimulus awareness (PAS scores) for colour and for position were indistinguishable at longer durations. In other words, we found a ceiling effect

for PAS scores for the experience of colour and position. We found a similar effect in the level of correct guesses. Figures 2b and 2c show that the level of correct guesses for stimulus colour and position were indistinguishable at longer durations. Both these ceiling effects are likely the result of the inability to present stimuli at shorter durations than approximately 16 ms. Furthre research is needed to test for the effects of colour and position experience on the level of correct guesses.

For stimulus form, our data show a positive correlation between the duration of stimuli and the clearness of the subjects' experiences. Each of the stimulus properties – shape, colour and position – show different correlative sets. However, the basic tenet remains; shorter stimulus durations produce gradually weaker experiences. The effects of duration on correctness of guesses demonstrate a similar tendency. For brief durations, subjects' guesses get close to (or they are at) chance level, while longer durations produce higher proportions of correct guesses. The co-variation between level of correctness and stimulus duration was found to be statistically significant.

In terms of stimulus awareness, our study demonstrated a similar tendency; brief exposures produced significantly more 'no experience' and 'brief glimpse' reports than longer stimulus durations. Similarly, longer exposures produced significantly more 'clear experience' and 'almost clear experience' reports.

Furthermore, an analysis of the relationship between correct guesses and level of awareness indicates some relationship between the clearness of experiences and the ability to guess correctly. It would however be too much to say that they rely on identical cognitive or neural processes.

This study has primarily had a focus on the use of a subjective measure of stimulus awareness. Yet, we have claimed that our study pertains to the study of subliminal perception, where verbal reports are used in a dichotomic fashion, as if the stimulus is either perceived or not. The general claim from studies of SP has been that subjects, even when they report being unconscious of a stimulus, are better than chance at guessing about certain features of a stimulus.

How would the results look if we had not given subjects influence on the categories, but forced them into a traditional dichotomy instead? The answer to this question would of course be speculative, but in order to demonstrate our point, we collapsed the 4-point scale into a 2-point scale. Based on our experiences with experimental subjects, we believe that 'brief glimpse' experiences would be reported as 'not experienced' given subjects only had the two options of 'experienced or 'not experienced'. We find it quite straightforward that subjects would report the stimulus as experienced when having 'almost clear experiences'. In this manner, we collapses 1 and 2 on our 4-point scale into the category of 'not experienced' and 3 and 4 into the category of 'experienced' (below).

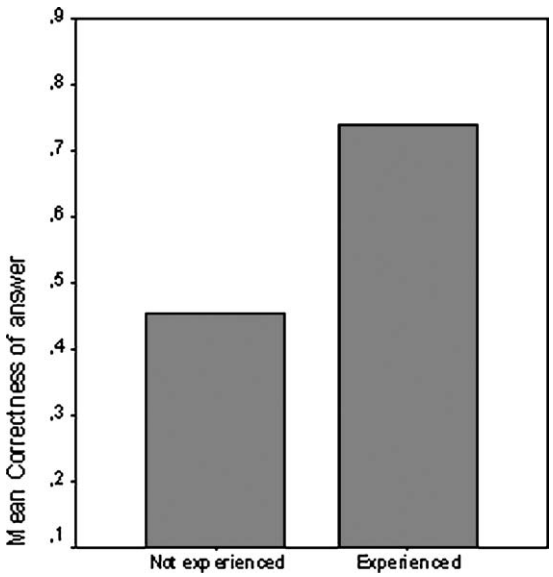


Figure 4. Collapsing PAS into a dichotomy replicates traditional findings in the subliminal perception literature.

Doing this, our data do in fact replicate findings from the traditional literature on subliminal perception (see Figure 4): Both bars show results well above chance level of 0.33. Although it is of course a strong interpretation of these results, we could put forward the claim that subjects who report not being aware of a stimulus, would have shown SP if they had been given a dichotomic instruction.

We believe that our findings demonstrate the importance of an elaborated scale for studying perceptual awareness. Furthermore, we would argue that the traditional use of a dichotomic measure of stimulus awareness is a source for missing vital information about the phenomenal aspect of perception. Thus, the consequence of this analysis points to the possibility that a proportion of studies claiming to find subliminal effects are invalid. Our perception awareness scale seems to be a viable remedy to assess this problem, and we suggest a series of replication experiments on the study of subliminal perception using our or a related methodology for subjective reporting.

Conclusion

In this study, we used subjective measures to assess the level of awareness of stimuli features. The use of similar scales of awareness has precedence

in the literature. However, we have provided a brief analysis of these approaches following which we propose an alternative scale for assessing stimulus awareness with an explicit reference to experience. This is in opposition to other scales referring to certainty about the correctness of the report. In addition, we sought a scale that was intuitive and easy to use for the subjects.

In this study, we have demonstrated that the use of a perception awareness scale can reflect aspects of subjects' stimulus perception not normally documented in the literature. In addition to this, our findings suggest that under certain conditions, claims of subliminal perception may be a result of errors in the assessment of subjects' level of awareness. In this way, we suggest that vital information and knowledge is potentially lost by using a traditional contrastive, dichotomic analysis. In this way, we claim that the conceptual dichotomy offered by contrastive analysis is insufficient to be used in the study of the mind.

We find it necessary to stress that we do not claim that subliminal perception does not exist. Decades of studies have produced a well-supported knowledge of different aspects of subliminal perception. However, we think that our initial findings are indicative of a methodological problem in traditional research and that contemporary assessment of stimulus awareness is insufficient, and in some cases may lead to erroneous conclusions.

The PAS is an initial attempt to study perception in a non-dichotomic fashion. In doing this, we have chosen to construct a scale based on a pilot experiment with our subjects, as well as the experience with the use of such scales during experiments. At this stage, many unresolved questions emerge, such as whether four categories are optimal for describing the relation between different degrees of clearness in perceiving visual stimuli; and whether the PAS applies to other sense modalities, even to non-sensory experiences such as imagery and dreams. More research is needed to elaborate on the issues presented here.

Notes

1. In the phenomenological tradition perception would imply there being at least a minimal level of conscious awareness. Even in the case of SP one would assume the presence of some kind of sensory experience. However, in the tradition of cognitive science, SP normally implies the complete absence of conscious experience.
2. To our knowledge, neither the prevalence of blindsight in hemianopic patients nor the prevalence of residual phenomenality is known. Future research is needed to assess the relationship between hemianopsia, blindsight and residual phenomenality.

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