From the Laboratory of experimental psychology, University of Leuven

Opposing the direct and the indirect theory in explaining the tunnel effect

By J. P. Wagemans and G. d'Ydewalle

With 2 figures

Introduction

Much has been said and written lately about whether perception is “direct” or “indirect” (e.g. Bruce and Green, 1985; Fodor and Pylyshyn, 1981; Turvey et al., 1981; Ullman, 1980; Wagemans, 1986). But little empirical research has been performed to decide between the two positions. This might be because the discussion can be viewed as a debate between two paradigms. It implies that no crucial experiment is ever possible that will be able to decide between the two approaches. Of course, this does not mean that one can not do any relevant laboratory research. Even Kuhn, who has introduced the term “paradigm” in the philosophy of science (Kuhn, 1970), admits that “in the sciences it is often better to do one’s best with the tools at hand than to pause for contemplation of divergent approaches” (Kuhn, 1977, p. 225).

It is always possible to look for phenomena that one of the two approaches cannot explain or cannot explain as well as the other one. If this kind of research accumulates and corroborates in a certain direction, it might be that in the long run one of the two paradigms (“the winner”) will eventually gain more and more adherents, and the other one (“the loser”) will slowly wither in silence. The experiments reported here are considered as a contribution to that long-term project.

One of the conditions for setting up relevant laboratory experiments is finding a phenomenon that is considered equally valuable by both direct and indirect theories. Perceptual illusions, for example, would not meet this criterion, because the two approaches have different views on the importance of perceptual illusions for the study of perception in general (e.g. on the indirect side: Gregory, 1970; Hochberg, 1978; Rock, 1983; on the direct side: Michaels and Carello, 1981; Shaw and McIntyre, 1974; Shaw et al., 1982). A phenomenon that does meet this condition has been found in the *tunnel effect*, first demonstrated by Wertheimer (1912) and further studied in our laboratory by Michotte and his coworkers (e.g. Burke, 1952; Glynn, 1954; Knops, 1947; Michotte, 1950, 1954; Michotte and Burke, 1951; Michotte, et al. 1964; Sampaio, 1962). When the books and articles of Michotte are read in light of the controversy between the direct and the indirect theories of perception, it becomes clear how often this issue was already touched upon,

implicitly and explicitly. This can be demonstrated by translating some passages of his work: "The generation of movement is thus *experienced directly*. It is not a case of inference nor an interpretation being imposed on the impression of movement; in other words, the 'given' is not a simple representation" (Michotte, 1954, p. 19, translation ours, italics Michotte's). In 1941, Michotte already spoke of "a pure phenomenon of the order of the senses, an *immediate* experience that does not need intellectual elaboration" (Michotte, 1941, p. 301, italics and translation ours). Obviously Michotte anticipated Gibson who was well aware of this: "It is a notable lesson in the convergence of experimental science that such a man as he (Michotte) and such a one as I, from totally different backgrounds, should have found ourselves agreeing so thoroughly and so delightedly . . . We got the same results. This is what counts. It makes one believe in the possibility of getting at the truth" (Gibson, 1967, p. 143).

The name *tunnel effect* stems from a verbal report from one of Wertheimer's subjects who was looking at a stroboscopic movement the path of which was hidden by a screen and who described it "as if (he or she) saw the movement going through a tunnel" (Wertheimer, 1912, p. 224, our translation). More precisely and omitting the constraints of stroboscopic movement, the tunnel effect can be defined as the phenomenal permanence of an object that is moving behind a screen and that suddenly reappears at the other end of it. People describe it as if they "see" the object moving behind the screen, although there is no physical information about it. Gibson (1966a, 1979) and his coworkers (Gibson, et al. 1969; Kaplan, 1969; Reynolds, 1968) have studied it frequently using the general *direct or ecological* approach: The perception of the object behind the screen is based on the visual pickup of the optical information provided by a transformation of progressive occlusion (s. Reynolds, 1968, p. 416). There is thus enough information to specify the existence of an object behind the screen and there is, in consequence, no need to rely on memory, inference, or some other kind of mediating processing. This explanation stands in sharp contrast with the one given by some indirect perceptionists. Rock explicitly relies on inference and "problem solving" (Rock and Gilchrist, 1975; Rock and Sigman, 1973; Sigman and Rock, 1974). Clocksin (1980) and Weir (1978) stress the need for computational processes that can be simulated by the computer. More recently, Kellmann and Spelke (1983) have done some elegant research with small children to demonstrate the dependence of perception on a specific kind of "world knowledge", i.e. knowledge of the object concept. In conclusion, the general contrast between the direct and the indirect theories still holds when they are applied to a concrete phenomenon and specifically the tunnel effect.

Before reporting the method used in the experiments, let us describe the variants of the tunnel effect. In the first one (named *control*, see fig. 1a), the following can be viewed on the monitor. First, nothing is seen at all, except for a pink background; then, suddenly, a purple polygon appears, which will further be called "occluder" (Michotte's usage); next, a small dark-brown square appears at the bottom of the purple occluder at location p_0 and starts moving to the right (the colors were not considered an important factor, but were chosen for purposes of contrast, so that background, the occluder, and the moving objects would be clearly distinguishable); when it reaches p_1 , it is accompanied by a little

square at the upper side of the occluder; from that moment on, both move at the same speed to the right side; when location p_3 is reached, the lower square disappears behind the occluder, which is why it is called "occluder", and the upper one keeps moving to p_4 , where it suddenly disappears. The movement from p_0 to p_4 , which covers a distance of 14 cm, takes about 10 seconds.

Fig. 1. Tunnel effect in the control (a), Occlusion 1 (b) and Occlusion 2 (c) conditions; p indicates the different locations of the moving square

Fig. 2. The stages (a, b and c) of the tunnel effect in the memory condition; p indicates the locations of the moving square

In the second and third variant (*Occlusion 1* and *Occlusion 2*, respectively), the displays look very similar (s. fig. 1b, 1c) but the starting point is somewhat before the occluder and the movement continues to p_5 , so that the subject clearly sees either one large rectangle (fig. 1b for Occlusion 1) or two little squares (fig. 1c for Occlusion 2).

The fourth variant (*memory*) is rather different though (see fig. 2). First, nothing but a pink background; then, a purple polygon appears (the shape of which resembles half of the occluder in the other two conditions, so it is called "half occluder") in the upper half of the monitor screen; next, a small brown square appears from behind the half oc-

occluder and moves to the right until it reaches $p4$ where it suddenly disappears (fig. 2a). The sequence just described is seen three times. Afterwards, the brown squares do not reappear, and the half occluder stands alone until another purple polygon appears in the lower half of the monitor screen. Next, a dark square appears at $p0$ of this lower half occluder and moves rightwards until it disappears behind the half occluder (fig. 2b). This phase is also shown three times. For four seconds, both purple half occluders are immobile and nothing happens. Then, a crucial event occurs: The two half occluders (with identical shapes, differing by a 180 deg rotation) start to move slowly towards each other. In the middle of the screen, they fuse to form the same kind of occluder as was used in the other variants (fig. 2c). After the fusion, which takes about 10 seconds, the subject is shown the control variant (fig. 2d).

In all variants the movement stops randomly at locations $p1$, $p2$, or $p3$ and the subject has to decide as fast as possible whether he or she saw one or two objects moving. Both the answers and reaction times are recorded. It must be stressed that, at $p1$, $p2$, and $p3$, the stimulus information is exactly the same in all variants, but it can be expected that the answers will differ according to what preceded. In the *control* variant the subject receives some ambiguous information: The moving brown thing(s) can be viewed either as one large rectangle or as two small squares. No special predictions are made by the direct and the indirect theories, but a slight tendency towards the seeing of one object is expected because of the Gestalt law of the common fate (Wertheimer, 1923). In the *occlusion* variants, the subject receives clear, disambiguating information: They see either one large rectangle partly occluded by the purple polygon or two small brown squares moving in parallel. Both direct and indirect theories predict that the subject will respond one and two, respectively. The basis for these predictions is quite different though. Direct perceptionists base their prediction on the covering and uncovering of one or two objects, which provide different stimulus information to be picked up or detected directly. On the other hand, indirect perceptionists will argue that people see one or two objects moving because they "remember" that either one or two objects moved behind the screen. The *memory* variant also provides supplementary information, but the disambiguating information must be recalled from the memory because it is contained in a previous display. Indirect theory predicts that people will make use of the memory information and will implicitly or explicitly "reason" as follows: First, there was one small brown object moving across the purple half occluder; next, there was another one, and finally, both half occluders fused, so one and one makes two. As we will see in the General discussion section, the direct theory of perception has some post hoc explanation for the findings of this memory condition, but it can fairly be stated that they would not really predict the results. A caveat is needed here: We do not mean to suggest that a direct theory of perception "predicts" the contrary, namely that observations in the past cannot affect perception in the present. All we want to say is that ecological perceptionists would not set up such conditions as the memory condition. The memory variant is, in fact, designed from within a cognitive framework, which is certainly not shared by ecological perceptionists.

Another typically indirect set of predictions concerns reaction times. From an indirect

framework, it can be predicted that answering in the memory condition will take longer than in the occlusion conditions. In the memory condition, the information has to be picked up from stored knowledge, whereas in the occlusion variants, the necessary information to disambiguate the pattern at $p1$, $p2$, and $p3$ is still present in the short-term memory. Furthermore, some "reasoning" has to occur in the memory variant, and such kind of information processing surely will take time.

Experiment 1

Method

Thirty-six subjects, all first year undergraduate students in psychology at the University of Leuven, participated in the experiment. All were naive concerning perception theory because the experiment was run in the first week of the academic year. They participated in partial fulfillment of a course requirement and received no remuneration.

The subjects performed the trials individually. When the name was typed in the computer, he or she sat down before the monitor and was told to observe what was happening on the screen. The subject viewed the displays on the monitor (48×24 cm) of a personal computer that stood 40 cm away. The subject could give the answers on the keyboard of the same computer, which was placed on the right. Reaction times were registered directly by the computer. When the experimental session was over, the answers and reaction times were printed automatically by a printer that was behind the monitor on another table.

There were three conditions with the subjects being randomly assigned to them. In the control condition, the subject received the above described control variant of the tunnel effect three times. When the observational phase was finished, instructions were given before the response phase started. The subject was informed that the movement would stop at some places and was instructed to decide whether they were seeing one or two objects moving just prior to the stops. This was to be indicated by pressing 1 or 2 on the keyboard as fast as possible. If the subject did not seem to understand, the same instructions were repeated in similar words until the subject said he or she understood it. It was also added that no response was needed at $p4$ (the experimenter pointed at the right place on the screen). The response phase consisted of nine trials in which the moving brown object(s) stopped randomly at $p1$, $p2$, or $p3$. The movement stopped until the subject pressed either the 1 or the 2 button. The randomization process was programmed in such a way that each of the three stop places was used three times in the nine trials. Immediately after the nine response trials, the answers and reaction times were printed by the computer.

In the occlusion condition, the subject received both of the occlusion variants, the order of presentation being counterbalanced. The first sequence of viewing and response phases was identical to the one in the control condition, but the answers and reaction times were not printed after the last trial. Instead subjects received the other occlusion variant followed by the same instructions (abbreviated to avoid redundancies). The results were printed only after both variants were viewed.

In the viewing phase of the memory condition, subjects received the memory variant of the tunnel effect immediately followed by the control variant which was again repeated three times. The subject was then told that the last part of the display would be shown several times more, and the rest of the instructions were given. Everything else was exactly the same as in the control condition.

Results and discussion]

Before going into the details of the results and their interpretation, some methodological remarks are in order. The two variants of the occlusion condition were run within subjects and consequently cannot be analyzed in the same design as the other two between-subjects conditions. Also, the stops were nested within trials, so that the two factors (stops and trials) are not completely orthogonal. For those reasons, the analyses were carried out according to the following principles. First, the occlusion condition is analyzed separately from the other two conditions. Second, a further subdivision is made between analyses with stops and trials as a separate factor, but the results are presented together to avoid redundancies. Some values had to be replaced (22 out of 864). This happened in two cases: When the reaction time was zero (when the subject reacted before the movement had stopped and when an answer was given at $p4$, contrary to the instructions) or when it was greater than 5 seconds (this was interpreted as evidence for the failure to understand the instructions, so they were repeated during the experiment). Those values would seriously distort the analysis and were therefore replaced according to a fixed criterion: Substitution value was chosen in such a way as to continue the tendency present in the subject's data. It must be stressed, however, that only reaction time values had to be replaced and never answer values (1 or 2). The rejection rate was set at $p < .05$ in all analyses, unless indicated otherwise. The reports of one vs. two objects should be treated as categorical data, since averages falling between one and two have no sensible interpretation. Nevertheless, the categorical data were recoded in order to use an ANOVA. For the reader, the data are displayed as categorical, namely as percentages of "two" answers.

Answers in the occlusion condition. The ANOVA on the answers reveals that the proportion of two-answers (59 % and 72 % for Occlusions 1 and 2, respectively) do not differ significantly in the two occlusion variants. Other main effects are also not significant. The interaction effect of order of presentation and occlusion variant is significant: $F(1,10) = 7.93$; $MSe = 0.153$. Paired comparisons reveal that there is a significant difference between Occlusion 1 and Occlusion 2 when the first variant is seen first: 44 % vs. 83 %; $F(1,10) = 8.93$; $MSe = 0.15$. With the reversed order of presentation, the difference is not significant: 74 % vs. 61 % for Occlusion 1 vs. Occlusion 2 (s. tab. I, Part A). This can be interpreted as follows: Once the display is seen as the parallel movement of two objects (Occlusion 2 variant) this continues to be so when presenting the Occlusion 1 variant afterwards. Other effects are not significant, except for one three-way interaction effect, order of presentation by occlusion variant by trials, which is difficult to interpret.

Reaction times in the occlusion condition. In the ANOVA on the reaction times, the main effect of trials is significant, $F(8,80) = 4.21$; $MSe = 98348$, and can be interpreted as a learn-

ing effect: With each trial subjects learn to react faster. This interpretation is confirmed by trend analysis: The linear effect is significant: $F(1,10)=15.46$; $MSe=108251$. Again, a significant interaction exists between order of presentation and the occlusion variant: $F(1,10)=15.41$; $MSe=102336$. Paired comparisons show that this can be explained by the learning effect: For when the Occlusion 2 variant is presented first, the reaction times are significantly longer for that variant (947 vs. 531 msec; $F(1,10)=15.26$; $MSe=102336$). When the order is reversed, the reaction times do not differ significantly (517 vs. 692 msec, s. tab. I, Part A). Other interactions are not significant except for the same higher-order interaction.

Tab. I. Average answers and reaction times in experiment 1 and 2

(A) Experiment 1				
Condition	Average Percentage of Answers "2" (%)		Average Reaction Times (msec)	
Control	39		746	
Occlusion (in the presented order)				
Occlusion 1—Occlusion 2	44	83	692	517
Occlusion 2—Occlusion 1	61	74	947	531
Memory	92		828	
(B) Experiment 2				
Control	41		1181	
Occlusion 1	12		744	
Occlusion 2	85		774	
Memory	84		761	

Answer in the total experiment. Because the order of presentation has an influence on the seeing of the occlusion variants (see above), only the data of the first presented occlusion variant are used in the analysis of the total experiment. This leads to a design with one between-group factor consisting of four levels with unequal numbers of subjects (control and memory condition have 12 subjects each, Occlusions 1 and 2 only six subjects each). Again, two analyses were made with stops and trials as a separate factor, but the results are presented together for the sake of convenience. The most important results from the ANOVA are those concerning the main effect of the between-subjects variable, which is significant: $F(3,32)=5.47$; $MSe=0.344$. Paired comparisons reveal only a significant difference between control and memory (39 % and 92 % respectively, see Table, Part A; $F(1,32)=14.60$; $MSe=0.344$). This confirms the prediction that can be made from within a cognitive framework: The seeing of the display can clearly be influenced by previous information which must be "remembered" during perception. The differences between the control and Occlusion 1 (39 % vs. 44 %), control and Occlusion 2 (39 % vs. 61 %), and Occlusion 1 and Occlusion 2 (44 % vs. 61 %) are not significant. Both the direct and the

indirect theories fail to predict these findings. It was hypothesized that the information about the occlusion of one or two objects would result in different answers for the two occlusion conditions. The main effect of stops is also significant, $F(1,32)=9.20$; $MSe=0.03$, and can be interpreted as follows: When the moving things are at $p2$, they can be more easily seen as two (namely, 67 %) in comparison with the stops $p1$ and $p3$ (49 % and 61 %, respectively).

Reaction times in the total experiment. Concerning the reaction times, there is a significant main effect of trials: $F(8,256)=5.81$; $MSe=222002$. Again this can be understood as a learning effect. The linear trend is indeed significant: $F(1,32)=8.29$; $MSe=851202$. The main effect of the between-group factor is not significant (control: 746 msec, memory: 828 msec; Occlusions 1 and 2: 692 and 947 msec respectively, s. tab. I, Part A). This runs counter to the predictions of the indirect theories which would expect longer reaction times for the memory condition. The interaction between information and trials is significant: $F(24,256)=1.227$; $MSe=222002$, but difficult to interpret, especially when one also takes the results of experiment 2 into consideration (interaction is not significant there, and the trends point in opposite direction). A clear interpretation would require further investigations, but we considered it an unessential detail as regards the aim of this study.

The most important findings are the differences between the control and the memory condition, which were only predicted by the indirect theories of perception and the lack of a difference between the occlusion variants, which runs counter to the expectations of both the direct and the indirect theories.

Experiment 2

Before introducing experiment 2 and the changed manipulations, we must explain what could have been the reason for the failed prediction of the occlusion results in the first experiment. One must imagine oneself as a subject in experiment 1 (watching the occlusion variants in particular). You receive the display three times during the viewing phase: You probably clearly see either one large brown rectangle moving behind the occluder (in Occlusion 1) or two small brown squares moving in parallel (in Occlusion 2). When the experimenter asks if you see one or two objects moving, you will hesitate and ask if it is really that simple. Apparently, some of the subjects believed they did not understand the instructions, or that they discovered the "trick" being played by the experimenter and *know* that the display can be seen in both ways. They then start hypothesizing about what would be the most intelligent answer. Although it was stressed during the instructions that the only right answer is what *they* see, they are suspicious. Maybe this effect is reinforced by the subjects being psychology students (who are, perhaps, aware of the duplicity of psychologists). All these cognitive processes might have had an influence on the perception of the display reported.

While this might be plausible, one may well ask for "hard" evidence to prove it. No a priori hypotheses were made that could predict the results in the occlusion condition,

but some post hoc arguments may be given. First, the interaction between order of presentation and occlusion variant may be considered an indication of this interpretation. When two objects have been seen, it is difficult to see one again. The seeing of two objects can be promoted by the mere mentioning of the possibility of two objects in the instructions. And when one explicitly looks for two small squares, it is very possible, indeed. This may distort the rest of the results from the same subject. Rock (1985, p. 9) has recently given some examples of situations where "knowledge" has a demonstrated influence on perception: "The stimulus array or transformation is ambiguous and is in some way impoverished or less adequate than it might be in order to bring to mind a particular, in fact, preferred solution. . . Given any hint or clue that suggests that solution, it can immediately occur and be maintained".

A further confirmation of this interpretation can be found in the data concerning the stops. In all conditions more two-answers were given at $p3$ than at $p1$ (control: 42 % vs. 33 %; memory: 92 % vs. 86 %; Occlusion 1: 50 % vs. 33 %; Occlusion 2: 61 % vs. 45 %; averaged over conditions: 61 % vs. 49 %), even though the stimulus information was exactly the same. This may be because of the slight tendency at $p2$ to view two objects (see the above mentioned quadratic effect of stops with 49 %, 67 % and 61 % two-answers for $p1$, $p2$ and $p3$ respectively). The second argument has more hard evidence behind it. Wrong answers take a consistently longer time than correct ones (with "correct" is meant according to the hypotheses): In the memory condition 1077 vs. 800 msec, in the Occlusion 1 condition 634 vs. 583 msec, in the Occlusion 2 condition 853 vs. 689 msec and in all experimental conditions together 741 vs. 715 msec. This might also be a plausible explanation for the finding that reaction times are not the highest in the memory condition. Apparently, there is more cognitive processing going on when watching the occlusion variants than during the memory variant. In experiment 2 some changes were introduced to see if the above described explanation holds.

In this experiment, the same displays were used, but several things in the experimental set-up were changed for two reasons. First, to check the plausibility of the post hoc explanation for the surprising findings in the occlusion condition of experiment 1; second, to avoid the complexities in the design and the analysis of the results of experiment 1. In the subsequent description of the method only the alterations and the reasons for them are given.

Method

Forty-eight subjects, all students of the University of Leuven, participated in the experiment. In this experiment, however, only students from other fields than psychology were asked. Some of the students (had) followed an introductory course in psychology, but their knowledge of perception research and theory was considered minimal. To recruit the subjects, the experimenter went to large student residences and asked students at random to participate. Although they were not paid for it, they participated willingly, when told that the experiment was just a perception experiment that took only five or ten minutes. The reason for the choice of non-psychology students should be obvious: We presumed they would be less suspicious.

Just as before, subjects came to the experimental room individually and were thanked for their participation. Unlike the previous experiment, however, names were not asked and only a number was typed in the computer. This made things look more impersonal. They were also told that the results would be analyzed anonymously because the experiment was about perception in general. The same instructions as in experiment 1 are given with the following being added: "This question is very easy, you don't have to think about it." Furthermore, subjects in the occlusion conditions were told a deception story. They were made to believe that they were in a kind of control condition, where the display was so simple and the question was so easy because only their reaction times were important. When the subjects appeared to understand the instructions, the response phase started, again consisting of nine trials in which the moving objects randomly stopped at $p1$, $p2$, and $p3$. Everything else concerning the procedure was exactly the same as in experiment 1.

The randomization was programmed differently. Every stop place was used one single time in each group of three trials. This meant that strings such as 122311332 would no longer occur. This facilitated subsequent analysis because stops and trials could be analyzed in one design. For the analysis, the data were reordered to get the following series of stops: 123123123. The trials were analyzed on three levels: first, middle and last. Another difference with experiment 1 was in the occlusion condition: Only one occlusion variant was administered. During the total experiment, subjects were allowed to talk and the experimenter made a special effort to create a relaxed atmosphere.

Results and Discussion

Analysis of the answers. The answers with the highest interest are those concerning the main effect of information, which is very significant: $F(3,44)=21.35$; $MSe=0.63$. The percentages of two-answers are 41 %, 12 %, 85 %, and 84 % for control, Occlusion 1 and 2, and memory, respectively (s. tab. I, Part B). The paired comparisons reveal all differences that could be predicted: All the experimental conditions (Occlusions 1 and 2 and memory) differ very significantly from the control condition: $F(1,44)=7.01$, 16.81, and 15.44 resp.; $MSe=0.63$. In contrast with the previous experiment, Occlusion 1 differs from Occlusion 2: $F(1,44)=45.54$; $MSe=0.63$. In this experiment, both the direct and the indirect theories have correctly predicted the results of the occlusion conditions. The results also confirm the indirect hypothesis concerning the memory condition. The main effect of stops is not significant, contrary to the main effect of trials: $F(2,88)=4.69$; $MSe=0.13$, which is mainly caused by the difference between the first and the second part, $F(1,44)=5.97$; $MSe=0.15$. The interpretation of this last finding is not very clear. The interaction effects are not significant.

Analysis of the reaction times. The main effect of information, though not significant ($p < 0.07$), reveals some important differences: The reactions in the control condition (1181 msec, s. tab. I, Part B) took significantly longer than in the experimental conditions of Occlusion 1 (744 msec), Occlusion 2 (774 msec) and memory (761 msec): $F(1,44)=5.44$, 4.73 and 5.03 resp.; $MSe=1893501$. This is understandable, since the information in the

control variant of the tunnel effect is the most reduced and, therefore, ambiguous, so hesitations may be expected. Why this is not so in Experiment 1 remains an open question though other factors may have affected the results there. The reaction times of the memory condition do not differ from the ones in the occlusion conditions, which is also surprising. There is a highly significant main effect of stops, $F(2,88)=16.14$; $MSe=154955$, in the expected direction: Answering at $p1$ took significantly more time (1004 msec) than at $p2$ (850 msec): $F(1,44)=11.10$; $MSe=135327$. When the movement stops at $p1$, the subjects were not yet prepared; when it is at $p3$, in contrast, subjects were very alert because it had not stopped yet.

Trials also show a significant main effect: $F(2,88)=18.84$; $MSe=270726$. Further analysis reveals a significant linear trend, $F(1,44)=24.90$; $MSe=416769$, which can be explained by the same learning effect as in experiment 1. The last finding is also in accordance with that experiment: Reaction times are higher for wrong answers. This is the case for the total experiment (999 vs. 718) and for every experimental condition separately (1250 vs. 675; 887 vs. 754 and 919 vs. 729 msec for Occlusion 1 and 2 and memory, respectively).

General Discussion

By introducing some minor adjustments in the designs of the two experiments, very different results were obtained. In the first case, only one prediction was fulfilled and it supports the indirect paradigm. The occlusion conditions failed by some factors that could be explained (only post hoc however) in a rather indirect conceptual framework. Some changes were introduced to test the plausibility of the explanation in the second case, in which the occlusion conditions yielded results that were predicted by both the direct and the indirect theories of perception.

We would therefore like to conclude the following: At present, the indirect theories show to be most flexible. They are able to provide correct a priori predictions and plausible a posteriori explanations that cannot be made by the direct or ecological theory of perception. This does not imply that we should forget that theory and consider it refuted. Indeed, *others* would be just as able to defend the direct theory of perception even with the results reported here. A full account of such a defense is not attempted here, but we give some indications of the line of reasoning that could be followed by ecological theorists. Concerning the memory condition, it may be stressed that theorists working in the ecological framework have taken pains to expand their domain from perception to cognition in general (Farber and Mark, 1985; Michaels et al. 1985; Shaw and McIntyre, 1974; Shaw et al. 1982; Turvey and Carello, 1981; Turvey and Shaw, 1979). In fact, Gibson only objects to the library metaphor of memory and the categorical claim that memory lays on perception as viewed by cognitive psychologists (Gibson, 1966b). Theorists such as Bransford and his colleagues (Bransford et al., 1977) have developed a resonance metaphor of memory in line with Gibson's tuning metaphor of perception. Related to this issue is the ecological view of stimulus information. A stimulus is considered a pattern extended

in space and time. The extension in space is clear from the theory of higher-order invariants; the enlargement in time is evident from ecological studies in event perception (Johansson, 1979; Johansson et al., 1980; Warren and Shaw, 1985), and from formulas such as $R(t+1) = f(H(t), S(t))$. The perceptual output at time $t+1$ ($R(t+1)$), as it is viewed by ecological theory, depends not only on the stimulus input $S(t)$ but also on the complete history of organism-environment interactions ($H(t)$). It can be seen as an alternative to memory, or more generally, to the organism's contribution to the perceptual output that is postulated by the indirect theories (Shaw and Todd, 1980). When viewed according to this line of reasoning, the memory variant used in the reported experiments only provides supplementary information about the "event", which can be seen in the control variant. But this information must not be assumed to be picked up from one or another memory storage. It can be argued that the fusion of the two halves of the purple occluder is just an element of the total information set that is directly picked up from the light.

Direct theory could also give the following explanation of the surprising findings in the occlusion variants of experiment 1. The laboratory situation is not ecologically valid, because the subjects were not free to explore the environment, and the displays were ambiguous because they were only generated by the computer and not by real events. It is, therefore, not very surprising that the results deviate from what would have been found in a natural environment without an experimenter manipulating viewing conditions and asking ecologically invalid questions.

As will be clear from this discussion, both the direct and the indirect theories of perception can explain the results reported here. Our conclusion that indirect theories are more flexible should therefore be qualified: The indirect theories may have won this battle, but they have not yet won the war.

Zusammenfassung

Es wird ein experimenteller Beitrag zum Problem der Kontroverse zwischen der direkten (oder ökologischen) und indirekten (oder repräsentationalen) Theorie der Wahrnehmung geleistet. Vier Varianten des Tunnelleffektes wurden entworfen, um zu demonstrieren, daß direkte und indirekte Theorien manchmal die gleichen Voraussagen auf verschiedenen Grundlagen machen und manchmal auch unterschiedliche Voraussagen treffen. Die Gedächtnisvariante stammt deutlich aus einem indirekten Rahmenkonzept, während die Occlusionsvarianten auf einer direkten Auffassung der Wahrnehmung beruhen. Jedoch sind die Voraussagen für die Occlusionsvarianten die gleichen für beide Arten von Theorien. Im Experiment 1 prädiktieren die indirekten Theorien die Resultate in der Gedächtnisvariante korrekt; aber ähnlich wie in der direkten Theorie prädiktieren sie nicht die Ergebnisse der Occlusionsvarianten. Einige Versuchsplanverbesserungen im Experiment 2 verdeutlichen die Daten aus den Occlusionsvarianten. Zusammengefaßt zeigen diese Experimente, daß die indirekten Theorien zumindest flexibler sind als die direkten Theorien.

Summary

An experimental contribution is made to the controversy between the direct (or ecological) and indirect (or representational/computational) theories of perception. Four variants of the tunnel effect were designed to show that direct and indirect theories sometimes make the same predictions on different grounds and sometimes make different predictions. The memory variant clearly stems from an indirect framework, whereas the occlusion variants rely on a direct view on perception. However, the predictions for the occlusion variants are the same for both kinds of theories. In experiment 1, indirect theories correctly predict the results in the memory variant, but, like the direct theory, they fail to predict the findings of the occlusion variants. Some design improvements in experiment 2 clarify the data from the occlusion variants. Taken together, these experiments indicate that indirect theories are at least more flexible than direct theory.

Резюме

Данная работа является экспериментальным вкладом в дискуссию между прямыми теориями и восприятия теориями косвенного (аналитического восприятия). Было запланировано 4 варианта эффекта тунеля, чтобы показать, что прямые и косвенные теории иногда предсказывают одно и то же, исходя из разных предпосылок, а иногда разное. Вариант основанный на запоминании; исходит явно из теории косвенного восприятия, а варианты, связанные с феноменом слияния, отражают прямые теории восприятия. Оба класса теорий предсказывают однако одинаковые результаты для вариантов, основанных на феномене слияния.

В первом эксперименте косвенные теории правильно предсказывают результаты для варианта, основанного на запоминании, для вариантов, основанных на слиянии эти предсказания, как и предсказания прямых теорий оказываются ошибочными. Несколько улучшенное планирование опыта, предпринятое для второго эксперимента, позволило объяснить данные вариантов, основанных на слиянии. В целом эксперименты показали, что теории косвенного восприятия оказываются, по крайней мере, более гибкими.

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Accepted: January, 21 1988

Author's address: Dr. Johan P. Wagemans
Department of Psychology
University of Leuven
B - 3000 Leuven

Z. Psychol. 196 (1988) 231–232

Buchbesprechungen

Fromm, E.: Über die Liebe zum Leben. Hrsg.: Schultz, H.-J. 186 S. München: Deutscher Taschenbuch Verlag 1986. *Dialog und Praxis*. Broschiert 9,80 DM.

Das Büchlein enthält ausschließlich Radiotexte aus dem letzten – dem achten – Lebensjahrzehnt Erich Fromms. Es sind Protokolle von Gesprächen, die in der Mehrzahl vom Herausgeber in der Wohnung Fromm's geführt wurden. Sie sind daher von einer solchen Lebendigkeit und Unmittelbarkeit, daß das Lesen großes Vergnügen bereitet. Das Spektrum der Themen reicht von Bemerkungen über Entwicklungstendenzen in der kapitalistischen Gesellschaft über psychoanalytische Problemkreise im engeren Sinne (Grundzüge der Theorie Sigmund Freuds und ihre Weiterentwicklungen, Aggressions- und Traumtheorie), über Auseinandersetzungen mit dem Hitlerfaschismus und aktuelle Fragen des Judentums bis zu einem autobiografischen Gespräch, in dem der Autor sehr viel über sich, seinen Werdegang, seine Auffassungen mitteilt. Auch wenn man sich den Ideen und Konzepten des Autors natürlich nicht immer anschließen kann, so bieten die Texte doch eine Fülle von Anregungen zu kritischer Auseinandersetzung. Sie stellen eine interessante Ergänzung seines umfangreichen Fachschrifttums dar und sagen wohl mehr aus über ihn als Mensch als die Fachliteratur. Der Herausgeber schreibt am Schluß seines Vorwortes: „Sein (Fromm's) Talent, dem Herzen beim Denken Mitspracherecht einzuräumen, hätte man früher mit dem Namen ‚Weisheit‘ bedacht“: das ist in jeder Zeile des Büchleins zu spüren.

Edith Kasielke (Berlin)

Human Assessment: Cognition and Motivation. Newstead, St. E.; Irvine, S. H.; Dann, P. L. 495 S. mit 20 Abb., 40 Tab., 16,5×24,5 cm. Dordrecht – Boston – Lancaster: Martinus Nijhoff Publishers 1986. *NATO ASI Series, Series D: Behavioural and Social Sciences, No. 27.* Kartoniert.

Der vorliegende Band enthält 44 Vorträge bzw. Vorlesungen sowie 43 Kurzfassungen von Seminarbeiträgen, die auf einer interdisziplinären Konferenz 1984 in Athen zum Themenkomplex der Bewertung und Meßbarkeit von Kognition, Motivation und Persönlichkeit zur Diskussion standen. Die Gliederung des Bandes folgt der der Konferenz. So werden in einem ersten Teil grundlegende Aussagen zur Thematik in Form von einführenden Vorlesungen mit einer meist sehr umfangreichen Bewertung des gegenwärtigen Standes an Hand der neueren Literatur bzw. der theoretischen Annahmen der jeweiligen Autoren vorgestellt. Dies geschieht in sechs thematisch gegliederten Sektionen. In Sektion 1 wird über psychometrische Zugänge zur Bewertung von kognitiven Fähigkeiten referiert. So stehen z. B. bei Carroll faktorenanalytische Untersuchungen im Vordergrund. Eysenck setzt sich mit der biologischen Basis der Intelligenz auseinander und Irvine bewertet Möglichkeiten der Erfassung interindividueller Unterschiede über den LIQ. In Sektion 2 widmen sich Hunt und Sternberg der Theorie der Intelligenz auf der Grundlage von Prozessen der Informationsverarbeitung. Die folgenden Sektionen sind sozio-kulturellen Fragen, unstandardisierten Zugängen, persönlichkeits-theoretischen Fragen sowie fähigkeits- und lerntheoretischen Konzepten gewidmet.

Im zweiten Teil werden in 3 Sektionen grundlegende Aussagen zur Anwendung der im ersten Teil formulierten theoretischen und methodischen Aussagen vor allem für den Bereich der Erziehung, Lehr- und Lerntätigkeit z. T. an Hand empirischer bzw. experimenteller Untersuchungen vorgestellt. In Sektion 1 werden zum Problem der kognitiven Fähigkeiten z. B. von De Guire faktorenanalytische Studien zu mathematischen Fähigkeiten referiert, Osseur und Rudnin behandeln den Einfluß von Metakognition, sozialem Kontext und personellen Faktoren auf die Lösung arithmetischer Aufgaben und bei Hains wird der Einfluß von Wortähnlichkeiten auf das Wortverständnis experimentell geprüft. In der Sektion 2 stehen Fragen der Persönlichkeit und der kognitiven Stile und in Sektion 3 soziale Faktoren und Milieueinflüsse im Vordergrund. Im dritten Teil des Bandes werden jeweils Kurzfassungen der 43 Seminarbeiträge zu folgenden Themengruppen vorgestellt: Computergestützte Bewertung, Psychometrie und klinische Bewertung, Testen und Itemfehler, Schlußfolgerungen für Erziehungs- und Bildungsprozesse, Kognition und Fertigkeiten, Entwicklungsaspekte sowie soziale und kulturelle Faktoren.

Mit der Auswahl einiger Autoren und Themen sollte exemplarisch die Vielzahl und Breite der behandelten theoretischen und praktischen Fragen verdeutlicht werden. Diese Vielfalt angeschnittener Probleme lassen ebenso wie die unterschiedliche Exaktheit der vorgestellten empirischen und experimentellen Studien den Versuch einer umfassenden wissenschaftlichen Würdigung einzelner Beiträge oder gar des gesamten Bandes als kaum möglich erscheinen. Gerade diese Umfassendheit der behandelten Fragen zum Themenkreis der Meßbarkeit von Kognition, Motivation und Persönlichkeit ist es aber, die den vorliegenden Band in mehrfacher Hinsicht empfehlenswert macht. Denn sie ermöglicht einen schnellen Überblick über den derzeitigen theoretischen Stand, zu methodischen Ansätzen und zu Möglichkeiten und Problemen bei der Umsetzung in unterschiedlichsten Praxisfeldern. Die über alle Beiträge zusammengefaßt angebotene umfangreiche Literatur stellt eine fundierte Ausgangsposition für die vertiefende Beschäftigung dar. Über die beigelegte Übersicht zu den Teilnehmern der Tagung wird darüber hinaus ein Überblick über die Institutionen vermittelt, an denen der Problemkreis Kognition und Motivation bearbeitet wird.

Elke Wetzenstein-Ollenschläger (Berlin)