RFID in Behavior Research at the Point of Sale - Possibilities and Limitations

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1. Introduction

The behavior at the Point of Sale (POS) is of paramount importance for the success of the manufacturers and distributors offering the product, as that is where many of a potential customer's decisions are first made and many preferences specified. Besides the buying behavior, however, the wayfinding and attention behavior is also of interest because, firstly, its helps explain the buying behavior and, secondly, contacts with the range of products can also produce medium to long-term attitude effects. Practically speaking, the wayfinding and attention behavior can ultimately provide information as to how successfully shop environments and product ranges can be configured. And for science, analyses of the wayfinding and attention behavior at the POS can help improve the theories of buyer behavior and marketing effects developed thus far.

In searching for rationalization possibilities in trade and industry, inventory managers already encountered the possibility of locating and identifying products via radio frequency years ago. "Radio Frequency Identification" (RFID) is a technique for locating and identifying objects without having to touch or even see them. These advantages, coupled with the falling prices of the technology, should see it become increasingly widespread in inventory management (Jones et al. 2005; Kärkkäinen 2003; Dutta et al. 2007). However, RFID technology also offers certain possibilities for stationary trade to register the wayfinding and attention behavior of shoppers. This article is aimed at investigating the use of RFID technology at the POS more closely for the first time. After all, Larson et al. (2005) already showed years ago with their study of shopper wayfinding behavior that using RFID for the purpose of researching behavior at the point of sale is technically feasible. Whilst some technology providers have latterly been intensifying their efforts to develop this market, at the same time some consumer representatives champion the view that tracking buying behavior without the appropriate consent constitutes an infringement of shopper rights and interests. In one prominent case, they even managed to expose the actual comprehensive infringement of the customers' personality rights (FoeBuD 2006). Consequently, the following article not only examines the technical possibilities of behavior tracking in stationary trade, but also the boundaries that legislature has drawn and that have arisen as a result of shopper interests.

In the specific analysis of all the possibilities that RFID holds for behavior tracking, two fundamentally different situations are distinguished in the following: the first concerns the current situation, where only a handful of products are fitted with RFID transponders; the second relates to a future where many products are equipped with RFID transponders. The experts expect the latter to happen in 10 to 15 years (e. g. according to Verdi 2007 p. 13, Schulz from the Real Future Store on 12.05.2008). In the next few years, we can expect a small number of primarily high-

ly priced products with RFID transponders, which are for instance used by Prada for virtual fitting rooms and customer advice (Uhrich et al. 2008 p. 230).

Different possibilities of an RFID-based recording of shoppers' wayfinding and attention behavior emerge for both situations; as a result, the RFID-assisted tracking of shopper behavior also has to be evaluated in a correspondingly differentiated manner. The basic designs that precede these analyses (in section 5 and 6) concern the shopper behavior to be recorded (in section 2), the partly concurrent classical methods of behavioral research (in section 3), and the RFID technology itself (in section 4).

2. Shopper Behavior

Shopper behavior that in theory is accessible via observation and registration can roughly be divided into three categories: wayfinding, attention and other behavior (Silberer 2006, 2009).

Wayfinding behavior concerns the way in which customers orient themselves. Recording this behavior yields information on the path the shopper took, and which departments or areas he visited or entered. Wayfinding can simply be represented as the sequence of areas entered; no wayfinding can be reconstructed solely from the contact frequencies.

The *attention behavior* is the attention paid to the range of products, POS media and other people on site. A shopper can view products on offer (visual attention), touch them (maybe also try on clothing), put them back, take them and pay for them at the checkout; he can talk to the shopping assistants, the sales staff, the service staff or other shoppers, or merely watch them. In the case of promotions, sampling drinks and food may also come into play.

Other behavior includes the choice of checkout system (e. g. a self-service checkout), packing or exchanging the goods, returning empties, relaxation in rest areas, and the usage of gastronomic services.

3. Classical Methods of Behavior Research at the Point of Sale

As wayfinding and attention behavior are observable behavior categories, *observation* was the method of choice from the outset. The researcher observes the shopper and records his observations immediately or shortly thereafter. In the case of *open observation*, the shopper is aware that he is being observed and has to have consented to it in advance; he can refuse or, should he give his consent, decide whether he will behave normally or differently. With *concealed observation*, on the other hand, selectivity and reactivity effects are eliminated (although the latter not always, such as if the person under observation realizes or suspects he is being watched and changes his behavior as a result, for instance).

In recording shopper behavior at the POS, the *interview technique*, where the shopper is asked to report on his behavior on site, also comes into question. It might well be far more straightforward than an observation, but one also has to accept that if the person is interviewed after the shop visit, he may only partially have registered his behavior consciously, may only be able to remember fragments of the consciously registered behavior, or might not even be willing to disclose the behavior recalled.

Customer behavior can also be recorded using *video cameras* (Janasch & Spiekermann 2004 p. 62; Polenz 2008 p. 17; Schneider 2003 p. 4; Silberer 2009 pp. 22-23). Room cameras can be used to record the wayfinding and attention behavior, shelf cameras the attention to the shelf in question, and head cameras the visual attention. In the case of such recordings, which can also be consulted as memory jogs (Silberer 2006, 2009), not only do the shoppers have to be informed and give their consent; they also have to tolerate the head camera, which could irritate both the wearer and third parties, thereby distorting the results. If there is a possibility that third parties, such as other shoppers and shop staff, might also be recorded, their interests are also affected.

In light of the effort that open and concealed observation entails and the narrow limitations of an interview and targeted videography, the logical step seems to be to examine the valid economic possibilities of representative behavior research at the POS in an inconspicuous, automatic, RFID-based recording of shoppers' wayfinding and attention behavior. Whether or when such a view is justified will now be discussed in detail.

4. Radio-Based Technique for Recording Locations and Movements

RFID systems record the locations and movement of objects or subjects via radio waves (Jones et al. 2005). They consist of transponders, which are attached to the mobile objects or subjects, readers and an IT system operating in the background (Dutta et al. 2007; Kummer et al. 2005 p. 15; Informationsforum RFID 2008 p. 2). The readers generate electromagnetic fields that reach the transponders and supply them with power for a short period of time. The transponders activated as a result receive signals in the process and subsequently send the data stored on them back to the readers. Consequently, the transponders are both transmitters and responders, as the word suggests. *Figure 1* illustrates the structure of an RFID transponder attached to an adhesive smart label.

Transponders can also be constructed as active units. Unlike passive ones, active transponders have their own power supply and thus afford higher reading ranges, can process more data and perform additional functions (e. g. sensory tasks). By way of contrast, not only are the passive transponders, which draw the power they need from the reader's field, smaller; they are also considerably cheaper than their active counterparts.

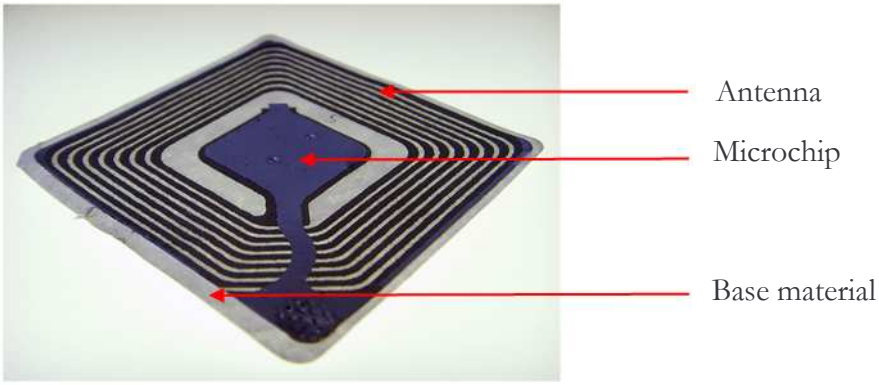


Figure 1: Structure of an RFID transponder

There are two kinds of readers: stationary and mobile. They can be differentiated further according to the frequency of the radio waves (see *Table 1*). The higher the frequency is, the bigger the reading range and rate (Informationsforum RFID 2008 p. 4). Three frequency ranges are currently used: low frequency (125-135 kHz), high frequency (13.56 MHz) and ultrahigh frequency (860-960 MHz) (Lampe & Flörkemeier 2005 p. 73). Low-frequency transponders have a lower range and reading rate, but are less sensitive to inference from metallic packaging materials and liquid product components, such as in canned goods and drinks (Lampe & Flörkemeier 2005 pp. 79-81; Jones et al. 2005; SToP 2007 p. 17). The high-frequency transponders' sensitivity to interference from metal is due to the reflection of the waves on the metallic surfaces. The susceptibility to interference depends on the kind of metal, the angle of incidence and other situational factors (Kern 2006 p. 43; BITKOM 2006 p. 29). At high frequencies, the penetration of liquid decreases as the field energy causes water molecules to oscillate, converting energy into heat and weakening the energy field (cf. Kern 2006 p. 42). By using special attachment techniques and placing the transponders on areas of the product that can easily be read, however, these problems can often be avoided. If transponders are located, their identification number can be redirected to the central computer via WLAN, for instance.

The main advantage of RFID systems over common barcodes lies in their non-contact, automatic recording and identification. Other benefits include no longer having to orientate the subject or object to the reader, their insensitivity to contaminants, the greater possible distance of the reader to the object, and bulk processing. Bulk processing means the simultaneous recording of several objects, e. g. the complete registration of all the articles on a palette or in a shopping cart or basket (cf. Kummer et al. 2005 p. 139; Jones et al. 2005; Kärkkäinen 2003).

Table 1: RFID frequencies and their fields of application

		Low frequency	High frequency	Ultrahigh frequency
Frequency		125 - 135 kHz	13.56 MHz	860 - 960 MHz
Reading distance		up to 1.5 m	up to 1.5 m	up to 4 m
Reading speed		5 kbps	10 kbps	60 kbps
Reading rates		10 - 40 tags/s	10 - 50 tags/s	100 - 500 tags/s
Influence of	**Water**	marginal	medium	strong
	Metal	marginal	medium	strong
Typical fields of application		access control, immobilizers, animal identification, automatic production	asset management, ticketing, book loans, smart labels	palette logging, container tracking

Sources: referring to Lampe & Flörkemeier 2005, Informationsforum RFID 2008, Kern 2006

5. Possibilities of the Radio-Based Recording of Wayfinding Behavior

5.1 Possible Starting Points for Recording Wayfinding Behavior

Recording wayfinding behavior can focus on three points: (1) the movement of the shopping cart used by the shopper; (2) the movement of the shopping basket used; and (3) the movement of the shopper himself.

(1) Tracking *shopping carts*:

As an advocate of using RFID systems to track shoppers, particularly with North-American supermarkets in mind, Sörensen perceives the movement of shopping carts that have been fitted with transponders as a good approximation of the shopper's movement and path (Larson et. al. 2005, Sörensen 2008). However – from a European perspective at least – two limitations should be noted in this respect: firstly, not all shoppers use a shopping cart; secondly, the carts are not always taken on every wayfinding route, such as if the shopper enters a narrow side aisle or goes along a shelf in search of a particular product.

(2) Tracking *shopping baskets:*

Transponders can be attached to shopping baskets provided by the individual stores. The baskets tend to be left much less frequently than shopping carts as the customer walks around a shop, making their movement a better indication of the wayfinding. However, the method also

has its shortcomings in that there are shoppers who prefer to use their own baskets or bags rather than the shopping carts and baskets provided by the store, or even do without such shopping aids altogether.

(3) Tracking *people:*

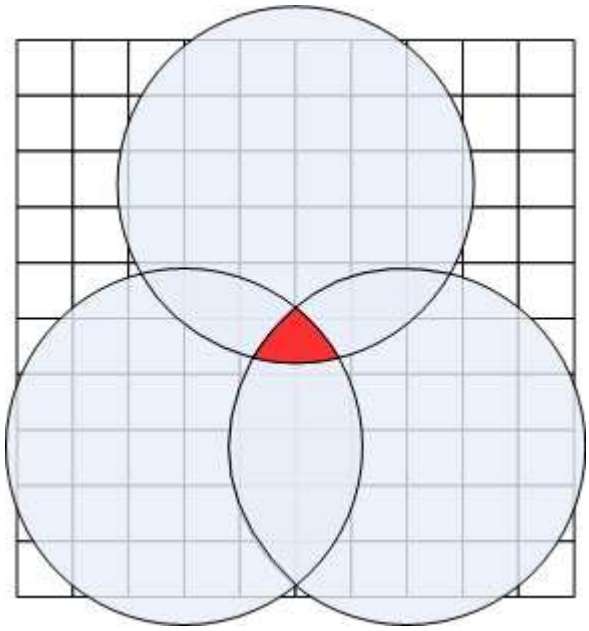
If shoppers carry objects with them that contain a transponder, their complete movements can be recorded. When transponders are incorporated into current fidelity cards (Bose et al. 2008 p. 194; Uhrich et al. 2008 p. 225), for instance, they only have a low transmission range due to the small antennae; and as fidelity cards are mostly kept in the purse, the transponders might be blocked by metallic coins. Consequently, visitor cards that can accommodate transponders with a larger range might be conceivable. The cards could be handed out prior to the store visit and collected afterwards, all the while being used completely anonymously (Rauch 2005 p. 8; Silberer 2009 p. 30).

5.2 Technical Possibilities of Tracking Wayfinding

In RFID-based shopper tracking, the readers (sometimes referred to as "antenna network"), transponders and the central server perform the main tasks (Hinske & Langheinrich 2007 pp. 10 - 12). The antennae installed in the floor, the ceiling or on shelves generate their frequencies and energy fields. If active or passive transponders in shopping carts, baskets and/or fidelity or visitor cards enter the respective area, they respond and identify themselves with their ID code. The antennae then transmit these responses on to the central server. The sequence of these signals and their mapping can then be used to determine the wayfinding.

There are two methods of calculating the location of the shopper: firstly, the so-called overlapping method, where the central server calculates the location of a transponder from the overlapping of the network fields created from the signals of a transponder with at least three antennae placed at different locations; and secondly, trilateration, where the central server calculates the location of a transponder from the response delay ("latency") in the transponder's signals to at least three antennae placed at different locations.

Figure 2: How the antenna network works



In the *overlapping method*, the antenna network (also referred to as "cell-of-origin system") is set up all over the store with several fixed installed antennae in the form of a structured network (cf. Hinske & Langheinrich 2007 pp. 10 - 12; Jin et al. 2006). The position of the transponder can be extrapolated from the overlapping of the reception area of several antennae; the transponder has to be in the overlapping area, or its signal would not be received by all the antennae. In *Figure 2*, the transponder, the signal of which is received by three antennae, is located in the area marked in red. The closer the antennae and the smaller the ranges are, the more accurate the localization because the network becomes increasingly close-meshed and the overlapping area increasingly smaller. This means several antennae can be managed by one reader to minimize investment costs. As the antennae emit the energy field, it is sufficient to use passive transponders.

Trilateration is a method that is also used in land surveying and satellite navigation. An active transponder sends out a signal, which has to be received by at least three readers; the position of the transmitter, i. e. the transponder, is determined from the signal's time difference of arrival at the receiving readers using trigonometric calculations (Hinske & Langheinrich 2007 pp. 10 - 12). It would also be possible to use the method in reverse, the position being determined in a transponder from the delay time of the signals emitted from at least three readers. However, the current transponders lack the computing capacity that such a calculation would require. Consequently, for the time being only the alternative with actively transmitting transponders is regarded as a viable option.

As far as the accuracy of the localization and movement detection is concerned, the following should be noted: the more closely meshed the network is and the smaller the necessary ranges are, the more accurate the localization. For smaller ranges, the transmission capacity of passive

transponders is sufficient. Measurement errors can also occur if the signals transmitted by antennae and sent back by transponders are reflected by metallic surfaces or containers for liquids (e. g. drink and soup cans) and the detour thus taken is not recognized. However, such errors can be minimized if the (greater) probability of the actual movement can be calculated using the previously recorded movements of a transponder (Hähnel et al. 2004 p. 4f.).

5.3 Evaluating Wayfinding Data

In the context of data evaluation, which goes beyond calculating responder locations, the following facts can be ascertained: the length of time spent in particular areas and at particular shelves, as well as the entire duration of the store visit; using several or even all shoppers, we can calculate how often which departments and shelves are frequented; using the corresponding "heat maps", it is then easy to recognize which areas are hardly visited at all as "dead corners"; "race tracks" can be identified using sequence frequencies; and, finally, recording "wayfinding patterns" via clustering is also a possibility.

If anonymous wayfinding data are merged with data containing personal information and recorded for entirely different purposes, the anonymous wayfinding data becomes personal data. Whilst data fusions of this nature improve the chances of obtaining better customer knowledge, however, the risk of breaking the law, annoying customers and alarming consumer safety groups also increases. This is particularly the case if such activities are carried out without the consent of those involved.

5.4 Legal Limitations and Social Acceptance

According to the (German) data protection law, which is based upon protecting privacy, personal data can only be recorded, stored and communicated if those involved authorize such activities and are informed about it fully in advance so that they can give their consent (see the provisions of the German Data Protection Act (BDSG), and BMJ 2006 and Polenz 2008). To record the wayfinding behavior at the POS, it is therefore important to verify *when* recordings involve *personal* data (Holznagel & Bonnekoh 2007 pp. 368 - 371). If the movements of shopping carts, shopping baskets and anonymous day and visitor cards are recorded and there is no subsequent fusion of the data that connects it to a person, according to the *BDSG* this does not require the shopper's clarification and approval; however, clarification and approval is always required if the tracking is linked to fidelity or payback cards (as recommended for instance by Ngai et al. 2008 at a supermarket chain in Hong Kong); if data fusion transforms the anonymous data into personal data; and if, even in the case of "anonymous shopper data", the individual shoppers are known personally to the store or certain staff members (cf. BMJ 2006; Holznagel & Bonnekoh 2007 pp.

368 - 371, 377 - 379; Holznagel 2008 p. 8 f.; Polenz 2008 pp. 92 - 96). If tracking based on transponders in fidelity cards is planned and the cards are equipped accordingly beforehand, (informed) consent needs to be obtained when issuing the cards.

If legal obligations are violated, shopper tracking can not only reckon with sanctions as stipulated by law, but also opposition from consumer and data protectionists (cf. Hüttl 2007, and the data protection officers' resolution from October 2006, the 2006 data protection officer conference, and the statement of the companies involved in the Informationsforum RFID from 2006). Campaigns against the RFID adoption already initiated by consumer protection organizations like FoeBuD (2006) and CASPIAN (2007) highlight this. However, even if all the legal standards are regarded, opposition on the part of the customer still cannot be ruled out; more or less reasonable criticism in the media alone can harm the image and thus trigger a decrease in sales. Consequently, in recording shopper behavior based on RFID not only should the statutory requirements and regulations be considered, but also social acceptance (Smith 2005).

Capgemini (2005) already pointed out a number of years ago in a representative study that 18% of European and 23% of American consumers had heard of RFID. 8% of the respondents indicated that they only had negative expectations of RFID; however, few were able to substantiate their expectations and misgivings. This should change all the quicker and more radically the more often problematic shopper tracking is practiced and the more often it is criticized in the media.

The fact that the attitude towards RFID is not only characterized by convictions but also emotions was established in a study by Boslau & Lietke (2006 p. 36). It revealed that consumers tend more to have a positive attitude towards new technologies, including RFID "per se" (p. 37). By contrast, in their representative survey of German consumers Günther & Spiekermann (2005 pp. 73 - 76) concluded that the expected advantages of RFID technology could not compensate for the feared encroachment into the private sphere and the associated loss of control. As insightful as such findings are, we are still a far cry from a specific analysis of the social acceptance of RFID-based shopper tracking on the part of informed shoppers.

6. Possibilities of the Radio-Based Recording of Attention Behavior

6.1 Relevant Attentions and their Recordability

If shoppers approach a shelf, unit or service counter, it might still be deduced from the wayfinding behavior. This does not apply to many forms of attention, however, least of all the attention to concrete product ranges. The attention to particular media utilized on site, such as posters, signs and display material, can only be deduced from the wayfinding behavior in exceptional

cases. On closer inspection, the attention to product ranges consists of visual attention, but also actions like touching, taking and putting back. For many media, visual attention is important; for store announcements, hearing; for samples, taste; and for information terminals, processing and reading behavior.

If the attention behavior is to be recorded using RFID, the question once again arises as to the starting points. As a reference point for an approach and thus a so-called "opportunity to see" (OTS), once again the approximation of shopping carts and baskets fitted with transponders comes into question, as does the approximation of people who, for instance, carry visitor cards equipped with transponders. However, products fitted with transponders are also possible reading points because the movement of a product can also be an indicator of the shopper's attention. This applies equally to touching, taking and replacing products. It does however raise the question as to when the attention behavior of a particular shopper can be extrapolated from such product movements. This would be the case if the wayfinding behavior of particular people was tracked, and the person and behavior could be correlated using precise time designations and spatial parallelism. However, in such cases attribution problems can also materialize if, for example, several people simultaneously turn their attention to the product range at a particular shelf.

6.2 Technical Possibilities of Attention Tracking

As long as only few or no products are fitted with transponders, the only possibility for attention tracking is to trace approaches and therefore the readout of transponders in shopping carts, shopping baskets, fidelity cards and visitor cards. The approach to shelves, displays and service counters, as well as the approach to in-store media, can be recorded via RFID reading systems or antennae that are attached to the stated attention objects and able to localize the approach behavior relatively accurately. And whether the shopper turns to the product range in the reach, stretch or bend zone could be established by attaching the antennae accordingly.

If in future many products are fitted with transponders, and if they are only products in a particular department or on a particular shelf, important attention data can be recorded via the movements of these products. In this case, it is critical that the readers be specifically oriented towards particular shelf areas in order to achieve the necessary localization accuracy. The problem of correlating product movements and people or their movements can also be solved in an anonymous approach where readers attached to shopping carts and baskets constantly record the products found there. *Table 2* provides an overview of the possible attention at shelves, the purchase of products and their recordability via RFID.

Table 2: The RFID-based recording of attention at shelves and product purchases at the checkout counter

Attention	Recording via RFID	Possible explanation
Taking	Product with a transponder leaves the reading range without returning	Customer is interested in the product and wants to buy it
Picking up & putting back a product at the same location	Product with a transponder leaves the reading range and returns shortly afterwards	Customer shows interest in the product and/or the product information, but decides against taking it
Picking up & putting back several products at one location	Several products with transponders leave the reading range and return	Customer shows interest and compares several products, but decides against taking any of them
Picking up & putting back a product at a different location	Product with a transponder leaves the reading range and returns at another location or is not registered at the checkout counter	Customer shows interest and initially decides to take and purchase a product, only to change his mind later
Purchase	Product with a transponder is registered at the checkout desk and entered as purchased and paid for	Customer buys and pays for the product (return at a later stage not ruled out)

The Metro Group's pilot project demonstrates what *attention tracking at a shelf* might look like with the "smart shelf" (Metro Group 2007 p. 30; Schneider 2003 p. 2; Verdi 2007 p. 27). Here, the registration system inside the shelf records any movement of the products it contains, and therefore what is picked up and taken or replaced. And if a product is put back in the wrong place on the shelf in question, the smart shelf alerts the members of staff responsible so that they can return the product to where it belongs (Vogell 2004 p. 12).

If products are recognized based on the product code and if this information, which is communicated to the central computer by the readers, also contains information on the location within the store, which products were put back in a different place to their habitual one can be determined automatically. This is also possible if the central computer provides information on the habitual locations. Consequently, it is also possible to establish the route via which a product that has been put back was taken, for instance whether it was returned shortly before entering the checkout zone.

Even if the central computer has to perform many calculations and storage functions for attention tracking on account of product movements in future, this should not founder on the provision of the necessary storage and computing capacities; however, the readers might prove to be an obstacle if the recording capacities reach their limits with a high number of products and customers. Should this be the case, a denser use of readers might be an option.

We can conclude that shopping carts and baskets could also be fitted with readers; and products, counters, places and in-store media with a transponder. The approach behavior can also be recorded in this configuration (cf. Jannasch & Spiekermann 2004 p. 37). Such a solution especially comes into question if mobile attention items are involved, e. g. display stands and information terminals, which can be erected alternately in different places.

6.3 Evaluating Attention Data

The evaluation of attention-related data can be used to answer very different questions. If we now single out some of these here, we start on the presumption that only the shoppers' attention behavior was recorded; in a second step, we assume that both the wayfinding behavior and the attention behavior were recorded.

Based on one shopper's recorded attention behavior, it seems reasonable to count how often he exhibited which behavior patterns. Based on several shoppers, however, such counts can be based on particular shelves and particular departments, but also particular times of the day, week days and periods of time. If data on the attention to product ranges *and* in-store media are available, the issue as to how the advertising contacts correlate with the attention to the brands advertised can be pursued. The duration of the attention, which is derived from the difference between the moment the products are picked up and the moment they are put back, might also be of interest for products that are replaced; however, whether the customer was concentrating on the product picked up the whole time cannot be ascertained for sure. Furthermore, the attention that leads to the product being taken and purchased can also be investigated. With regard to the competition between different product brands, how often and in what sequence competing brands were removed from the shelf, taken and replaced can also be calculated.

If data is available that provides information on both the wayfinding behavior and the attention behavior of a shopper, the following questions can be answered via the aforementioned evaluation steps: how often was a section or shelf visited before a product was taken? How long does the shopper stay near a shelf before a product is taken? Which attentions took place when a shelf or freezer was repeatedly visited? How does the number of particular attentions correlate with the wayfinding pattern and the duration of the store visit?

6.4 Legal Limitations and Social Acceptance

For the recording of attention behavior and its statutory regulation, the same observations already mentioned above for recording the wayfinding behavior apply. The crucial factor is not only the direct personal nature of the data, but also the transformation of initially anonymous data into personal data. One particularity in the matter of data fusion should be noted, however:

if an attention analysis yields data from which the products that were taken can readily be detected, it can easily be compared with the scanner checkout data; if the individual can be identified on the basis of this comparison, such as on the basis of a fidelity card for instance, the initially anonymous attention data has to be regarded as personal. The attention data involved and the remaining personal data may only be stored, used and passed on with the informed consent of the person concerned.

As regards social acceptance, it can be assumed that shoppers, customers and the public perceive the analysis of the attention behavior as a greater intrusion into the privacy of shoppers than the analysis of the wayfinding behavior; the customers thus having become one step more "see-through" (Smith 2005). Retailers especially fear an aversion on the part of the consumers in the use of RFID fidelity cards (Uhrich et al. 2008 p. 225). The danger that customers might react with indignation and migrate, the media with critical reports, and third parties with protests is certainly greater for attention tracking than wayfinding tracking; however, it should be considered that the scope of shopper tracking is scaleable, i. e. variable, and that the social rejection can hence be reduced. Shopper tracking can namely be conducted on a random basis: on the one hand, as a random test in particular store areas; on the other hand, as a random test in particular time phases. This means attention tracking can readily be restricted to particular sections and shelves, as well as particular time phases, such as a few weeks a year for instance.

7. Summary

To sum up, it can be said that RFID systems not only open up new possibilities in the field of inventory management, especially rationalization opportunities, but also for behavior research at the point of sale, especially for the automatic recording of shoppers' wayfinding and attention behavior. This is especially true if the products on offer in a store are fitted with transponders. From a technical viewpoint, the attachment, functions and effectiveness of the readers and transponders are of particular importance. However, potential sources of error and the possibilities of reducing localization errors should also be taken into consideration.

Anyone who is looking to discover all the aspects of shopper behavior, such as the visual attention and cognitive and emotional reactions, cannot content himself with automatic behavior registration; he then has to fall back on other methods like observation, interviews, thinking-aloud and videography (cf. the differentiated representation of such methods in Silberer 2009). In many cases, it stands to reason that one might combine various methods if not only the observable, external behavior is to be recorded, but also the concealed, internal behavior of the shoppers.

Compared to the outlined technical limitations of using RFID for behavior research at the point of sale, the limitations set by legislature and the limitations arising from social acceptance

are more significant and restrictive. This does not only concern using these systems in such a way that they are not even noticed by the shopper, thus violating the legal norms; it is also concerns the refusal of shoppers, and maybe even staff, to consent to the collection and analysis of personal data. Moreover, it also involves public and private fears regarding an intrusion into the private sphere and data abuse, which might well be unfounded in individual cases but, doubtlessly, will also prove justified through instances of abuse in the future. At any rate, users of RFID systems in behavior research must not content themselves with observing the legal norms; anticipating opposition and encouraging acceptance by informing the consumer and allowing him to decide for himself must follow.

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